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# DESIGNING SUSTAINABILITY FOR ALL

Edited by Marcelo Ambrosio and Carlo Vezzoli

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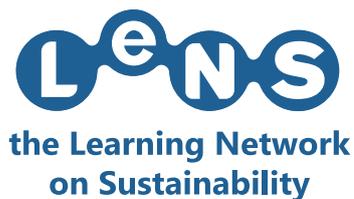
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# Designing sustainability for all

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## FOREWORD

*Designing sustainability for All was a call for contributions and actions to the whole world design community, which is not limited to design researchers, design educators, and design practitioners but also unites other disciplines such as architecture, engineering, economy, policy-making, and sociology.*

*The Conference has been a unique event hosted simultaneously in Mexico City (Mexico), Curitiba (Brazil), Cape Town (South Africa), Bangalore (India), Beijing (China) and Milan (Italy), on 3rd-5th April 2019. In fact, in each of the 6 venues, it has been possible to listen to any of the presentations happening in the other ones.*

## LENSIN PROJECT

LeNSin, the International Learning Network of networks on Sustainability (2015-2018), is an EU-supported (ERASMUS+) project involving 36 universities from Europe, Asia, Africa, South America and Central America, aiming at the promotion of a new generation of designers (and design educators) capable to effectively contribute to the transition towards a sustainable society for all.

LeNSin ambitions to improve the internationalisation, intercultural cross-fertilisation and accessibility of higher education on Design for Sustainability (DfS). The project focuses on Sustainable Product-Service Systems (S.PSS) and Distributed Economies (DE) – considering both as promising models to couple environmental protection with social equity, cohesion and economic prosperity – applied in different contexts around the world. LeNSin connects a multi-polar network of Higher Education Institutions adopting and promoting a learning-by-sharing knowledge generation and dissemination, with an open and copyleft ethos.

During the three years of operation, LeNSin project activities involve five seminars, ten pilot courses, the setting up of ten regional LeNS Labs, and of a (decentralised) open web platform, any students/designers and any teachers can access to download, modify/remix and reuse an articulated set of open and copyleft learning resources, i.e. courses/lectures, tools, cases, criteria, projects.

LeNSin will also promote a series of diffusion activities targeting the design community worldwide. The final event will be a decentralised conference in 2018, based simultaneously in six partner universities, organised together by the 36 project partners from four continents.

## THE LENS CONFERENCE

The Conference is the 3rd edition of one of the largest design international conferences for lecturers, researchers, professionals, and relevant institutions and organizations. It has become a reference event where experts from all over the world get together to present and share their knowledge, projects, tools, and visions to diffuse sustainability for all.

The Conference is organized as a part of the LeNSin, the International Learning Network of networks on Sustainability project (2015-2019, EU funded Erasmus+ program) that aims to be both visionary and pragmatic, and to stimulate new ways of thinking.

The scope is to share the latest knowledge and experiences around the concept of sustainability for all.

This will be achieved through cross-fertilizing a wide range of disciplines: predominantly design, but also engineering, economy, policy-making, and sociology.

## LENS MANIFESTO

A new ethos for a design community: towards an open source and copy left learning-by-sharing attitude/action.

We, the undersigned, aware of both the urgent changes required by sustainable development, the potential role of design (and design thinking) in promoting system innovation in the way we produce, consume and interact, as well as the opportunities offered by the ever more interconnected society, propose the adoption and diffusion of a new ethos within a worldwide design community:

To view design as a unique multi-polar learning community promoting, enabling and activating any possible learning-by-sharing process aiming at effective knowledge osmosis and cross-fertilisation in design for sustainability in an open and copy left ethos.

We, the undersigned, commit our selves in such an ethos, trying our best to apply this in our daily life as individuals or representatives of institutions in the design community.

In relation to our competencies and possibilities we will make our acquired knowledge to be, as far as possible, freely and easily accessible in a copy left and open source modality (while safeguarding our authorship and scientific recognised publication activity), that enable others in the design community to acquire them free of charge, with the possibility to replicate, modify, remix and reuse, through e.g. adopting creative commons licences.

As researchers, this knowledge includes our acquired research knowledge base (e.g. papers, books, etc.) and knowhow (e.g. methods and tools).

As educators, this knowledge includes our educational resources (slideshows, texts, video of lecture, educational support tools, etc.)

As designers and design thinkers, this knowledge includes the design for sustainability concept proposal of products, services, systems and scenarios, as well as a knowhow they used to design them.

We commit our selves to seek the commitment of other individuals or institutions in such an ethos within the design community. In relation to our competencies and possibilities we will:

do our best to commit individuals such as researchers, educators, professional designers and design thinkers as well as institutions such as research institutions, design schools, and designer's associations to adopt the same ethos

do our best to generate and/or enable open learning networking of sustainability of design researchers, design educators, professional designers and design thinkers.

## **6. DESIGN FOR SUSTAINABLE CULTURAL AND BEHAVIORAL CHANGE**



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## ARTISTIC CRAFTSMANSHIP VS DEGRADATION RISK OF HISTORICAL AREAS

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### ABSTRACT

This paper aims to focus on the relationships between artistic craftsmanship, as activity characterized by a cultural content and a form of distributed economy, and the quality of the anthropic environment. If the environment generated forms of craftsmanship, can we hypothesize that new handicraft activities can regenerate the degraded environment? In this historical moment, design seems to embrace two areas that just few years ago were separated: technological innovation in production methods and craftsmanship. The ART LAB NET project, funded by the Interreg program, aims to train artisans towards new technologies, and support them to innovation. A parallel objective is based on the specific case of the historic district of Sanremo called La Pigna and seeks to stimulate the redevelopment of the anthropized environment in its physical, economic and social complex. ART LAB NET organizes events and training activities aimed at supporting artistic craftsmen wishing to settle in historical building areas.

Key Words: craft, history, artisan, digital

## 1. INTRODUCTION

This paper reports on the current activities underway related to the Interreg Marittimo Italy-France project called “ART LAB NET Centres of resources and innovation for the art and craft professions”, considering the close relations that exist between artistic craftsmanship activities and the recovery of historical urban centres (from a social as well as an architectural point of view). Supporting artistic craft activities can be an opportunity to reflect on the cultural association of local “know how,” which through rediscovery, craftsmanship can be an instrument of retraining, above all in a social perspective. In particular, the paper focus on one of the contexts in which these activities are developing: the historical centre of Sanremo, called La Pigna.

## 2. RELATIONSHIP BETWEEN CRAFTSMANSHIP AND DIGITAL MAKING

As early as 1938,<sup>1</sup> Bruno Munari signed the “Manifesto del Macchinismo” (manifest of machinery), which announced a society of machines in which artists would abandon canvas, colours, and chisels to begin making works of art with machines with knowledge of mechanical anatomy and language.

No more oil colours but an oxydric flame, chemical reagents, chrome, rust, anodic colours, and thermal alterations. No more canvases and frames but metals, plastics, rubbers, and synthetic resins. The assumption is that the use of the instrument – in this case the “machine” – implies the superiority of the creative phase over the executive one or, at least, the possibility of devoting more time to the design of the object, speeding up or simplifying its realization.

The progress of technology over the past few decades has brought production closer to the consumer and beyond: it has opened new scenarios for the processing of materials and the development of shapes. The main innovation of the new millennium was the introduction of new technologies, such as 3D printing, and of new creative, productive, distributive, and communicative processes built around the open web that are defining new horizons for the artisan objects of the future. These products are created with a Do It Yourself (DIY) approach by digital artisans using new 3D modelling technologies, transforming them into creative entrepreneurs capable of directly managing the entire production process, a network with many benefits in terms of times / costs, and also managing distribution via e-commerce sites such as Amazon or Etsy (Anderson 2012).



[Figure 1] Clay 3d Printer, MasEdu, Sassari Academy of Arts

This revolution began in 1986 with Chuck Hull, co-founder of 3D System, who coined the word “stereolithography” or 3D printing. It is an additive technology, which works by adding material, in reverse of a traditional machine (such as a milling machine or a lathe), which starts from a block of matter and digs. 3D printing is based on the opposite principle: instead of digging, it adds material in layers, and the materials that can be used are disparate, from polymers to metals [Figure 1]. Finishing processes are performed manually and it is at this stage that the pieces can be customized by hand. Today, in fact, the manufacturing vocation is flanked by technological innovation in craftsmanship and involves various sectors, such as fashion, design, and art. What emerges is a pluralism of languages, experimentation, and research that characterize the production of the 21st century.

Tangible assets account for 90% of total trade, but until now the production of tangible goods has been the prerogative of the manufacturing economy. This is due to a production methodology that cannot be followed by normal user due to lack of experience, the need for specific equipment, and the costs required for the production of large-scale goods.

<sup>1</sup>Bruno Munari (1907-1998) was an Italian artist and designer.

According to authors such as Chris Anderson (2012), the monopoly of production by large companies can now come to an end thanks to “digital production”: it is possible to produce a material good from a computer design, perhaps sharing it online, and producing it concretely thanks to the new 3D printers. Anyone with an idea or a good project in mind can send their files to a service that produces the object, in small batches or in large quantities, or make it themselves with digital manufacturing tools such as 3D printers or laser cutters. In recent years, many “Maker Spaces” or “Fab Labs” - digital manufacturing laboratories, shared systems, often created by local communities - have emerged around the world. What started as a cultural change is now creating an economic change. As the entrepreneurial instinct makes its way and hobbies become small businesses, the makers’ movement is starting to change the industry and it is doing it in a completely new way, starting from the bottom-up, in many cases supported by collective funds raised on crowdfunding sites.

Since the 1980s, the passion to build objects with our own hands has faded. Manufacturing no longer promised a stepping-stone to achieve the middle class and, with the fall of industrial employment, school courses on technical applications have lost their appeal. In their place are computers, tools that in those years were used by skilled workers. Computer courses have thus gradually supplanted the old laboratory where manual skills once developed.

The figure of the artisans, as a *Homo Faber* (Sennett, 2008), who, in spite of the economic crisis, still resists, somehow needs to relocate in this scenario: on one hand they are the guardian of a know-how, often linked to tradition, which risks disappearance; on the other hand, they need to be placed in an increasingly competitive and global market. New technologies are a resource to experiment and innovate, keeping tradition and hybridizing it with new languages. The designer is an intermediary figure between the craftsman and the maker, able to wield new and computer technologies. At the same time, the designer is able to speak to the history and culture of the product, something that less experienced makers are not always able to do, fascinated by the instrument rather than the concretization of the object itself or its genesis. All this has generated the rise of an artisanal production even on a large scale with the creation of a strong demand for specialized articles, and niche products aimed at different potential buyers have imposed higher prices (consider high fashion). Ultimately, it is correct to state that Makers’ objects have more to do with the process of creation than with the products themselves. The craftsman and designer are able to network and combine different skills to provide a high quality product, differentiating from what is already offered by large industries.

### 3. THE HISTORICAL AREAS: GENERATING AND REGENERATED

Cities have always been places for opportunities and meetings, both economic and cultural. Ancient city centres were sources of traditional know-how and the artisanal objects made there were, therefore, direct expressions of their histories. Facing a generalized crisis in the redevelopment of historic centres, can we hypothesize that today’s crafts can be an instrument for the redevelopment of the historical centres themselves? In the cities where historical centres have survived both physically – avoiding the insults of the war or the “sanitation” of overly dense building settlements – and socially – which have suffered limited gentrification – rent prices have remained at acceptable levels. In these spaces, on the ground floors, we can still often find small shops. Some experiences in Italy seem to support this hypothesis: the symbiotic relationship between territory and craft activities has been assumed, for example, by the Independent Artist and Artisan Association Balarm of Palermo (Alab), which today counts about 80 laboratories and 300 members. Their manifesto states: “We create a diffused network of microeconomics for the urban redevelopment of the territory ... We spread creative craftsmanship as economic and cultural innovation in squares, in schools, training both the youngest and those seeking to make a real alternative.” The Association declares its intention to create a space of cultural initiative that produces growth of knowledge to encourage and incentivize art and crafts, both among the public and within itself. According to the members of Alab, artistic craftsmanship is a fundamental economic and productive resource, which leads the association to conceive a rebirth of the historic centre of Palermo, an area that risks abandonment. An itinerary has thus been defined for citizens and tourists to discover the artistic and craft work and distinguish it from industrial production, thus enhancing a profession in which manuality and intellect meet and where the artisan / artist lives the entire cycle of processing.

Another initiative comes from the Finale Ligure, Noli, and Borgio Verezzi municipalities, which have joined in a territorial marketing project designed to protect and improve the image of the territory, the quality of hospitality services, and the quality of the natural and urban environment. In order to promote and enhance art and craftsmanship, the Fatto a Mano Finalborgo association was established a few years ago. Finalborgo represents the medieval historical centre (although archaeological remains date back to the foundation several centuries earlier) of the coastal town of Finale Ligure. In 2014, the head office was created in order to provide space for the dissemination of manual work and ancient crafts through products created by artisans and guest artists to showcase their skills and knowledge, and creativity and talent, demonstrating and exhibiting their handmade creations and involving the public with courses or workshops.

A third example is that of the historic centre of the city of Perugia, where in 2009 the cultural association “Artisan shops of the historic centre” was set up to promote artistic craft activities, both traditional and innovative. The association promotes craft activities located within the historic centre, placing them within the historical-artistic tradition to which they belong in order to disseminate, protect, and communicate the culture, the craftsmanship, and its product.

These kinds of initiatives – even among many others that could be mentioned – often arise during public funding aimed at recovering the most degraded, but full of potential, portions of the urban territory, favouring the establishment of economic activities and their product. These projects are not always able to activate self-generating mechanisms and create autonomously; virtuous processes are able to sustain the activities in question, since it is necessary that new entrepreneurs are actually able to maintain competitiveness also at the end of the financial aid. In the case of artistic craftsmanship, the difficulty in sustaining the costs that a small-scale production and commercial activity means that this activity increasingly orients around seasonal work (to be considered pieces of handicraft, the products must be made of unique pieces or very limited series). A temporary activity, linked solely to the festive days “markets” may introduce a category of part-time artisans, “operators of their own talent” (with normative variations from region to region) who can sell their works in a limited number of public events a year, with no obligation to register with trade associations, providing that the annual amount that defines the “occasional” work activity is not exceeded. This “temporariness,” in addition to being difficult to control from the fiscal point of view, leads to consequent difficulties for the artisan to grow and subsequently transfer artistic skills to new generations.

It is therefore necessary to provide structural support to this production area to bring real change to the market vision and also possibly hybridization with productive forms of digital making so that new generations will understand the importance of keeping alive traditional know-how in a realistic and not anachronistic or nostalgic perspective.

#### 4. THE ART LAB NET PROJECT

In an increasingly globalized society organized through solid company structures, dealing with craftsmanship might seem anachronistic, although it could be a necessity, because of the globalized and globalizing context in which it is located.

The partnership of the ART LAB NET project sees artistic craftsmanship as an explanation of the typical areas of the program’s cooperation territories: Liguria, Sardinia, the coast of Tuscany (not involved in this project), Corsica, and Région Sud (formerly Provence-AlpesCôte d’Azur, or PACA).

Art and crafts professions, mostly carried out by older people or in any case from skills developed in extracurricular training, suffer from substantial difficulties in entering the current market, where the use of digital tools for production and communication, such as social media, make it almost impossible to continue operating businesses according to procedures belonging to another time and to another society. The complexity of today’s society requires the participation of diverse professionals working in groups, making it difficult for individuals such as artisans to practice their own professions. Self-management takes away from the main task, that is the production of the artistic object, and the use of many different support professionals for administrative and legal (but also advertising and commercial) work implies often unsustainable costs. Consequentially, even in areas where artistic craftsmanship maintains a strong role, with close ties to tradition and the appreciation of the public - as in Sardinia – many artisans are disappearing or are unable to transfer their know-how to the next generation.

This project seeks to combine artisans’ creative and manual skills with contemporary instruments and growth processes in order to increase their capacities, communication skills, and marketing reach. Based on a survey of needs carried out on the project’s territories, training activities (by person and virtual) and tutorials were offered, allowing for a better understanding of the digital tools useful for communication and required to sell products. In order to innovate and stimulate production capacities and to attract the new generations to little-known work, four Resource Centres were designed and built. These Centres are laboratories able to host advanced machinery such as 3D printers and laser cutters, allowing new and experienced artisans to experiment and hybridize traditional production technologies.

#### 5. CONCLUSIONS AND FUTURE PERSPECTIVES

A very particular part of the project sees the art and craft as a form of social redevelopment – and, consequently, of building recovery – of the old Sanremo district called La Pigna. Its name comes from the form of its planimetry, in which its paths form the scales of a pine cone. The neighbourhood [Figure 2], founded around 1000s and consolidated until the 1500s, after the boom of flowers cultivation in Sanremo, has seen a progressive abandonment that has left it almost without human and economic resources but allowed for a substantial crystallization, so that today find a historic settlement of great charm, still virtually inviolate.

In the district of La Pigna, most of the ground floors are closed and remain unused, with few activities. What is there is mainly commercial, such as bars, restaurants, and brocanterie, with almost no craftshops.

Because of that, the opening of the “Textile and digital fabrication” Resource Centre by the Pigna Mon Amour association aims to train new artisans and bring new small commercial businesses to the neighbourhood, which is essential for the survival of La Pigna and its incredible charm. Bases on the presence in the neighbourhood of many unemployed women, some from North African countries, and the willingness of the association members and sympathizers, it was considered most profitable and simple to implement, as a first activity of the resource centre, some sewing and tailoring courses. Particular attention was given to the concept of “ethical fashion,” including the organization of a seminar day called “Fashion, style and lifestyle”. In underlining the need to keep intact the historical memory of the district, from which its charm derives, a short workshop on the restoration of the plaster was organized, attended by students from the School of Specialization in architectural and landscape heritage. The activities were filmed and videos were produced, testimonies to the development of the project that will end this spring.



[Figure 2] The gate of the La Pigna district

If at the end of the project, as prefixed, new art and craft artisans are established in La Pigna, ART LAB NET will have demonstrated in a real way how it's possible to revitalize a neighbourhood such as La Pigna, which is downscale but full of cultural interest.

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## **STRATEGIES FOR ECO-SOCIAL TRANSFORMATION: COMPARING EFFICIENCY, SUFFICIENCY AND CONSISTENCY**

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### **ABSTRACT**

Redirecting human progress needs more than superior ethics and good will. Effective forms of management and governance are required (Metzner-Szigeth 2011). Realizing sustainable development takes place under conditions of targeting-conflicts about priorities, utilization competences about resources as well as divergent interests and contrasting visions. Facing great challenges of humankind therefore means tailoring well-designed interventions: in communicative culture as well as in material culture, in the organizational sphere as well as in the technological sphere. But how to do so? Three well-known strategies are “efficiency”, “sufficiency” and “consistency”. They are driven by contrasting rationalities, respond to different groundings and favour distinct instruments. They are supported by different arguments and seem to exclude each other. As strategies, they are competing for attention for being accepted and converted into practice. But how to combine them with productive principles of design such as to enable far reaching transformations in material culture and social life?

Key Words: sustainability, efficiency, sufficiency, consistency

## 1. INTRODUCTION

The Learning Network on Sustainability (LeNS) places mediation, exchange and elaboration of knowledge and skills at the center of its efforts. Hence, this is about a special type of “professional competences”, namely those that are suitable for promoting processes of sustainable development (SD). They cannot be understood as “theoretical” or “practical” anymore according to the classic dichotomy that divides scientific knowledge and abilities as if they were essentially “pure” or “applied”. Instead, the best way to conceive their combined, dynamic and novel character is to address them as “transformative” competences (Hirsch Hadorn et al. 2010; Wiek & Lang 2016).

Unfolding some comparative overview about SD strategies is for sure especially useful with concern to problem-based and solution-oriented teaching-learning projects (Lehmann et al. 2008; Cörvers et al. 2016). But strengthening a good command of methodological issues is not less valuable with regard to similarly organized professional R&D projects that are essentially inter- and trans-disciplinary (Laws & Loeber 2011, Ceschin & Gaziulusoy 2016).

LeNS (2019) declared vision is “to foster a new generation of designers (and design educators and researchers) capable of effectively facing, the challenge to envision, design and contribute to the transition towards the sustainable world for all”. A “sustainable world for all” – that sounds nice, convincing and self-evident. Nevertheless, the proposition needs clarification. Gaining a good comprehension about what is indicated by 1.) the adjective “sustainable”, 2.) the noun “world” and 3.) the attribute “for all” is anything but trivial.

- 1.) The conceptual composition of “sustainable” and “development” turned out to be just as promising as of far-reaching consequences. That happened instead, or actually because of the fact that it was created out of two opposing components. Thus it exhibits the characteristics of an oxymoron (from Greek “oxys” = sharp-witted, sophisticated and “moros” = stupid, moron). This rhetorical figure presents a phrase made up of two contradictory terms, such as in the “peaceful warrior”. At least at this point the question arises: How could it be that something might become preserved (= sustained) and simultaneously renewed (= developed)? Well, the related problem of validity refers, on the one hand, to the origin of SD. The concept is known to be negotiated and invented within a series of international political conferences and therefore represents a kind of “compromise formula” (cf. i.a. Michelsen et al. 2016). On the other hand, it also points to the substantial difficulty of forming a concept which must also be “future-capable” in itself. Drafting a meaningful concept that is robust and resistant as well as adaptive and extendable implies to keep its contents interpretable in the sense of a “regulative idea” (Stables 2013).
- 2.) The second clarification concerns the issue whether “world” is a synonym for “planet”. Is it constructed as if it were some single place, like in the term “global village”? Or does it count as a manifold and contradictive unit as indicated in the composite notion (cf. Robinson 2008) of “glocalization”? This point is especially relevant for global cooperation networks and world-wide distributed conferences like LeNS (2019). The way “global challenges” are represented on site, in Mexico City - Curitiba - Cape Town - Bangalore - Beijing - Milan - or elsewhere, is just as different as the conditions that shape the reality of the people who live in these places. These include political and social, economic and ecological, cultural and geographical conditions, which form specific constellations.
- 3.) A third clarification concerns the expression “for all”. Sustainable well-being for all will become possible only (acc. to Costanza et al. 2012, p.vi) if three preconditions are fulfilled: a.) that we acknowledge the fact that we live “within planetary boundaries – within the finite capacity of our planet to provide the resources needed for this and future generations”; b.) that we agree “that these resources should be fairly distributed within this generation, between generations, and between humans and other species”; and c.) that we use “these finite resources as efficiently as possible to produce sustainable human well-being, recognizing its dependence on the well-being of the rest of nature”.

Anyway, in order to really become effective, it does not need actions alone, but adequate and coherent thinking-approaches and courses of action. All we need to do is search and find them, work and test them. That is an open search, trial and learning process. This conclusion corresponds to an approach that culminates in the idea of transformation design (Jonas 2016, Yee et al. 2017). It is about the idea of “drafting” change and of “designing” everything that is important to it, instead of “planning” change “top-down” from a drawing board in order to “implement” it afterwards, as it were in the past, in the times of unbroken prevailing technocratic thinking. Meanwhile we have entered a transitional phase towards “co-creative” practices (Orr 2004). These include and integrate experts and laymen, producers and consumers, planners and citizens much stronger into inter-active and inter-connected processes of designing and negotiating results and products.

Realizing sustainable development in practice takes place under highly diverse conditions of targeting-conflicts about priorities, utilization competences about resources as well as divergent interests and contrasting visions of how “our common future” (WECD 1991) should look like (Metzner-Szigeth 2014; Michelsen et al. 2016). Facing the “great challenges” of humankind (Royal Geographical Society 2015) therefore means tailoring well-designed interventions into the ongoing dynamics of existing patterns: in communicative culture as well as in material culture, in the organizational sphere as well as in the technological sphere. But how to do so?

## 2. PROFILE DEFINITIONS

There are three crucial strategies for SD in general and certain professional practices like design, engineering or management. They are well known in sustainability science, science-technology-studies and systemic design. Their

labels are EFFICIENCY, SUFFICIENCY and CONSISTENCY (cf. i.a. Huber 2000). [An additional strategy, resilience, is not included here - and this for pragmatic reasons only.] They can be characterized as follows:

EFFICIENCY focuses on environmental resources, i.e. on the productive and consumptive use of material and energetic resources (exhaustible and renewable raw-materials, geophysical processes, eco-systemic functions). Its aim is to improve the ratio between the input of material and energetic resources and the output of goods and services. The medium to do so is primarily technology. Its intention is not simply to increase, but to multiply the general resource productivity. This intention finds its expression in formulas like “factor four: doubling wealth - halving resource use” (cf. von Weizsäcker, Lovins & Lovins 1998).

Optimizing existing systems is not sufficient then. Instead, disruptive innovations are striven for, culminating in a “revolution of efficiency” (ibid.). The aspired result is an equivalent reduction of the consumption of environmental resources and a release of environmental and climatic burdens. This seems possible, but only under the (*ceteribus paribus*) condition that the overall amount of goods and services remains constant. Its formula of success and promising perspective is therefore (on side of the input) to reduce the exploitation of environmental resources and (on side of the output) the burdens for environmental media (like water, earth and air). The central parameter for this approach is energy and material or CO<sub>2</sub>-intensity per product or service-unit (cf. Baccini & Brunner 2012, pp.162ff.). Conventional economic strategies, in contrast, try first and foremost to increase labour and capital productivity, and not resource productivity. Efficiency, as a SD strategy, is interested in achieving an optimal allocation of material and energetic resources in order to reduce negative environmental impacts. Nevertheless, its consequences may result in reducing costs (especially with price-intensive resources) as an appreciated side-effect, as well. But that bonus counts and is the basis for the affinity of efficiency to industry and commerce, especially in so far companies are interested in following the road to sustainability.

SUFFICIENCY focuses on human needs. Its aim is to limit and to directly decrease the (individual and collective) demand for products and services. This is followed indirectly then by limitation or reduction in the consumption of material and energetic resources (Fischer & Griefßhammer 2013). The medium to realize that is culture where a shift to post-materialist values, more conscious consumption patterns and sustainable life-styles is aspired, up to thoroughly novel ways of life. The mechanism for reaching these intentions is by influencing consumer choices, individual behaviour and habits. Good reasoning to do so lay at hand especially with concern to energy and material intensive products or such that are rather dangerous for the environment or decidedly harmful to the climate. Originating from the Latin “sufficere” (= to be enough) sufficiency is by its etymology prone to be associated with terms like adequacy or suitability.

From this context the question arises “How much do we really need for a good life?” that is typical here. And this asks for making a distinction related to “What is superfluous, luxury or only wasting?”. Self-Limitation of one’s own needs or desires, and ideals such as frugality and living in self-sufficient communities, represent characteristic key elements. They often occur together with ideas of social fairness, egalitarian values and environmental justice (foremost in its distributive sense). These topics and positions coincide with worldviews that make sufficiency particularly attractive for NGOs and members of environmentalist movements. The ambition of sufficiency is nothing less than stopping or even turning around the mega-trend of ever more commodities and the expansion of the “affluent society”. In other words, sufficiency puts a hold on a certain standard of material welfare or even lowers it to some degree as expressed in the ideology of post-growth.

CONSISTENCY focuses on procedural and substantial qualities. Its goal is less a reactive reduction of quantities, but rather a foresightful and encompassing design of life-cycles. That includes entirely novel products and manufacturing procedures as well as their utilization in processes of consumption and re-cycling. This should allow an almost permanent and as complete as possible re-use of components and resources in interconnected chains, networks and closed loops.

Moreover, it should guarantee an ideally 100% bio-compatibility of artefacts, compound-materials and substances if there is need to revert them from the technical cycle back into nature’s cycle. Embedded in the metabolism of nature and powered by renewable energy sources only (like wind, solar, geothermy, biomass) this concept strives to organize anthropogenic and geogenic flows of materials either so they do not disturb one another or in ways that allow their interdependent reinforcement in a symbiotical sense. The principles of the cradle-to-cradle design (C2C) are prominent within this field and fulfil the criteria of consistency in an ideally-typical way. C2C was originally elaborated by biochemist Braungart and architect McDonough. Both were inspired by the approach of “remaking the way we make things” instead of simply remaking things without any further plan (Braungart & McDonough 2009). Many examples of how to implement this principles were elaborated by them, as originators, as well as by many followers (cf. i.a. C2C e.V. 2018).

Consistency, etymologically connotes with coherence, constancy and unity. A familiar association is made with the natural principles of life. These teach us how to successfully practice organic farming or permanent horticulture. Biochemical pathways of complex systems like that of photosynthesis represent models here, in so far as they show how to realize the idea of preventing “waste” within complex networks where metabolic products generally become the feeding substrates for operations and reactions that follow. The medium in which the consistency approach in general and the principles of the C2C design in particular are thought to be realizable is ecology or, more precisely, “industrial ecology” (for a definition cf. Lifset & Graedel 2002, p.4).

### 3. COMPARATIVE DISCUSSION

The three transformational strategies are driven by contrasting rationalities, respond to different groundings and favour distinct instruments. Nevertheless, we can understand efficiency, sufficiency and consistency as strategies that highlight their diversity up to the point where they seem to exclude any combination of them because they are competing for attention on the public agenda to be accepted and have the chance to become converted into practice. The following points of critique and their counter-arguments correspond to that background (cf. i.a. Mathis 2018):

Achieving intentions of EFFICIENCY is constantly at risk in so far rebound effects might cancel them out. Realized gains than become compensated (or even overcompensated) by an additional consumption of goods and services that have become cheaper, better or more acceptable. Moreover, sectoral reductions in the use of environmental resources may not result in a general reduction simply because of the ongoing growth in the overall production and consumption of goods and services. Efficiency's confidence in technology is associated with a bias towards ignoring the importance of culture and its mainstream orientation on materialist values and economic growth. In its essence the strategy may easily become misunderstood (not only by its opponents but as well by its protagonists) as if it were interested in cost-efficiency only. That burdens its acceptance and could inhibit the realization of possible efficiency driven reductions of needed material and energetic resources.

SUFFICIENCY, as an approach that requires a lot of individual commitment, needs to stimulate some re-definition of own needs and wishes. But individual preferences and consumer choices are determined by a potpourri of highly diverse world views, predominant attitudes and personal motives - especially under circumstances of an open society. Together, they form an inert complex that is difficult to alter in adequate measures and tempo. The representatives of this strategy mostly emphasize the voluntary basis of the reduction. Nevertheless, diminishing the demand of certain consumer goods (that count as especially harmful for climate or environment) or of the cumulated amount of material consumption in general could be as well forced by prices and taxes, that is, by the market, or by norms and laws, by the state, or discriminated by negative sanctions of fellow people, that is by the media and by influencing the public opinion. Sufficiency does not refer to the manner of production and to the quality of the produced. Therefore, negative environmental consequences of modes and properties are neglected, because the quantitative reduction of consumer goods is given entire priority.

Realizing CONSISTENCY is hardly possible because of missing options, in so far as required technological basic innovations are not at hand. They would need to be invented first and to be elaborated during time-consuming follow-up processes before that consistency strategy can release significant impacts. Consistency neglects the consequences of too great quantities and oversized material flows because of its prevailing concentration on qualities, like harmlessness (for humans, other beings and the natural environment) and integral compatibility (with metabolic pathways of ecological systems) as well as re-usability and re-cycling-ability of components and ingredients with respect to the cycles of their utilization in productive and consumptive processes. A precondition of its success is the need of a complete redesign of the whole economic system towards products, services and techniques, operations and procedures that are consistent with nature. This implies a great demand for information and knowledge sharing because of the need to integrate loops of in- and outputs according to appropriate qualities of resources, re-used products, by-products in networked systems of production and consumption.

STRATEGY	DIMENSION	FOCUS	GOAL	EXAMPLES	DESIGN	PROBLEM
Efficiency	Technology	Resources	Reduce energy and material intensities per good/service	Drip irrigation LEDs	Passive buildings	Rebound effects
Sufficiency	Culture	Needs	Limit consumption of goods/services	Car sharing No meat	Self-sufficient communities	Inertia of habits
Consistency	Ecology	Qualities	Close cycles of material flows / Energy streams out of renewable sources	Compostable plastics / Solar and hydrogen power	Cradle to cradle	Missing options

[Table 1]. Synopsis of some characteristics of the efficiency, sufficiency and consistency strategies / Source: by the author.

My preliminary balance of their "pros" and "cons" is based on the profiles of the three strategies, the summary of points of criticisms, and above all on a comparative reflection of some of their essential traits (as table 1).

In order to become really effective the efficiency strategy requires great technological investments and huge efforts. Nevertheless, under given conditions and taking into account its potential for reducing costs it is a very feasible approach. The sufficiency strategy requires fundamental social and cultural change. Nevertheless, it has the advantage of possibly carrying out onward leading actions even as an individual consumer or citizen. The consistency strategy requires a far-reaching reconfiguration of the human metabolism with nature. This cannot be done without lasting collective efforts. Nevertheless, this approach is attractive because it offers a model for the "circular economy".

In his resume about SD strategies Huber (2000, pp.282-283) comes to three conclusions: At 1st he refers to Schumpeter's analysis of processes of "creative destruction" as a standard form of socio-economic change. Against this background it becomes clear that eco-social transformations as well cannot to be realized without conflicts.

Here, the precise diagnosis of Huber reads: “Complex innovations of the ‘basic’ or ‘system’ type come with both pleasant and unpleasant implications. They represent major structural change, and this means processes of ‘creative destruction’ (..). There are winners and losers, and, therefore, social and political conflicts. New generation knowledge, knowhow and skills imply a devaluation of older generation knowledge, know-how and skills. New capital stocks have to be built up, as old ones will have to diminish and dissolve. New sites and regions may see chances, while old ones face the dwindling of theirs” (ibid.). The 2nd point concerns the scope of all three transformative strategies, regardless of the fact that Huber addresses consistency in particular: “Thus, a programme of ecological consistency of the industrial metabolism is not only a call for the innovative productive capacities of industry and the means-mobilizing capacities of finance, or for the inventiveness of research, construction and design, but is concurrently as much a call for social support and political leadership” (ibid.). The 3rd point goes beyond the obvious idea of combining the advantages of the strategies. Instead he unfolds a successive logic: “The strategies of sufficiency, efficiency and consistency can be combined, although the degrees of combinatorial freedom are less arbitrary than one might think. The best overall strategy will be the one that places priority on long-term consistency and utilizes mid-term efficiency as much as possible, while fully acknowledging that certain limitations, thus sufficiency, must finally be respected” (ibid.).

#### 4. RESEARCH DESIGN

Besides focusing on the advantages of a balanced approach in theoretical reasoning there is considerable demand to initiate and realize further empirical research. Indeed, there is urgent need to perform inquiries about concrete applications of these strategies, about best practices and what could be learned from failures. Moreover, unintended consequences should be taken into account, probable rebound effects and, finally, possibilities to deploy them in smart combinations together with accompanying measures. But how to elaborate a comparative research design that is able to effectively address all these issues?

Efficiency, sufficiency and consistency can be analysed, separately or comparatively. Both can be done theoretically, for example in the context of the debate about the limits of economic growth and the need to reintegrate the industrial metabolism of humankind quantitatively and qualitatively into the global metabolism of nature, thereby respecting planetary, regional and local carrying capacities as well. (In this case, the work would be directed by ecological economics as predominant discipline.) Both can be done empirically as well, for instance within the framework of discourse analysis. How these three strategies are constructed within public and professional debates would be one of the guiding questions then. Another key question would be how they stimulate alterations in ways of addressing, framing and prioritizing problems and, thereby, preformatting how to approach solutions. (In this case, the work would be directed by environmental sociology as predominant discipline). A third way to work on them, either separate or in comparison, is inspired by the idea of praxeology. This alternative option is above all interested in evaluating their transformative potentials related to practice. The research question pushed into the center then would read: What are the conditions under which it becomes possible to unfold and to realize these strategies enhancing their probability to become successfully implemented within projects. (In this case the work would be directed by sustainability science, in the sense of transformative science, as predominant discipline).

The two types of approximation which would be allowed and promoted under the umbrella of this combined transformative and praxeologic research design are: First, not only to observe, but to participate in these projects. This would be as accompanying action research that needs either to maintain some distance to the (observed) practice and, simultaneously, to ensure not only free access to information but its own (practical) involvement. Second, to holistically tackle professional practice together with its conditions and its consequences.. In this form professional practice can be investigated not exclusively as paid labour in entrepreneurial and institutionalized frameworks, but moreover with regard to all kinds of organized work in more open collaborative networks.

No matter whether it concerns efficiency, sufficiency and consistency, or strategies labelled otherwise: they all represent conceptual concepts or, in more simple terms, linguistic tools we can use to reflect on practices and projects. Hence, it is about the conditions of possibility to create successful societal practice with their help, namely advised and supported by them. But what does “successful” mean? Our criterion for this is whether and to what extent they contribute to the implementation of “transformative” steps. What “transformative” steps are, can in turn only be identified by reference to the “regulative idea” of SD. To meet the need for greater practicability and clear operationalization the answer to this question may, however, simply be tied to the essential provisions of the 17 SDGs and 169 targets in the UN 2030 Agenda (United Nations 2015).

#### 5. OUTLOOK

We want to intensify our comparative research about these three transformational strategies. Our leading question is how they can be utilized to stimulate design projects either as teaching-learning projects or in form of professional R&D projects. For that, we wish to find suitable international partners.

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## **SYNTHESIZING SOLUTIONS: EXPLORING SOCIALIST DESIGN AND ITS MODERN RELEVANCE THROUGH THE MEDIUM OF PLASTICS**

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### **ABSTRACT**

Plastic is synonymous with the industrial revolution of the 20th century. However, it has earned a reputation as being hazardous to the environment. It is not the material that is truly a hazard but the way we choose to use it.

An alternative ideology to the utilization of plastics is that of the former Communist German Democratic Republic (GDR). Plastics and design were interlinked with the political discourse and helped shape a breed of frugally innovative designers. Plastic came to be viewed as a valuable commodity for producing products built for durability. Socialist ideology on design overlaps with the current ideology on sustainable design.

The main question addressed is; with the imminent spread of the internet, knowledge is more accessible and less commodified. Infrastructure complementary to socialist design ideologies is now available to a much larger part of the population. Hence, are socialist design ideologies of the past viable choices for sustainable design solutions for a post-capitalist future?

## 1. INTRODUCTION

Plastic can be viewed as the defining material of the 20th century and the backbone of the manufacturing industry post Second World War. Plastic is one of the most versatile material known to man. It is used in massive range of applications, from toy airplanes to military grade stealth bomber fuselages.

Despite its functionality, plastic has an undesirable reputation as a threat to the wellbeing of our planet. The problem lies not in the material itself, but the way we choose to use it. Plastic polymers can be created and modified in the laboratory as per requirements. Plastic being non-biodegradable, it does not deteriorate for an indefinite duration of time. Herein lies the problem. Why do we use a material that lasts forever to make stuff that we throw away after using once?

A throwaway culture has characterized and underpinned our economies for more than half a century. Too many goods do not last as long as they could – or should – do. Some fail, others become unwanted. Quality is compromised as companies cut costs to remain competitive. Poor design and externalization of costs have caused repair and upgrading to become fringe activities. The hallmark of linear product development is planned obsolescence – the opposite of any attempt to make products last. Products are designed to fail or become too expensive to use after a set period of time. Perceived obsolescence is another factor: Corporations, through advertising, want consumers to believe that products within their home are inferior to those currently on the shelves.

### 1.1 Capitalism

The emergence of consumer society was neither inevitable nor accidental. Rather it resulted from the convergence of four forces: a body of ideas saying that the earth is ours for the taking; the rise of modern capitalism; technological cleverness and the extraordinary bounty of North America, where the model of mass consumption first took root. Of the 100 largest economies today, 51 of them are corporations.

### 1.2 Perception of Plastic

In 2011, I travelled across India, trying to understand the role plastic plays in the urban middle- class kitchen. Plastic kitchenware has come to be associated with urban nomads, who prefer it as it as a cheaper option compared to metal or ceramic, that can be disposed of when moving homes.

Even in pop-culture, plastic is perceived as ersatz or fake. English Football club Chelsea FC unexpectedly came into money in the year 2003. Fans of the club began being labeled as ‘plastic’ fans. The reason for such jibes was the simple fact that they accepted free plastic flags distributed by the club during a game.

### 1.3 Recycling

Plastic can be recycled. But, in the real world, plastic bumps into limits – limits of a broken economic system, of finite resources, of energy, of human rights, etc. Each time plastic is recycled, it leaves behind a carbon footprint and the fidelity of the material deteriorates. To quote Heather Rogers from her book: *Gone Tomorrow*: ‘The feel good aspect is at the heart of much of the debate about recycling. Is recycling a con that keeps us deluded into feeling like we are helping the planet, while leaving industry free to keep churning out ever more badly designed toxic stuff?’

### 1.4 Alternatives

A dynamic example of a relationship between Socialism and plastic was found in the former German Democratic Republic (GDR), also known as East Germany. The industrial designers from the Bauhaus movement in the GDR successfully convinced their citizens and government that plastic was a truly socialist material. Market scarcity and ideology converged to make plastic manufacturing a key industry.

## 2. HISTORICAL OVERVIEW

After the conclusion of the Second World War, the social conditions in Soviet-occupied East Germany were grim. Unlike the Marshall Plan implemented by the USA in Western Europe, East Germany did not receive substantial financial assistance from the Soviets. As a result, people were more concerned with survival than the expectation of a comfortable life. The ruling Sozialistische Einheitspartei Deutschlands (SED) party used propaganda and brutality to keep the masses in check.

In East Germany, the Stalinist system of production was known as *tonneideologie* (ideology of tons). It was characterized by fulfillment of production quotas to steel, coal or machinery.<sup>9</sup> Nikita Khrushchev’s ascent to power in the Soviet Union began to transform the Eastern Bloc politically, culturally, and economically. In order for Soviet socialism to succeed; it would have to build a consumer class of citizens without abandoning principles of equal distribution of wealth, abhorrence of individualism and personal accumulation of material goods. Under the shadow of what many termed a ‘capitalist economic miracle’ in West Germany, planners and party members lumped consumer products together under the rubric “the 100 small things of goods and services”.

East Germany was a landlocked country without many natural resources. After the World War 2, it did not possess any colonies to exploit for resources. With a failing economy, the East German Mark had little value on the international market. What East Germans did have, however, was a rich history in applied chemistry. On November 3rd, 1958 a Chemistry Conference was convened by the then SED Secretary Walter Ulbricht to announce a campaign named the Chemistry Programme. This programme would power the consumer turn of East Germany.

The rise of modernist design in East Germany begins with the re-appearance of a number of former Bauhaus disciples. At the time, the state-controlled production sector had no trained designers onboard. The discourses of aesthetics were looking to past German tradition for inspiration. It was hoped that this would establish a German working-class identity that the SED viewed as “authentically” German. The enduring Bauhaus ideology had been that design should reflect the times. The advent of a Socialist state meant that the era of rationality and functionalism had finally been ushered in. At the time plastic was known as an imitative material – used for the production of cheap imitations of older traditional designs and other kitsch. It was the Bauhaus designers who stepped in to alter this perception and stop plastic being wasted on cheap goods.

“The Friendship Pipeline” connecting East Germany with the oilfields of the Soviet Union boosted East Germany’s contemporary significance. Locked into the economic network managed by COMECON (the Council for Mutual Economic Assistance), East Germany’s factories were to process this material, supplying plastic products for use in industry and domestic consumption throughout the Soviet Bloc. At the same time, oil was, for the Kremlin, a means of propping up the East German economy. A new wave of consumer goods appeared on the shelves of East German shops over the course of the 1960s; bright portable radios, camping and picnic equipment suggested new lifestyle opportunities, whilst colourful wipe-clean furniture and PVC flooring promised an efficient domestic landscape within standard housing. Here was the material evidence of socialist prosperity. Advice and home décor magazines acted as propaganda mouthpieces of the government. Specialist plastic goods shops, Chemie im Heim, KONSUM and 1000 Small Things retailed the latest state-approved designs. Magazines like Guter Rat, Fur Dich and Form + Zweck stressed to its readers the superiority of plastic goods. They also answered reader questions and provided advice on the maintenance of plastic goods.

In the West, overproduction, plummeting cost and ubiquity relegated plastic items to the lowest status in the taste hierarchy of consumer goods. In the GDR, the underproduction of plastic items and a combination of functionalist design and government propaganda made them extremely hot commodities.

Many steps were taken to stabilize the plastic industry over the years with limited success. The crux of the problem was still tonneideologie.

Calculating that x tons of ethylene or phenol would result in y tons of polyethylene or phenol plastics was something that planners could handle. But, calculating then how many y tons of polyethylene would result in z tons of combs, z1 tons of buckets, z2 tons of ice cube trays, z3 tons of toothed gear wheels for radio alarm clocks, and so on, was difficult to the point of being impossible.

The lack of co-ordination led to the waste of precious plastic and sub-standard goods. Due to numerous bottlenecks in production, items would mysteriously appear and disappear from shelves every fortnight. The VVB (Vereinigung Volkseigenebetriebe- Union of People’s Own Factories) plastic processing umbrella body during the 1960’s could only control 81 of the 312 manufacturing factories (VEB’s). The rest were either ‘half state’ or privately owned, meaning they were free to use plastics however, they wanted. The industry could be described as a symphony without a conductor.

The government were successful in convincing the population that qualities of modern design that adhered to durability, proper use of different types of plastic and ease of use was what made socialist design better than capitalist design. However, they were unable to make these idealistic socialist designs a reality for the people. Socialism did win their ‘hearts and minds’ but did not live up to its own standards in many cases.

### 3. DESIGN ANALYSIS

A substantial difference between designs of Western capitalist nations and the Eastern Bloc is that in the Eastern Bloc – the GDR being a good example – the designer assumes a state of material scarcity but an abundance of information about the product and material. The designer and state were willing to make every aspect of their designs visible and accessible to the customer. In the West, factors like carbon footprints and the finite nature of resources were not yet considered relevant. Multiple designers and manufacturers were making the same category of product, trying to outdo one another by using grand superficial styling and making the inner workings of their products a trade secret.

The movement for sustainability in designed products has been gaining momentum in recent times. One aspect of sustainable design that needs more attention is design for longevity. Attention in the sustainability domain has largely been focused on closing the material gap, going from new to recycling and onwards, back to (almost) new again. In the case of production, this has led to a combination of requirements with respect to efficiency and clean processing. During their period of use, sustainable products should consume a minimum amount of energy. Products should be easy to disassemble and use one kind of material for each part, to facilitate shredding and re-generation. A factor that requires greater attention is maintaining the value of a product over time: starting with a strong proposition and nourishing it in order to keep it alive.

These six strategies compiled by researchers at the Delft University to improve the lifespan of products.

#### 3.1 Design for Attachment and Trust

This is the Holy Grail for designers. It is near impossible to design with only this strategy in mind as many complex socio-economic factors beyond the control of the designer influence its success. The re-appearance of GDR designs

in Germany today is termed as *Ostalgie* (nostalgia from the east). It is not just older former East Germans who are purchasing these products but people from across the country and beyond, even those born after the fall of the Wall. The classic chicken shaped plastic eggcups are even more popular in present day Germany than at the height of the GDR regime.

### 3.2 Design for Durability

Durability was a hallmark of all GDR products. There is an interesting anecdote from design historian Gunter Hohne, in an interview where he speaks of an incident at the Leipzig Trade Fair: On observing the sturdiness of East German textile, West German buyers turned it down, as they were worried that it would last many years and reduce return customers and income from maintenance. Today brands such as Buy Me Once use this strategy by offering a lifetime warranty on their products.

### 3.3 Design for Standardization and Compatibility

An iconic example is the stackable porcelain tea set produced for Mitropa for use on GDR railways. Popular modern examples are LEGO and Meccano toys. A rather interesting example is the *Ver Bien Para Aprender Mejor* in Mexico. It is a series of unbreakable plastic spectacle frames, with easy swap colour options, that are to be distributed free of charge to underprivileged schoolchildren.

### 3.4 Design for Ease of Maintenance and Repair

A prime example here is the Mokick S50 moped designed by K. C. Dietel and L. Rudolph in 1967. These can still be spotted on the road today. This moped is designed so that an untrained individual could safely open, repair and even customize the vehicles components. I would say that it even fits into the next two categories I will introduce. A modern example would be the Ultimaker series of desktop 3D printers.

### 3.5 Design for Adaptability and Upgradeability

A modern example would be the recent hype for modular cell phones. The most utopian is the Phonebloks concept by Dave Hakkens. Phonebloks was a speculative work that managed to gauge user demand for modular phones. Phone makers are now attempting to fulfill such demand. The Fairphone, made using ethical raw materials and built for easy repair and disassembly. The most ambitious was Google's project Ara, which attempted to create an ecosystem of modular components by collaborating with a wide range of electronics manufacturers. Their attempt was abandoned in 2016.

One example in this category stands far above the rest in application of this principle: the sinisterly notorious Kalashnikov or AK-47 assault rifle. It was designed in Soviet Russia just after World War 2 and was inducted into the Soviet Red Army. Over 75 million AK-47's have been produced around the world since then, not to mention another hundred million unlicensed versions derived from the original AK-47 design. The design is so simple and effective that, unlicensed, even homemade, versions can be found on the black market across the world, making the AK-47 a favourite weapon among terrorist networks.

## 4. CONCLUSION

Karl Marx suggests in *The Fragment on Machines* that once knowledge becomes a productive force in its own right, outweighing the actual labour spent creating a machine, the big question becomes not one of "wages versus profits" but who controls "the power of knowledge". Given what Marxism was to become—a theory of exploitation based on theft of labour time—this is a revolutionary statement. Once you understand that information is physical, that software is a machine, and that storage, bandwidth and processing power are collapsing in price at exponential rates, the value of Marx's thinking becomes clear. We are surrounded by machines that cost nothing and could, if we wanted them to, last forever. In these musings, not published until 1973, Marx imagined information coming to be stored and shared in something called a "general intellect"—the mind of everybody on Earth connected by social knowledge, with every upgrade benefiting everybody. In short, he had imagined something close to the information economy in which we live. Its existence, he wrote, would "blow capitalism sky high".

If the 20th century was the age of the industrial revolution, the 21st century can be considered the age of technological revolution. The spread of information technology has brought in a whirlwind of change in the way our society operates. First, it has reduced the need for work, blurred the edges between work and free time and loosened the relationship between work and wages. The coming wave of automation, currently stalled because our social infrastructure cannot bear the consequences, will hugely diminish the amount of work needed – not just to subsist but also to provide a decent life for all.

Second, information is corroding the market's ability to form prices correctly. That is because markets are based on scarcity while information is abundant. The system's defense mechanism is to form monopolies – giant tech companies – on a scale not previously seen in the past 200 years. Third, we are seeing the spontaneous rise of collaborative production: goods, services and organisations are appearing that no longer respond to the dictates of the market and the managerial hierarchy. These collectives use network technology to produce goods and services that only work when they are free, or shared.

The latter is of most interest to me as an industrial designer. A major cause of failure of the GDR business

model was the inability to manage the supply and demand of plastic products. With collaborative production, that problem is greatly reduced. Even plastic products, the backbone of the manufacturing industry, can now be produced and recycled at a cottage industry scale. For such collaborative production initiatives that rely on interpersonal relationships to succeed, they would need the state to create the framework. Just as it created the framework for factory labour, sound currencies and free trade in the early 19th century. The physicist Ilya Prigogine put it beautifully. “When a system is far from equilibrium, small islands of coherence have the capacity to shift the entire system”. Our priority now should be to develop islands of coherence in our own contexts and connect with other islands when the need arises. It is within this new system or ‘new game’ as I call it, that I wish to see more designers practicing in.

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## **MOTHERS FROM INOSEL: AN EXERCISE IN COLLABORATION TOWARDS A MORE SUSTAINABLE SOCIETY**

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### **ABSTRACT**

This article reports on a case study involving a collaboration project in which mothers with children attending Inosel school received capacity building based on design development activities. The school is a catholic charity school based in Rio de Janeiro, Brazil, which admits both deaf and hearing students. As many of the children need the help of their parents/guardians to get around the city, their caregivers stay at the Inosel premises during school hours. Having identified this work opportunity, the following research question was formulated: Can collaboration activities based on the opportunity to develop design projects help empower people to act productively in the development of a project, making and marketing artisan objects? The idea was to draw on methods and procedures from the methodology of design to train groups with creative potential. A methodological approach was devised, enabling the group to work on the different stages of design development and, as a consequence empowering them.

Key Words: Design in Partnership, Collaboration, Sustainability, Inosel.

## 1. INTRODUCTION

Discussions about sustainability first emerged from the perception of the need to preserve our environment, and were soon adopted by design as a way of enhancing the humanization of its projects.

Concerns about sustainability in the field of design were first voiced in the 1970s, especially by Victor Papanek in his book *Design for the Real World*, in which he called on designers to “design solutions for the real world, which was disintegrating into hunger and misery, racial conflicts and political protests, civil wars and independence struggles [...]” (Cardoso, 2012, p.18).

Since then, a number of authors, including Ezio Manzini, have put sustainability at the heart of their work, guided by the ideas of strategic design.

Manzini (2008) believes social innovation is one of the drivers of research in design oriented towards sustainability, and defends the idea that the designer’s principal function is to improve the quality of the world, not just the aesthetics of products. As he sees it, in strategic design the designer is an agent responsible for social, environmental, and economic change, a precondition for which is the abandonment of unsustainable and individualistic projects; an agent capable of fostering the transformation of common communities into creative communities and making them self-sustaining.

Certain ideas have burgeoned from this perspective. It follows, for example, that it is not just the environment that needs to be cared for and preserved; sustainability affects other spheres of life, especially the economic and the social. De Ross et al. (2012) show that social sustainability is still a major challenge, explaining that its role is to enhance the quality of life of human beings and that it is related just as much to the indoor environment of abusiveness as it is to the outside world, being directly linked to work relations.

The issue of sustainability, which should be a routine part of everybody’s lives, still spawns contradictions. According to Cardoso, (2012) “while some negotiate wage increases or shorter working hours, other employ multitudes of workers in conditions of quasi-slavery” (Cardoso, 2012, p.43). Unfortunately, for many, profit continues to be a priority, and the relationship between sustainability and consumption has always sparked conflicts. The author goes on: “How can two legitimate concerns be reconciled – that of consuming more to generate wealth, and that of consuming less to preserve resources?” (Cardoso, 2012, p.250).

Profit and consumption are fundamental preconditions for the capitalist system, which is grounded on mass production for a globalized market, all orchestrated by those who control the production processes. In Brazil, very much a part of this system, there is a high level of social inequality, with people often being unable to express or fight for their most fundamental of rights. In a context like this, design cannot disengage itself from the exercise of power, which stands in the way of designers who wish to take a more socially oriented stance in their work.

This point brings up a crucial question for the field of design: How can designers act for the benefit of social innovation and change?

In our reality, it is no simple task for a designer to stand up against mass production and ignore a global culture in his/her desire to take more socially oriented actions that value the local workforce and their culture.

In a bid to incentivize change, research and initiatives that look at the designer’s work from a different perspective are vital, because they represent new paths based on sustainable, collaborative principles.

One such approach is the Social Design methodology, which emerged as a pedagogic practice in the Design degree course given at PUC-Rio, Rio de Janeiro, Brazil, in the 1980s, which was later renamed Design in Partnership. Social Design, or Design in Partnership, has much in common with the concepts of Co-Design, which in the last decade has been the label used to designate partnerships between designers and the people with whom they develop project processes.

As such, we begin with a short background introduction to Design in Partnership, as this practice served as inspiration for the methodology developed in the research reported on here, since its principles are fundamental for the construction of a route towards social sustainability. According to Couto (2017), Social design is an ethical, human rights-based professional practice that considers the principles of equality and respect for individual qualities. It is sustainable par excellence and its social dimension is only effectively realized when it is guided by these questions (Couto, 2017, p.32).

In Design in Partnership, the designer involves the future user in every stage of the design process. What sets it apart so fundamentally from other design methods in this “doing with”, rather than “doing for” or “doing to” other people, which is only possible when designer and user spend time together throughout the project process.

Unlike what some people believe, this methodology is not some form of welfare, even if it is sometimes geared towards less economically advantaged communities. Its primary focus is on the empowerment of the participants or future users through their involvement in every stage of the process. This is why the term Social Design was dropped in favor of Design in Partnership, in order better to reflect the concept behind the practice.

Pacheco and Toledo (2015) argue that this practice of involving end users in every stage of the design project began in the 1970s with other names like co-creation and co-design. They conclude that these participative design methodologies have expanded gradually in the last thirty years, because, as Saunders and Stappers (2008, cited in Pacheco and Toledo, 2015) put it, the practice has little relevance in the labor market.

Manzini (2017) shows that there is now a whole host of possibilities for dialogue between design and society, which could be called Social Design in its broadest sense. He stresses that this dialogue, which he calls social dialogue, is an expression of co-design.

As he sees it, the generation of significant social innovations, solutions that emerge from new social organizations and new economic models, is indispensable, whether or not these innovations involve the poor or the wealthy. He concludes that in the face of the global social and economic crisis, it only makes sense for this social innovation to address socially sensitive issues.

## 2. DEVELOPMENT<sup>1</sup>

Our founding assumption was that collaborative exercises based on opportunities to engage in design projects could help empower people to act productively in the development of projects and the making and sale of artisanal products. The methodology for identifying project opportunities could constitute one of the guiding elements for the formation of creative communities, putting the designer in the role of facilitator, contributing to the formation of groups with creative potential towards a society based on more sustainable principles.

The research reported on here counted on the partnership of Inosel (Instituto Nossa Senhora de Lourdes), a school in the Parque da Cidade community adjoining the Rocinha favela in the south zone of Rio de Janeiro. The school has existed since 1959 and is a reference in the teaching of deaf and hearing impaired children. It is a catholic charity school that teaches preschool and the first nine years of basic education to mixed classrooms of deaf and hearing students.

Inosel has an agreement with the Municipal Department of Social Services and, as a private nonprofit school, it offers scholarships worth up to 50% of its fees for hearing students. There are also 50 scholarships for deaf students that exempt them from the fees, thanks to the agreement with the local authority, which pays a portion of the fees. However, for the agreement to take effect, Inosel has to agree to the terms of reference for special social protection services of medium complexity for disabled people (2016), which include certain requirements, like broadening the network of people with whom the disabled person's family interact, share the same culture, and exchange experiences, fostering the social inclusion and enhancing the quality of life not just of the disabled children, but of their families and guardians as well. As most of the children live far from the school, their parents/guardians have to stay at the school during school hours. As such, this project was conceived to provide some occupation for these women while their children were having lessons.

One peculiarity of the case study presented here was the heterogeneity of the group of mothers from Inosel, who were born and lived in quite different parts of the city and most of whom had never engaged in any manual work before. How could such a mixed group with no unifying cultural thread and no skills be worked with?

The inspiration for the research came from the precepts of the operative group<sup>2</sup>, described by Pichon-Rivière (1994). The idea is that the heterogeneity of groups can be overcome by the homogeneity of the tasks they engage in. The operative groups technique consists of systematic observation together with the analysis of mind operations in social exchanges and interactions with the outer world. Pichon-Rivière (1994) believes in the power of the interdisciplinarity that stems from a group's heterogeneity, which is a peculiar feature of the group of mothers from Inosel. This happens when each member of a group interprets the information imparted to them in different ways, reflecting their own personal experiences, and it is through cooperation that these exchanges happen, enriching the work. This is only possible through a shared task.

Despite some changes that took place during the course of the work, the course began and ended with nine members, who are referred to here as P1, P2, P3, P4, P5, P6, P7, P8, and P9<sup>3</sup>. The women were aged between 30 and 55 and had deaf children aged 10 to 19. Just three of them had a job; the others had worked in different activities but at the time of the course were devoted full-time to caring for their children.

To prepare the work methodology, the Design in Partnership approach was used, focusing on exchanges between the designer and the social group, in which design project techniques are taught in order to foster empowerment. Together with this approach, operative group practices, as proposed by Pichon-Rivière (1994), were also used, based on homogeneous tasks that took full advantage of the interdisciplinary potential of the heterogeneous group of women.

Three key stages of the operative group methodology were performed: the pre-task, the task itself, and the project. The first stage (pre-task) consisted of visits to the group in order to make a preliminary diagnosis, which was guided by the ideas of Branco (1991), who holds that in Design in Partnership, the researcher should engage in participant observation with the group with no preconceived ideas. Through this interaction with the group, they will then discover what the research goal should be.

The second stage was the training proper, or task, to use Pichon-Rivière's (1994) nomenclature. This consisted of 18 three-hour sessions, totaling 54 hours. This stage was split into three modules, which are described below. The project was concluded in the final part of the third training module.

<sup>1</sup> The research reported on in the article is a case study done for the master's thesis in Design at PUC-Rio by one of the authors.

<sup>2</sup> The operative group technique was created in 1946 by Enrique Pichon-Rivière, when he was the head of the service for adolescents at the psychiatric hospital Hospital Neuropsiquiátrico de Hombres, in Buenos Aires, Argentina. The technique is used today not just in the training of psychologists, but also in advertising creation, institutional work, leadership development, leadership studies, and acting. Any situation where a face-to-face group can turn into an operative unit of the task (Pichon-Rivière, 1994, p.130).

<sup>3</sup> Used to protect the participants' identity.

According to Portas<sup>4</sup> (2016), the case study in question did not aim to form a social enterprise, but was more geared towards the individuals, which is why the explanation of the methodology was supplemented by information on the group, their particular characteristics, and what they produced.

## 2.1. METHODOLOGY

The first module, called Tilda dolls, lasted six sessions, during which the participants learned how to make a Tilda rag doll<sup>5</sup>.

At first glance, making a Tilda doll seems quite a challenging task, but after a few stages it becomes clear that despite the complexity of the technique, it is simple to execute. The training began with this technique to boost the women's self-esteem from the outset, so they would then feel ready to tackle a different task. Another important point was the ease of obtaining the raw materials, because the dolls are made from scraps of fabric and leftover haberdashery and wool.

The Tilda doll technique is practically universal and was consistent with the research goals, namely:

- The desire the women had expressed during the diagnostic stage to learn how to use a sewing machine;
- The sentimental issues behind the technique, with which the women could identify;
- The chance to go through and teach different stages in a design project.

In this module, the participants went through the stages of a design project, but without reflecting on their actions, which led to a degree of inertia on their part. Even so, some gains could be perceived from the activity, as reported in the participants' statements.

P4 and P7 highlighted the importance of the learning process in the first module.

I've already made dolls to sell. This work will help us a lot." (Statement by P4, 2016)

This work inspired me to earn some money, because we're mothers of special children and we can't work. The work helped us to develop, think, and create how, with a piece of fabric, we can make a doll. (Statement by P7, 2016).

In every group there is a distribution of roles, and these two participants, P4 and P7, were fundamental for the development of this work. For the communication necessary for the tasks to be effective, each group member takes on a role according to their own individuality and subjectivity. Imbroisi (2011) stresses the importance, in this kind of work, of two key figures: the leader, who in this case was P7, and the skilled worker, who was P4.

As soon as we arrived we realized how important a leadership role P7 had in the group. Her child had been at the school for ten years, so as an old hand she could build a bridge between the school and the other mothers. She was very keen to learn the craft techniques and was always making or teaching the other mothers how to make bags and cushions. Pichon-Rivière (1994) emphasizes the importance of the leader in understanding a group's dynamics.

The second module, called basic and compound forms, also lasted six sessions. The students were encouraged to use scraps of cloth to make basic and compound shapes. The first shapes were basic ones – the circle, square, and triangle – all using fabric, until all the different techniques had been used up.

This module served to show the women that creativity and originality should not be limited by a shortage of raw materials. Indeed, some apparent problems, like a shortage of resources, may even prompt greater creativity.

The aims of this module were:

- to develop the women's autonomy in the different stages of a design project;
- to show the great variety of forms and objects that can be developed from used materials, working on techniques that can be developed from basic forms, such as the circle, using fabric yoyos (*fuxico*)<sup>6</sup>.

The autonomy barrier in the project stages was overcome, but now we had a new problem: a lack of originality in the products developed. The visual references presented in the classroom, which were designed to broaden the students' visual repertoire, were inhibiting their creativity.

The third and final module was called image abstraction and also lasted six sessions. Compared to the stages proposed by Pichon-Rivière (1994), this could be considered the last stage, which he calls a project, because it was at this stage that we managed to attain the goals proposed for the methodology as a whole.

Taking basic concepts from visual language and reinforcing figurative representation through the abstraction of real images, the idea was to make the products the participants developed more original. The heterogeneity of the group revealed the lack of any cultural unity and limited familiarity with craftwork on the part of most of the participants.

<sup>4</sup> Comment made by Roberta Portas in an orientation session, 23/09/2016, Rio de Janeiro.

<sup>5</sup> The Tilda doll was created by the Norwegian designer Tone Finnanger in 1999, when she was 25 years old. She had always enjoyed arts and crafts and dreamed of making dolls and sets for animation films while she was working in a craft shop. The idea for the doll was inspired by family members who were also artisans. The original Tilda doll measures 63 cm and its main features are its little face with two dots for eyes and rosy cheeks. She does not have a mouth because she speaks with her heart. Today, Tilda is a craft brand that produces books, craft materials, fabrics, craft paper, and decorations. Each artisan who makes a Tilda doll gives it her own special touch. Available at: <<http://questadeafeto.blogspot.com.br/2014/03/tilda-historia.html>>. Accessed on January 28, 2016.

<sup>6</sup> There are no records of the origins of fuxico, or the making of fabric yoyos, but it is widely used in Brazil. We chose this technique because the women showed interest in learning it. Another curious point is that this technique was once commonplace amongst groups of women in rural parts of the country, who would "fuxicar" – or gossip – while they worked. Not in the sense of badmouthing others, but in the sense of talking through their everyday problems, and this is a very strong feature amongst the Inosel mothers.

The aims of this module were:

- to reinforce the stages of a project, which had already been gone through in the second module;
- to resolve the problem of lack of originality of the products made.

In tasks of this kind, where designers are interacting with groups of artisans, what stands out is how much they draw culturally on local artisanal practices. It was through basic concepts of visual language, reinforcing figurative representation through the abstraction of real images, that this originality was sought.

The idea was therefore not just to expand the participants' visual repertoire, but also to develop their visual literacy. They were asked to do exercises to help them understand the concepts of abstraction based on real images. According to Dondis (1997), visual literacy is responsible for enhancing an individual's capacity to understand and create a visual message.

Dondis (1997) explains that the process of abstraction is a reduction of visual elements to simplified lines. In abstraction, details are irrelevant, while essential lines become the focus.

As such, some element was sought out that could interlink all those women. So we started observing the school and its surroundings. It is set in a very attractive landscape, with elements that epitomize the city of Rio de Janeiro: forest, mountains, a river, and the Rocinha community. They took photographs of their surroundings and, as a group, picked five of these to work on. These images were enlarged to A3 format and each woman chose one as her reference.

Some of the participants successfully grasped the idea of abstracting the image, and presented excellent results, such as P1 and P8. Others, like P2 and P5, turned away from the concept of abstraction and moved towards symbolism. This concept can be seen in P5's collage, which includes a kite to represent the favela, and in P2's, who puts a house alongside a coconut palm, although the perspective of the photo, taken looking upwards, does not show the ground.

We cannot fail to highlight the work of P3, who adopted neither the abstraction of the photograph, like P1 and P8, nor recourse to symbolism, like P2 and P5; rather, she deviated from the proposed approach to engage in creative signature work of her own.

P3 did not enroll for the course at the beginning of the year. She joined half way through without letting us know she wanted to take part. The first day she showed up, she said she was there just to see what it was like, so we asked her to help another participant make an object using *fluxico*. After this day, she continued to frequent the lessons. Every lesson, she would do something different from what had been asked of the participants, deciding on her own initiative what she was going to work on, without any guidance. After a few sessions like this, we talked with her and she explained that she did not know any handicrafts but that she wanted to take part in the lessons. We started working with her individually, and she showed creativity and an unrest that needed to take expression through art. This became clear in the third module of the course, the only one she took part in from beginning to end. The most important thing in dealing with P3 was to let her express herself without interference, for her to build her self-confidence. The recompense came in the quality of her work and her statement.

It was a real challenge for me, because I don't have a way with art. I joined the course thinking of making a rag doll. I skipped some stages and almost gave up. The girls supported me, even knowing that I hadn't understood the course dynamic.

I gave them a bit of a tough time. I joined at the end of the course and I didn't know there were stages and there was a process. I joined in the middle of the process, I skipped stages. I gave them a lot of trouble. I said, "guys, I'm going to give up. Today's my last day," and they said, "today's not your last day." We started doing some collage. Every person has their own view. The girls were really obedient, but I was, like, completely disobedient. Whatever went through my mind, that's what I did. At the end of the day it was really good. This work, it's added a lot to my life. Everything I ever started I'd stop. I decided I didn't want that for my life any more, and this course helped me carry on and now I'm really pleased with myself. (Statement by P3, 2016)



[Figure 19] Photo used by P3 in module 3. Source: personal archive.

[Figure 20] Collage on fabric done by P3 in module 3. Source: personal archive.

[Figure 21] Painting on fabric done by P3 in module 3. Source: personal archive.

[Figure 22] Product developed by P3 in module 3. Source: personal archive.

### 3. CONCLUSION

The methodological steps described for the three stages of operative group tasks by Pichon-Rivière (1994) – pre-task, task, and project – were fulfilled. There was not necessarily a standard result of products to be attained, but rather certain expectations about the development of design project autonomy on the part of the participants. The goals set at the beginning of the study were therefore attained: based on design methodologies, we incentivized and trained the group to create and produce original objects, stimulating their creative and innovative potential, while boosting their self-esteem, entrepreneurial spirit, collaborative capacity, and citizenship.

The point is not so much what type of work is done, what type of methodology is used, or what this kind of initiative is called, but that through this process a path is taken towards a society based principles of social sustainability. Through this research, it is possible to trace a reorientation of the designer's work in the labor market based on more sustainable principles. The quest of some designers for a more socially-oriented professional direction for the common good and less geared towards market demands and consumerism may help contribute to the understanding of the true role and responsibility of the design professional in relation to the problems of our society.

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## THE ECOLOGICAL AESTHETIC CONNOTATIONS IN CHINESE TRADITIONAL ENVIRONMENT CONSTRUCTION SKILLS

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### ABSTRACT

This paper tries to explore the ecological aesthetic connotation of Chinese traditional environment construction skills (CTECS) from ecological benefits, ecological aesthetic experience ways, ecological aesthetic taste. (1) CTECS formed a pluralistic and complete system. Some of them are less damage to nature and consume less resources in the course of their creation, which are beneficial to the sustainable development of human and nature. (2) As two common aesthetic experience ways, far view and static view, which set at the beginning of the construction of CTECS, keep a certain distance between human and nature, which have some ecological significances. (3) The creations of some of CTECS with good ecological benefits have unique aesthetic tastes which are ecological aesthetic affordances. The study mentioned CTECS research working hypothesis highlight new research frontiers potentially extending the aesthetic role of it under a sustainable design approach.

keywords: Environment construction skills, Ecological aesthetic, Ecological benefit, Sustainable development

## 1. INTRODUCTION

As an intangible cultural heritages, CTECS are all the skills that used in the construction of human settlement by Chinese and inherited by generations from ancient times to the present. They have been formed a pluralistic and complete system and reflect the ability to transform the natural environment, the unique spiritual value and the mode of thinking, which incarnate the vitality and creativity of China. In 3, 000 years ago, the Chinese traditional architecture structural system had emerged(Liang Sicheng, 2013: p.5). The division of CTECS labor has been specialized in Song Dynasty(960-1279 AD). There were some types of work of CTECS: wood, stone, earth, tile, oil paint, color paint, laminating and so on, on the whole, in the wooden factories in Beijing in the Qing Dynasty.

Ecological aesthetic is a new aesthetic paradigm and originated in the middle of the 20th century. Aesthetics theory should be rethought and reconstructed by the ecological principles in *Notes Toward an Ecological Aesthetic* published in 1972 which is the first article used 'ecological aesthetic' as a terminology. Meeker considered that aesthetic theory should combine the artistic creation with the natural creation and break the boundaries between science and humanity(Meeker, 1972: p.120-136). The alternative viewpoint is that ecological aesthetics which opposes the dualism of human and environment is a paradigm of environmental aesthetics. Inclusive unity, dynamic balance and complementarity can explain aesthetic experience and aesthetic quality of designs and other creative products(-Koh, Jusuck, 1988: p.177). Ecological aesthetic should reform the traditional aesthetic concepts and be based on the modern ecological principles when there is a conflict between aesthetic value and ecological sustainable value(Gobster, 2007: p.972). In the mid-late 1990s, ecological aesthetics was introduced to China and aroused great research interests in Chinese scholars. It gradually moves towards the stage of establishing an ecological aesthetics system that is a bridge of China and the West, past and present from the initial stage of calling for the ecological consciousness.

Ecological aesthetics, which integrates ecological knowledge into the construction of aesthetic theory, coincides with the sustainable development of human and nature. As a new aesthetic idea in ecological civilization era, it is a response to the ecological crisis which is become more and more serious in the world. It is an aesthetic redemption of the ultimate goal of ecological ethics(Guo Qingge, 2015: p.218). We must sublimate anthropocentrism and adhere to ecological holism(Zeng Fanren, 2005: p.48). Ecological aesthetics should establish an aesthetics research model centered on the aesthetic that is the three-way model of the aesthetic ability, the aesthetic affordance which are what the aesthetic object offers, and the aesthetic experience(Cheng Xiangzhan, 2016: p.328). The Chinese traditional ecological thoughts provide some references for the ecological aesthetic(Xu Hengchun, 2000: p.8-9).

Some of CTECS can produce the ecological benefits which is propitious to the sustainable development of human and nature. The creations of CTECS are important aesthetic objects in Chinese traditional aesthetic. There are some distinguishing characteristics of ecological aesthetic in the aesthetic experience ways and the aesthetic tastes of CTECS.

## 2. ECOLOGICAL BENEFITS

Chinese regarded the economic use of natural resources as a virtue very early in ancient times. In ancient books *Shi Ji*, it is recorded that Huang Di, who is the legendary ancestor of the Chinese people, saved water, fire, materials and everything. Later, some dynasties also enacted regulations about environment construction to avoid unnecessary waste, such as *Ying Zao Fa Shi* compiled about 900 years ago and *Qing Gong Bu Gong Cheng Zuo Fa Ze Li* codified in 1734.

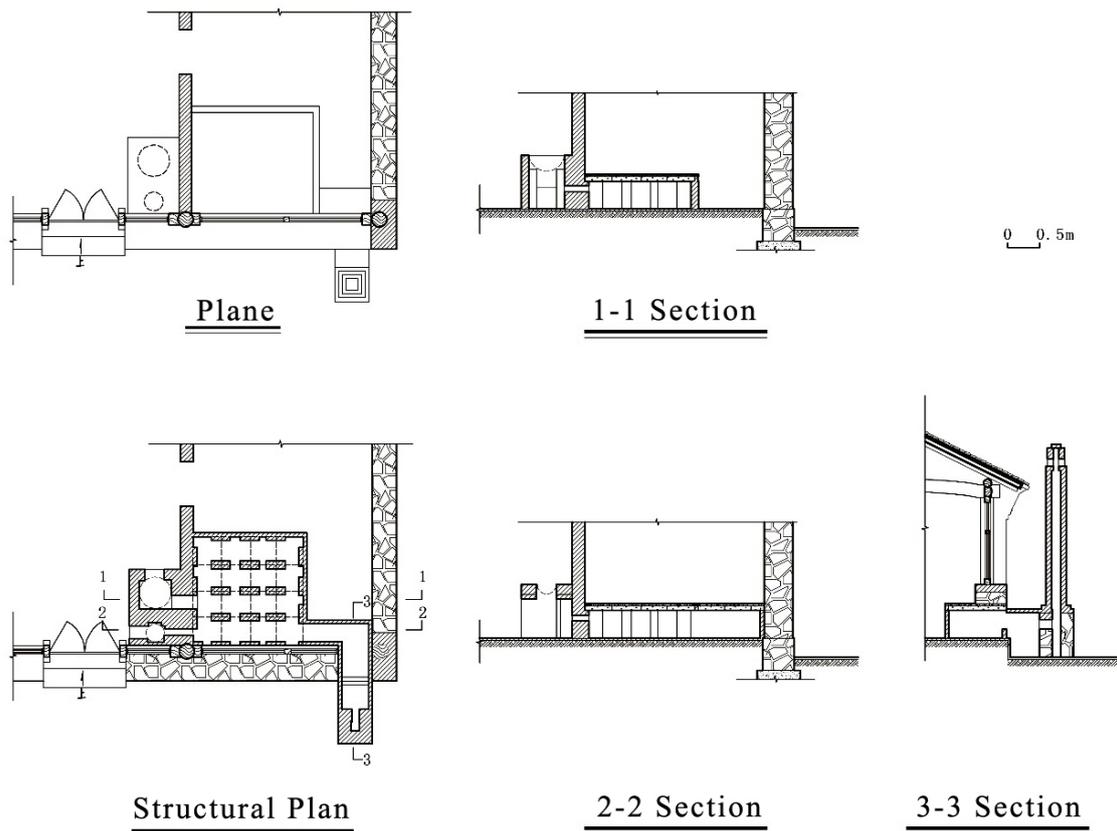
Most of the materials of CTECS are got as near as possible in the locality, especially in the traditional folk houses. Soil, crop stalk and hemp, which are the basic materials of CTECS, are also obtained from the nearby farmland. The way is less damage to the environment, and not consume exceedingly much resources on the material transportation. Some ways of getting materials in the locality destroyed the local natural environment, such as felling tree. But the excessive exploitation is not the inevitable consequence of it. In terms of ecological benefits, getting materials as near as possible in the locality is a ecological construction way.

China is one of the oldest countries to use wood. CTECS have accumulated the rich experience in the use of wood. Even its history is the history of the use of wood. The wood is used on the basis of the characteristics of it. The main materials of the building unit exposed outside are Korean pine, mongolica pine and willow, such as handrail, pillar, door and window. The wood meeting the ground or the wall easily absorbs water and decay. According to the positions, Chinese ancient craftsmen adopted different preservation measures of wood. The common moisture-proof measures include ventilation, brushing tung oil, filling lime or charcoal and so on in Beijing. For example, the air vents with brick carving were fitted on the upper and lower of the walls with wooden pillar inside for maintaining good ventilation. The part of wooden stake sinking into soil was filled with white lime slurry or covered with charcoal.

In ancient China, cooking and heating are the main ways of energy utilization. Kang(Figure 1), which is a simple central heating system, widely set inside the residential buildings in northern China. It is a bed, which people sleep on, made of bricks or soils along a side of the interior. The lower part of kang can be burned with any fuel from outside. The rudiment of it had appeared before the Song Dynasty(Zhao Lisheng, 1996: p.207). In the traditional folk houses in Beijing, kang is generally connecting with the fire stove. In the cold season, people combine the behaviors of cooking and heating by this ingenious design, so as to improve the utilization efficiency of the energy

resource. It is commonly known as “a fire for cooking and heating.” In many villages in Fangshan District of Beijing, water tank is fixed under the ground next to the fire stove of kang. The waste heat from the stove cooking food will heat up the water in the tank to meet the needs of people for daily washing. A recessed space of about 30 centimeters set on a side of kang is used to put shoes in. This can make the shoes dry and warm in winter. These simple and intensive energy-saving technologies of CTECS can reduce energy consumption.

There are some ecological practices for the protection of trees in *Yuan Ye* which is the first monograph on Landscape Art in China written in 1631. Because poplars and bamboos are easy to survive and grow, the new garden should plant them in order to improve the survival rate. The exquisite buildings are available, but old trees are not easy to grow. When the garden is renovated, the old trees should be preserved. If a old tree hinders the construction of the new house, it should be considered taking a step back from the wall to avoid cutting down the tree or cut off some unimportant branches(Ji Cheng, 1981: p.49).



[Figure 1] Observation Map of Huo Kang at No.30 Chaoguan Village, Gubeikou Town, Miyun District, Beijing.  
Source: Draw by Tan Changliang, 2019.

If there is water in Chinese traditional garden, people will farm fish. From tall trees, low flowers to goose, ducks, fish and other aquatic animals, they comprise a small and diverse ecosystem, even weeds have a certain ecological significance to survival. This idea that person live in harmony with all creatures is different of the traditional concept of garden-making in the West.

The main materials of CTECS can be decomposed naturally after use. The biodiversity is better conserved in the living environment. In the stages of the creation, such as getting materials, building and using, some of CTECS consciously consume less resource and protect the nature around human settlement. It means that some good ecological benefits are directly produced. When the creation of CTECS enter into aesthetic experience, the idea is consistent with the value orientation of ecological aesthetic.

### 3. ECOLOGICAL AESTHETIC EXPERIENCE WAYS: FAR VIEW AND STATIC VIEW

In the season suitable for tourism, some scenery spots with beautiful nature landscape are overcrowded. The curious aesthetic behaviors about animals and plants spawned a large number of circus, zoos and botanical gardens. Most of these aesthetic behaviors are the destruction of biodiversity, which is the unsustainable development of natural ecosystem. Therefore, the influence of aesthetic experience ways on the sustainable development of human and nature needs to be focused in the studies of CTECS.

The building forms of pavilion, waterside pavilion, windowed veranda, tower and gazebo are very popular in the creations of CTECS(Figure 2). Their main function is to meet people’s aesthetic needs. The classic aesthetic experience ways of them are far view and static view which are set at the beginning of the garden construction.

Far view is a way keeping a certain distance between the aesthetic person and the nature. Static view means that the aesthetic person needs to reduce his intervention in the growth micro-environment of animals and plants. The two aesthetic experience ways mainly depend on the visual perception of people. Although their aesthetic experience is not optimal, they have distinct ecological significance. Improper behaviors of human including some aesthetic experience ways are the roots of ecological crisis. In many cases, only far view and static view can avoid destroying the natural ecological environment in the course of appreciating beauty. CTECS provide a very useful enlightenment for the study of ecological aesthetics.



[Figure 2] Zhi Chun pavilion at the Summer Palace of Beijing. Source: Photograph by Tan Changliang, 2017.

Aesthetic behaviors have an impact on natural balance. From the perspective of protecting the stability and integrity of whole ecosystem, in the majority of cases, far view and static view are the ecological aesthetic experience ways when people appreciate the beauty of nature. It is surprisingly that they are already inhere in the traditional Chinese aesthetics reflected in CTECS.

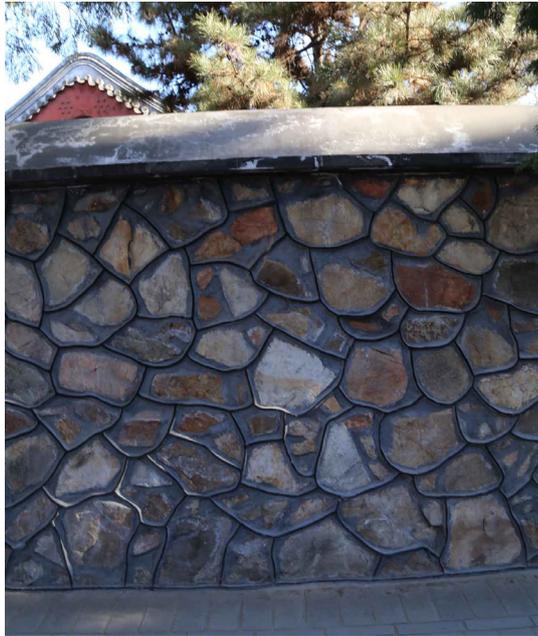
#### 4. ECOLOGICAL AESTHETIC TASTES

As an aesthetic terminology, aesthetic taste, which has a very rich connotation, refer to aesthetic characteristics, aesthetic style, aesthetic preference and so on. There are great diversity in the understanding and the needs of the appreciation of beauty among people, so aesthetic taste is universal and emotional. When faced with a specified aesthetic object, aesthetic behavior may not necessarily happen because of the preferences of aesthetic taste.

In a stable external environment, CTECS will form some aesthetic tastes. The creations of CTECS with good ecological benefits can give people sense of pleasure, which means that they have aesthetic affordance. If these aesthetic behaviors were stable and widely accepted, some aesthetic tastes had naturally formed. In Chinese traditional folk houses and gardens, a large number of raw materials are directly used without deep processing, which makes irregular woods and stones everywhere. At Cuandixia Village of Beijing, the houses and walls are constructed by raw stones. The wall with the drop of more than 20 meters is a visual leading role for the mountain village which is ups and downs (Figure 3). Those practices of CTECS are also common in traditional Chinese gardens and even royal gardens, such as tiger skin wall. The wall, which is a typical form of wall in Chinese traditional architecture, is built with stones of irregular shape. The seams among the stones are filled a few limes. The shape of the seams like the stripe of tiger skin. The appearance of tiger skin wall is simple and wild (Figure 4).

[Figure 3] Cuandixia Village, Zhaitang Town, Mentougou District, Beijing. Source: Photograph by Tan Changliang, 2016.





[Figure 4] Tiger Skin Wall of Huo Kang at the Summer Palace of Beijing. Source: Photograph by Tan Changliang, 2017.

Chinese was infatuated with the curved growth state of plants. In the construction of CTECS, lawn consisted of a kind of grass was not planted and trees, flowers and bushes were not trim to regular geometry shapes. Compared with the West, this aesthetic taste about nature beauty is less artificial and reflects a more ecological consciousness.

Because some aesthetic tastes of the environments which provided by CTECS can improve some good aesthetic experience, They were endowed some ecological attributes. Any aesthetic standard need to be built on a certain form. There are precisely some true forms of ecological aesthetic in these distinctive aesthetic tastes, which close the emotional distance between human and nature and awaken the consciousness of protecting nature.

## 5. CONCLUSIONS

CTECS are the productions of Chinese agricultural civilization. Although they are not completely ecological, they have many ideas and methods that are beneficial to the sustainable development of human and nature. According to the above analysis, it can be found that the ecological aesthetic connotations in CTECS are mainly in the following aspects. (1) In the process of creation, the good ecological benefits produced by some of CTECS are objective. Some methods can no longer be adopted by the modern environment construction, but those ideas consisting with ecological aesthetic are worthy of our reference. (2) In the process of appreciating beauty, far view and static view set by CTECS can reduce the damage to nature and the creation of CTECS with good ecological benefits formed some delightful ecological aesthetic tastes.

Ecological aesthetic originated from the modern ecological consciousness. As an aesthetic paradigm, it should not be limited to the concepts and the methods of the creation of protecting nature. It should be expand into the aesthetic experience of visual forms. More researches about the typical structure of visual forms, such as symmetry, duplication, should be continued in the future study.

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## **UPCYCLING IN COMMUNITIES: LOW CARBON DESIGN PROMOTES PUBLIC ENVIRONMENTAL AWARENESS AND OPTIMIZES SOCIAL**

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### **ABSTRACT**

This article concludes the Upcycling activities in China in a range of locations including cities such as Shanghai, Guangzhou, Changsha and in the Chinese countryside, as well as activities in Lincoln, UK from 2014. The communities that joined in the Upcycling activities were traditional urban communities, new industrial communities and rural communities at the junction of urban and rural areas. The design and organization of the activities in the project is based on the characteristics of communities, utilizing various themes, scale of project and presentation. This specific article analyzes the effect from the eight years of practice and considers how these low carbon design activities, represented by Upcycling, have improved the environmental awareness of communities and the general public, in addition to the special effects in social governance.

Keywords: Upcycling, Low Carbon Design, Public Environmental Awareness, Social Governance

## 1 PREFACE

### 1.1 Background

In 2011 the Guangzhou Low Carbon Industry Association connected with their member companies that specialize in the industrial leftover recycling business. The association created the opportunity to utilize industrial waste as a raw material for a design competition. The research group organized for over 20 designers to visit and discover materials.

As a design activity coupling environmental protection with a low carbon approach, Upcycling undoubtedly has social and educational significance especially when the public are so intrinsically connected. Since the initiation of the activities in 2012, the Upcycling project team has placed great emphasis on the societal relationships and in particular the interaction with different communities. The interaction has embraced various forms, such as exhibitions, forums and creative workshops. This Upcycling practice, during a period of 8 years, has evolved from being a professional design activity into a burgeoning, socialized public welfare activity. The design activities have not necessarily involved everyone in a community but the outcomes impact on everyone. It is important to recognize that the various Upcycling activities have been constructive in solving various social problems, including social aging and environmental education within the community. In this article, the interaction of Upcycling and communities will be classified by category, analyzed and summarized, in order to discover a regular pattern.

### 1.2 Organization

Supported by The British Council, the research group collaborated with DESIS-CHINA, which includes Tsinghua University, Tongji University, Jiangnan University, Hunan University, Guangzhou Academy of Fine Arts and Hong Kong Polytechnic University, and other design institutions from the UK. All the academic institutions were invited to appoint teachers and students to come to the competition held in one of the colleges in DESIS-CHINA. The first competition in 2012 was held at the Guangzhou Academy of Fine Arts.

## 2 GENERAL SITUATIONS

### 2.1 Exhibition

Since the project began in 2012, Upcycling exhibitions have been staged after the activity as a form of understanding comprehension, but there have also been public exhibitions where the theme is associated to low carbon practice, in various institutions. R Buckminster Fuller states that ‘Every time man makes a new experiment he always learns more.

‘He cannot learn less’ (Fuller 1969).(1)

Table 1 below shows the details (in chronological order).

No.	Time	Location	Name of Exhibition	Visitors (person time)
1	2012 12	GUANGZHOU	(I'MART)	30000
2	201305	QINGDAO	DESIGN WEEK	60000
3	201404	YANGZHOU	DESIGN WEEK	45000
4	2015 10	BEIJING	DESIGN WEEK	120000
5	201606	WUXI	INDUSTEY EXPO	80000
6	201706	GUANGZHOU	HAIZHU ART EXPO	65000

[Table1] The public exhibition that Upcycling had join in past (Only include exhibitions that over 30,000 visitors)

Our team also pays attention to the effect of the presentations. According to the various surveys outlined below, the public show a huge interest and demonstrate high participation to the Upcycling activity. The public were also prepared to pay a reasonable price for the designed works.

Feedback Reports from 128,000 Visitors

Age Distribution: Young people are the main visitors. The proportion of 17-28 years old is over 80%.

Gender: Women showed more interest in Upcycling, accounting for 62.5%

Occupation: Students and designers are the main audience of the exhibition; the total share is close to 90%.

The overwhelming majority(>77%) of visitors have carried out Upcycling at home, which suggests that the audience has a strong interest in Upcycling. Almost all those that attended have increased their interest in Upcycling because of their visits. It appears that if the conditions are right, most people are willing to try Upcycling. More than 70% of visitors are willing to pay for the event. Nearly 60% of the participants said they would decide whether to buy Upcycling products based on the cost-effectiveness ratio.

Some of pictures from the exhibitions are below.



[Figure 1] FMART (2012, Guangzhou)



[Figure 2] International Design Week (2013, Qingdao)

According to the survey, young visitors between 17 to 28 years old are more interested in Upcycled designs than any other age group. They would carefully study the material, design and create the work.

Designs that were generally larger in size were typically harder to produce. There is no inherent instruction book for Upcycling. The mix of materials, the unexpected combinations, perhaps akin to the anti-design ideals of Memphis (1981) (2), mean that experimentation is key. Dutch designer Jurgen Bey states ‘the language of products is the language we give them’(3). Usually visitors had a preference to simply appreciate the work rather than interact despite having an interest in it.



[Figure 3] Yangzhou International Design Exhibition (2014, Yangzhou)



[Figure 4] Guangzhou Haizhu Art and Design Exhibition (2017, Guangzhou)

Most of the visitors, as part of the comprehension process, still required some element of explanation from a professional designer to understand the design principle and thinking behind the work.

Our project team encouraged visitors to actually interact with and enjoy the design outcomes. As T.S Eliot said ‘Genuine poetry can communicate before it is understood’ (1929) (4).

**2.2 Workshop**

Since the project began in 2012, Upcycling has not only held professional workshops with Design Colleges, but has also held workshops that engage the public. Those workshops attracted a range of participants including urban community residents, rural residents, factory workers and ordinary citizens.

NO	TIME	LOCATION	TITLE	participants
1	201408	SHANGHAI	MEMORY	66
2	201502	SHANGHAI	LIGHT	138
3	201604	GUANGZHOU	JELLY FASHION	336
4	2016 12	GUANGZHOU	WASTE TO WAIST	128
5	201606	LINCON(UK)	STREET FASHION	172
6	201706	GUANGZHOU	FURNITURE	266

[Table 2] List of public workshops in Upcycling project

The first public workshop held in 2014, was conducted in Shanghai. This professional workshop, which was held at Tongji University, had the theme of “design for community” and therefore ensured that many designers considered the community’s low carbon needs. The workshop utilized a lot of waste materials in the creation of the de-

signs. Findings show that there is a large amount of waste that stays within the housing of community residents and this can provide opportunity to encourage the imagination toward Upcycling project solutions. At the same time our project team realized that urban communities have an urgent need for low carbon design that could contribute to solving environmental problems but also provide stimulation and encourage creativity in their free time. More importantly these activities could help a community and the general public further understand the concept of Upcycling waste and ultimately enhance the awareness of environmental protection.

The approach and subsequent success in working with the Shanghai community was applied in communities in Guangzhou. The team organized a couple of creative Upcycling workshops with different themes. These were conducted within a factory and also a countryside environment and both received positive outcomes and feedback. At the same time, the team experimented with the project overseas and conducted a workshop, aimed at bringing a diverse community together in the UK. The project was trailed in Lincoln (UK) and again many local residents, with very mixed backgrounds, got involved. There was a positive response to our project which has led to further UK based workshops.



[Figure 5] Memory (2014, Shanghai)



[Figure 6] Light (2015, Shanghai)

In the Memory design workshop conducted in Shanghai (2014) the main participants were community residents that had retired from mainstream employment within the last 10 years. The theme was “Memory” and the intended aim was to let participants use waste to design their own works associated to their specific areas of interest. The retired ship captain (fig 5) made outcomes using worn-out electronic components and was able to exploit the beautiful colors found in such pieces that are so frequently overlooked. In other works, residents that had been employed in textile mills, created purses using a series of bottle caps.

The Lamps and Lanterns workshop conducted in Shanghai (fig 7) was held during the Lantern festival. The community residents that participated in this particular project were different ages, and the experiment managed to combine both industrial waste and also household waste that the residents provided. This workshop shows unexpected imagination, creativity and the team spirit of public. With the guidance from professional designers, these residents created over 100 lamps which were placed along the roadside on the day of the Lantern festival. The scene contributed to the overall festival atmosphere, demonstrated low carbon environmental consciousness and significantly represented cohesion in the community.



[Figure7] JELLY fashion (2015, Guangzhou)



[Figure 8] Home Furnishing Decoration (2017, Guangzhou)

The Jelly Fashion project was conducted in 2016 with residents living in the countryside village Liu Cun. The purpose of the project was to develop individual confidences and bring the community together through education and creative practice using locally sourced, waste material. Utilizing the abandoned and found materials formers were created through simple means for printing from whilst on the street. The project also embraced the creativity of local street makers that were able to construct garments from the prints that the community produced. The outcome of the work was a community fashion show and although this was a short three-day project the connection with the villagers was substantial with well over 300 villagers getting involved.

The project was named Jelly because it was the name of a local resident that became intrinsically involved in developing community enthusiasm. The Jelly Street project was subsequently exhibited at the National Centre for Craft & Design UK (2018) for a six-week period.

In 2017 the Upcycling workshop centred on a theme associated to Home Furnishings and was conducted in

a commercial space which introduced additional challenges. Despite the change in approach and the various constraints the project outcomes still attracted much interest and provided an opportunity for young designers to consider and explore realistic entrepreneurial opportunities. With each project that is conducted additional challenges are introduced in an aim to make the projects not only environmental friendly and to connect communities, but also to ensure that they are commercially sustainable.

### 3 SOCIAL GOVERNANCE EFFECT

From the descriptions above relating to the workshops and exhibitions that have been conducted we can clearly see that an Upcycling mentality has a positive impact in addressing a variety of social problems which we refer to as “Design for public, design from public”.

#### 3.1 Solutions to the Aging Problem

During the workshop and exhibitions with the Shanghai communities, our team had collaborated with local authorities, held six low carbon design workshops and organized regular activities. Our team worked with designers to ensure that they could guide residents in being creative and appropriately responsive to the different themes, the different materials and different processes. The main participants were individuals that had retired within the last 10 years with abundant experience and ability and capable of teaching their grandchildren. The population of junior retiree in current Chinese society is high and the Upcycling project could not only help release their knowledge and experience but can also bring them psychological and spiritual satisfaction. During the workshop these particular residents demonstrated a high interest by active participation and fruitful result. It seems reasonable to suggest therefore that these Upcycling activities in the community are effective in solving some of the communities aging problems.

#### 3.2 Public Education

The main idea of the Upcycling activities in the different communities is public education on environmental awareness and the concept of low-carbon design. From the feedback received during the project, and our subsequent analysis of data, we find that all the participants have developed a better understanding of reuse and the upgrading of waste through their experiences when they take part in those activities. The Upcycling project also made individuals and communities aware of the amount of consumption associated to low carbon design. Most of the participants and visitors were of the opinion that the completed design works in the various Upcycling projects could be sold as a viable product. The groups also recognized and accepted the value of higher prices for such works due to the creative design and more time required for the output to be created. The Upcycling activities in the countryside and the factories have also had a special education effect. The workers in the factory environments collectively developed a deeper understanding of the work they engaged in, whilst the farmers realized they could also make use of their daily waste and be more constructive in environmental protection.

#### 3.3 Entrepreneurial opportunity

The team held the workshop with a Home Furnishing Decoration theme in order to test the commercial effect of the works and the possibility of publishing works as a product by using commercial spaces. It was positive to note that the visitors were interested in most of the works and were willing to pay an appropriate price for them. This outcome is encouraging to those designers who plan on making a living out of Upcycling. Some designers have started their own business on Upcycling design.

## 4 CONCLUSIONS

4.1 According to the activities in different communities, Upcycling has a high public engagement.

4.2 The Upcycling project has a positive effect in social governance by help solving problems associated to the aging problem, the employment problem and the environmental education problems.

4.3 Positive interaction between professionals and the general public occurred during Upcycling activities.

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4. T.S. Eliot, *Dante Essay* (1929)

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## FASHION DESIGN FOR SUSTAINABILITY: A FRAMEWORK FOR PARTICIPATORY PRACTICE

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### ABSTRACT

To foster an understanding of our interdependence as humans in the natural world, new ways of knowing, doing, being and learning to live together<sup>1</sup> must be formed. Such a dramatic shift from dominant worldviews of control over nature towards co-existence involves critical reflection of intentions, beliefs, habits and practices at personal, societal and species levels<sup>2</sup>. Fashion Design for Sustainability (FDfS) explores living well together in nature through fashion's social, industrial, cultural, economic and educational dimensions from micro to macro scales. This research explores FDfS with participants across a spectrum of engagement, circumstances and locations to invert the current fashion system from one that exacerbates relationship inequalities, to one of interdependence. This paper describes a framing for fashion in such a context, developed to be in constant beta, maintaining its underlying ambition, whilst informed by participants.

Keywords: Fashion Design for Sustainability, participatory frameworks, ecological context

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1 United Nations Economic and Social Council. (2011). Learning for the future: Competences in education for sustainable development. Retrieved from <https://www.unecce.org>

2 Walker, S. (2011). *The spirit of design: Objects, environment and meaning*. London: Earthscan.

## 1. INTRODUCTION

This paper articulates critical reflections on an iterative, explorative process of designing and delivering a framework for FdFS in educational and business contexts. This framework has been created from an ecological and equity viewpoint and draws on an approach to fashion education and industry practice that is socially, culturally, economically and thus environmentally transformative. It terms design and designing as a set of actions and interactions undertaken by those engaged in fashion's business, social, personal and educational practices. It offers a substantially different approach from many fashion and sustainability endeavors (with notable exceptions) predicated on product, material and business growth. Through reflection on applications of this model, the paper identifies challenges and opportunities of working in this way. This includes connecting and relating pragmatic product-based outcomes and the sometimes less visible values-based explorations and decision-making processes involved. It offers an emergent framework for diverse participants to participate in critically needed, radical change to the fashion system.

## 2. BACKGROUND

Designing for sustainability connects the values, visions, practices and capabilities of those who wear, care for, conceive, make, buy, sell or otherwise engage in the elements that make up attire. Worn on the body, representing identity, time, culture and much more, fashion is a highly visible and distinctive barometer of our relationship with nature and each other<sup>3</sup>. The fashion industry has a heightened interest in sustaining its substantial \$2.4 trillion a year heartbeat<sup>4</sup> due to environmental and social concerns<sup>5</sup>. This paper, however, draws on a definition of prosperity that broadens out fashion's ambition for sustainability to encompass 'prosperity as the capabilities that people have to flourish within the resource constraints of a finite planet'<sup>6</sup>. This shifts the focus of sustainability from products that create profit with minimum harm, to human capabilities to live well, together in nature, recognizing its boundaries. The current fashion system is already recognized as no longer tenable,<sup>7</sup> so a recalibration of what it means for individuals and business organizations to exist within society, and society exists within the environment<sup>8</sup> takes sustainability from the margins towards a central tenet of fashion.

There is a clear tension between those seeking to sustain the current fashion system, with the economy at the centre of nested systems and those who explore fashion from an ecological and equity paradigm. However, in order for us to learn to live well together, we must all engage in transformation of our current anthropocentric behaviours. This framework embraces this tension, from ten years of research, education and business practice. This paper articulates the framework's dimensions and development, highlighting reflections and learning from its recent application as part of a free to access, online course: *Luxury Fashion in a Changing World (FutureLearn)*<sup>9</sup>. This has engaged more than 20,000 learners from 151 countries to date with learners from undergraduate to high profile fashion maisons.

## 3. A DESIGN FRAMEWORK AS NAVIGATION

FdFS acknowledges our biophysical limits and human equality at the core of thinking and practice. It recognizes interdependencies between people and nature's wider resources and activities in a dynamic, living system<sup>10</sup>. It embraces an exploration and understanding of design as personal and professional actions<sup>11</sup> and interactions of nature and labour. Thus, fashion pieces 'exist partly in relation to climate and partly in relation to social world and mediate between both of these things'<sup>12</sup>. Fashion pieces configure our relations, so designing is an agent of that configuration. We need to develop sustainability led selves and sustainability led products, services and systems.

Designing 'can cast ideas about who we are and how we should behave into permanent and tangible forms'<sup>13</sup>. These forms offer displays of the designer's activities and relationships, decided through decision-making processes that are based on a combination of values and access to knowledge and trusted sources of information<sup>14</sup>. 'Design's iterative, affirmative, reflective, practical and visioning skills as well as its position at the interface of producer and

3 Williams, D. (2018). 1990 – Present. In Ehrman, E. (Ed.) *Fashioned from Nature*. London: V&A Publishing. (pp.149-173).

4 *The Business of Fashion & McKinsey & Company*. (2016). *The state of fashion 2017*.

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6 <https://www.cusp.ac.uk>

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9 FutureLearn is an online learning platform [www.futurelearn.com](http://www.futurelearn.com)

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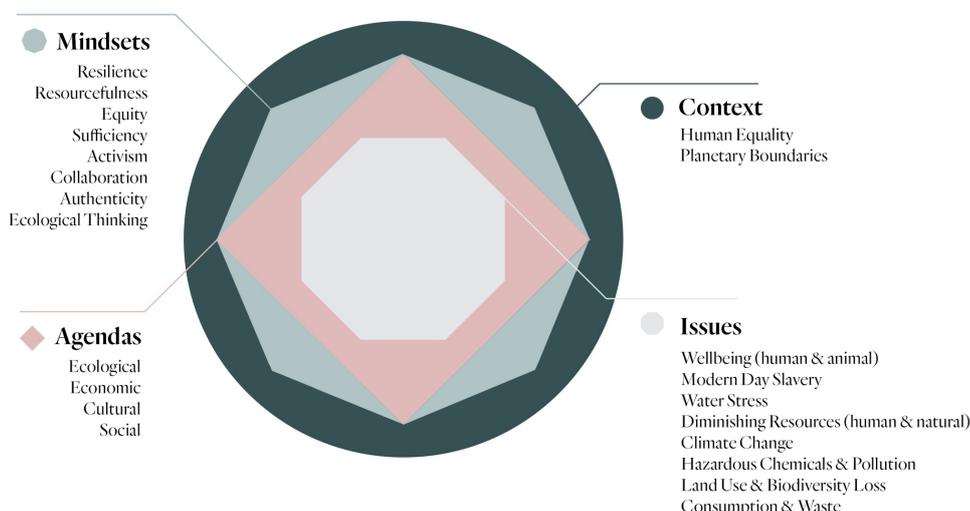
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consumer and technology and society<sup>15</sup> means that, as actions and ideas, it is well positioned to re-imagine fashion and to explore prosperity that can enable those designing in a professional and non-professional capacity to contribute to prosperity. To undertake such an expansion in thinking and practice requires a navigation system to embrace fashion's multifarious dimensions. In order to bridge the gap between an ecological paradigm and the current state of things, this framework offers a multi-dimensional navigation relating to a spectrum of circumstances, roles and timescales.

The framework has been created through an extended, cyclical period of research, prototyping, testing and review of teaching and professional practice, based on theoretical concepts of sustainability. Led by this paper's author, working with Nina Stevenson, it is informed by a range of participants from MA and BA courses, Non-Governmental Organisations (NGOs) and industry. Applications include a co-created course, developed with Kering, a world leading fashion business. Research has involved gathering qualitative data, via semi-structured face to face interviews<sup>16</sup> focus groups, longitudinal studies and participant reflections on personal and professional practice of a values led and knowledge-based approach to transform both the process and the products of designing<sup>17</sup>. It draws on seven pedagogic principles<sup>18</sup>, referencing Education for Sustainability<sup>19</sup>. To consolidate learning from this extended research process (2008-2016) into a more sharable form, the framework was tested in professional settings with designers, product developers, buyers and technicians and reviewed for validity and usability.



[Figure 1] CSF Framework (Williams, 2018)

Through a process of listening, defining, ideating, prototyping and amplifying, the framework (fig 1) opens up considerations of fashion's macro context. This includes a questioning of the errors of modernity perpetuated through a techno-optimistic, eco-efficiency approach<sup>20</sup>. It prompts engagement in a 'profound reappraisal of human values in today's society, a consideration of human meaning and connection to the locale, tradition, culture'<sup>21</sup>. Reflections on the context of designing are then applied into a set of agendas to apply values into tangible settings. Four critical, cross cutting agendas are mapped out and overlaid with personal experience and interests to identify points of intervention which participants can directly and indirectly affect. Whilst concepts such as the triple bot-

15 Fletcher, K., & Williams, D. (2013). Fashion education in sustainability in practice. *Research Journal of Textile and Apparel*, 17(2), 81-88. doi:10.1108/RJTA-17-02-2013-B011

16 Kvale, S. (1996). *Interviews*. London: Sage.

17 Williams, D., & Toth-Fejel, K. (2016). The will and skill of fashion design for sustainability. In Leal Filho, W., Azeiteiro, U.M., Alves, F., Molthan-Hill, P. (Eds.), *Handbook of theory and practice of sustainable development in higher education* 4(1),79-95. doi:10.1007/978-3-319-47877-7

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tom line<sup>22</sup> have informed these agendas, culture is a critical addition in terms of its leverage of change and the distinctive contribution that fashion makes to shaping and responding to culture and socially accepted practices.

Following an exploring of the wider systemic elements in designing, participants then approach current, urgent issues, identified in the framework. Whilst presenting themselves as critical considerations, they are seen as symptoms, rather than underlying causes of our current vulnerabilities. Learning from previous research, of the overwhelm that can be felt by taking on sustainability thinking, a range of mindsets were developed through review of student and professional projects. Each mindset is linked to methods and practices to espouse or try out.

#### 4. OPENING UP THE FRAMEWORK: FINDINGS AND LEARNINGS

Early iterations of the framework were delivered face to face with UK based participants. In order to open up the framework to a broader audience and to elicit feedback, it was adapted into a Massive Open Online Course (MOOC) format. Changes were made to the transmissive tendency of this format, to embed multi directional dialogues, through discussion threads, padlet boards and live debates. Extension of these interactions is encouraged into offline, geographically placed-based environments.

The discussion threads open on every step of the course enabling two-way listening and participation by tutors and learners. Anomised data relating to specific questions regarding change in self and in practice enables a rich and multifaceted understanding of this values-based approach. Thematic analysis of data from the first two runs of the course, used a manual approach and process described by Miles and Huberman (1994)<sup>23</sup> encompassing data reduction, data display, and conclusion drawing. Emerging themes have been identified, exemplified by representative evidence (italics).<sup>24</sup>

##### 4.1. THEME ONE: ENGAGING IN VISIONING OPENS UP AVENUES FOR CREATIVITY

Responses evidence an expanding of the role of fashion designing beyond that of the creating and acquiring of goods, towards a facilitating of prosperity in broader terms.

Sustainability is important for all of us, both for our lives and for our business, all it takes is a new way to approach things and ideas. It is an opportunity to add sustainability to the concept of valuable, of profit..I think we have the last chance to re-build our way to look at what wealth really means and includes.

Sustainability is important to me because it gives me a wide and long-term goal to reach, injecting energy and determination in my daily actions... it gives me the opportunity to contribute to a positive change that will last over me. It makes me feel as part of human kind.

This expansion of the definition of designing and of prosperity beyond a narrow focus on economic gain evidences a deep questioning, not only of the fashion system, but of wider societal infrastructures. It also suggests that participants are imagining ways to create change with fashion as a conduit, where sustainability acts to expand creativity.

##### 4.2. THEME TWO: EXPLORING VALUES ACTS AS A MEANS FOR DECISION MAKING

In the course, learners reflect on personal and professional values, combined with new knowledge. Questions relate to participant values as judgements based on a notion of what is good and what is bad.<sup>25</sup> Responses evidence a shift towards a rejection of elements of fashion identified as negative/ bad and towards an alignment with elements identified as positive/ good.

We have reached a point where there is no other way for us to see the future of fashion and of all the other sectors of activities without sustainability at its core.... Our job is also to make sure our passion and work does not inflict terrible consequences upon our planet, but on the contrary use them to make a difference and improve the industry and the society.

##### 4.3. THEME THREE: SUSTAINABILITY PRACTICES INVOLVE LETTING GO OF SOME CONTROL

The process starts with the meta narrative of fashion and then offers practical undertakings at personal scale to consider possibilities and contributions at micro scale. Findings reveal that this process of acknowledging elements within and beyond our direct control is important to grasp.

I am convinced that this framework is really useful and sets the basis to start reflecting on such a complex topic... It has helped me prioritize my concerns and rank them in order to select the ones that I most care about, although I would love to solve them all! The frustrating part is.... that one person can't take into account all the issues, but still must acknowledge them to go on with just 1 or 2.

..the framework is a good tool to start focusing on sustainability and directing efforts towards specific issues. Although.. it would be best if companies started off already with these values in mind,

22 Elkington, J. (2009). Triple bottom line. Retrieved from <https://www.economist.com/news/2009/11/17/triple-bottom-line>

23 Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Thousand Oaks, CA: Sage Publications Ltd.

24 All evidence taken from *Luxury Fashion in a Changing World* online course forum.

25 Veugelers, W., & Vedder, P. (2003). Teachers and teaching: Theory and practice, 9(4), 379. doi:10.1080/1354060032000097262 Carfax Publishing, Taylor and Francis Group.

#### 4.4. THEME FOUR: DEVELOPING CAPABILITIES IN SELF AND OTHERS

The framework-related activities in the course connects participants through conversation, group assignments, peer evaluation and sharing of visual and text-based materials. The discourse evidences capabilities of co-operation, openness and honesty about not knowing as well as sharing of knowledge. The data suggests an acknowledgement of the importance of such capabilities.

What I like most is the holistic approach of all this analysis. Every step and issue are interconnected and you can't work on one without considering the impact on the other.. This could be so powerful both for the workers and for the society.

By engaging in a series of feedback loops between values and actions, data suggests that participants can find their own ways through complex and sometimes uncomfortable considerations.

This framework gives me a better sense of where to start logistically in my own work. It has allowed me to breathe life into the solutions I have found within my manifesto, and reduces the mental stress that comes with carrying the weight of climate change and inequality around in my day-to-day life.

### 5. CONCLUSION AND NEXT STEPS

If we are to live within biophysical limits and to reduce the wealth-poverty gap, there is a need to deeply change our own behaviour and enable greater equity in our communities and societies. We need to re-align ourselves in a more balanced interaction in nature, the life system in which we are a part. This framework offers ways towards such a re-balancing through fashion designing.

I feel so much more equipped to function as a designer with the underpinning of the CSF framework and all the valuable knowledge gleaned.

From data gathered in a post course survey of 136 respondents, we sought to establish the extent to which engagement in the framework could evidence change in personal perspective and professional practice. The results are encouraging. 81.18% – The course content was relevant to my profession or field ; 77.65% – I gained knowledge or skills relevant to my profession or field by taking the course ; 48.24% – My perspective has changed as a result of taking the course.

The overall findings from this research progresses an ambition to further apply this framework. It is, however, important to acknowledge its limitations. It seeks to contribute to a wider challenge between an ecological, participatory, equity-based model and the increasingly mechanistic, growth driven focus of both education and business practice. The framework must be at once inclusive and decisive. It cannot compromise on its aim to invert a fashion system based on limited and untenable view of success towards a system that balances a range of elements in prosperity.

Sustainability simply means 'chance for future' to me and therefore it's extremely important to my own practice.

This paper sets out a framework for FdFS education and industry practice. The ecological, participatory, transformative basis of this framework is broadening fashion's possibilities. Sustainability involves a multifarious range of concerns, activities, approaches and discussions. 'It should be considered in the context of the development of human ideas'<sup>26</sup> and 'the sense that what isn't yet could be'<sup>27</sup>. Such possibilities could and should not be limited by a single, or even multiple frameworks. However, it is only through exchange of ideas across sectors that designing beyond an anthropocentric, myopic view can expand. There is a vital in 'bringing intentions into actions' by creating and 'using professional tools to enable people to make things happen'<sup>28</sup>. There has never been a more vital and critical opportunity to engage a range of participants from around the world in a transformation of the fashion system. In sharing the construct of this participatory framework, it is hoped that it can contribute towards a re-defining of what it is to be human in 21st century. Let's not sustain unsustainability!

Thank you CSF. You have changed my world and way of thinking.

Findings from this research indicate that the definition of prosperity outlined at the start of this paper is within our grasp 'We, as agents and actors, make ourselves in the world that makes us and in so doing, contribute to the making of a world that makes others'<sup>29</sup>. This will only be realized if and when we create, share and apply frameworks and a multitude of other ways, to guide us towards ecological and equity based knowing, doing, being and learning to live together in the world.

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## A DIFFERENT DEFINITION OF GENERATIVE DESIGN

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### ABSTRACT

There are different definitions of “generative design”, but this research is focused on the role of generative design to support and provoke creative thinking; it means, as a developer of a common language that everyone can use to express their ideas —“everyone” includes all social stakeholders, even whom Ezio Manzini calls “diffuse agents” or those who experience the problem and for this reason become a fundamental source for the creation of possible solutions.

An important fact to consider is: creativity does not happen inside a person’s head but in the interaction between a person’s thoughts and a socio-cultural context (Csikszentmihalyi, 1996); as Sanders (2001) has stated collective creativity can be very powerful and can lead to more culturally relevant results than individual creativity does.

Here relies the importance of studying this perspective as an important piece of sustainable development, which “embodies integration, and understanding and acting on the complex interconnections that exist between the environment, economy, and society ” (Drexhage & Murphy, 2010).

Key Words: Social innovation, design research, generative capacity, creative thinking.

## 1. INTRODUCTION

There are different definitions of “generative design”, but this research is focused on the role of generative design to support and provoke creative thinking; it means, as a developer of a common language that everyone can use to express their ideas —“everyone” includes all social stakeholders, even whom Ezio Manzini calls “diffuse agents” or those who experience the problem and for this reason become a fundamental source for the creation of possible solutions.

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The proposed approach take advantage of creative and innovative ideas that come from the most unexpected quarters: Insights emerged from common people. This shift demands a need (for designers) to nourish our “expert” mindset with “participatory” skills.

A previous advance of this research topic has been presented last year in Barcelona through the paper *Generative Design as a Tool for Social Innovation: A Methodological Approach* developed by Cruz, A., & Cortés, E. (ICDHS, 2018). The contribution of this paper is to explore experiences in order to open the discussion about important elements for facing systemwide projects, because as Findeli has stated design far from being responsible for solving linear problems, is responsible of proposing alternative systems to the existing ones. Remarking as one of the most relevant elements: generative design, applied to the creation and modification of rules or systems that interact to generate the finished design autonomously. The difference of designing this mood relies on mastering the relation between process specification, environments, and generated solutions.

## 2. DEFINING GENERATIVE DESIGN

“Generative design” from a theoretical-methodological point of view is a proposal that starts from the morphological processes in design as a fundamental unit of study, which usually is synthesized in a set of detailed instructions to determine the design shape and ends at unpredictable results (Casonato, 2012), depending on the context results can be:

- 1). a morphogenetic process that uses structured algorithms as non-linear systems that seek endless, unique and unrepeatable results generated by a code as in nature (Soddu, 1994 in Agkathidis, 2015), or
- 2). a process of design driven by geometry.

However, a totally different concept of generative design, defines it as a source that enables the collective, inclusive and horizontal creation - a “rhizomatic” approach (Deleuze and Guattari, 1980)—. This perspective include all the stakeholders involved at development of artifacts and interactions, in order to support or improve their ability to “generate”.

Professional design practice today involves advanced knowledge. This knowledge is not solely a higher level of professional practice. It is also a qualitatively different form of professional practice that emerges in response to the demands of the information society and the knowledge economy to which it gives rise (Manzini, 2015), and also given the possibilities that the latter open. We are experiencing a constantly changing situation, therefore we cannot understand knowledge as a body of “finished knowledge”. This would result unproductive; we need ductile and adaptable knowledge, nomad or rhizomatic<sup>1</sup>, but above all cumulative<sup>2</sup>, nowadays knowledge should be built from a number of intertwined processes and stakeholders.

## 3. GENERATE = CREATE

Design is not just about visualization and the application of individual creativity anymore. The problems that designers are being invited to help identify and solve cannot be addressed by individuals, no matter how smart or creative they are, the situation so far is too complex. We face significant challenges since the problems are wicked and the new landscapes and boundaries of design are fuzzy. But we can address the challenges of wicked problems and fuzzy pathways through collective forms of creativity and generative design thinking (Sanders, 2012).

It turns out that creativity is not some rare gift to be enjoyed by the lucky few—it is a natural part of human thinking and behavior (Kelley, 2013), generative design approach works on how to encourage this human ability among system stakeholders, using skills and tools.

The importance of creativity for generative design is essential. We need to help people rediscover and boost what they already have: the capacity to imagine—or build upon—new-to-the-world ideas. But the real value of

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1 Deleuze and Guattari use the terms “rhizome” and “rhizomatic” to describe theory and research that allows for multiple, non-hierarchical entry and exit points in data representation and interpretation.

2 Increasing or growing by accumulation or successive additions.

creativity doesn't emerge until you are brave enough to act on those ideas. That combination of thought and action defines creative confidence: the ability to come up with new ideas and the courage to try them out (Kelley, 2013).

An example of this creative confidence can be seen in grassroots innovations which involve improvements on traditional practices, resources or skills, and traditional ways of knowing and experimenting.

Due the complexity of the faced problems, multi, inter (Manzini, 2015) and non-disciplinary teams are required (Diseño Detonante, 2018): we need people enabled with skills for crossing boundaries<sup>3</sup>, it is not only important to empower professionals, but the entire social body to work, listen and learn from each other while considering alternative scenarios as design tasks (Manzini, 2003).

Lined up as a result, and given the urgent need to conform specific forms of design understood as a know-how, participating in the complex chain of social innovation process.

### 3.1. Tools for Creation

For generative design is suggested that tools have to be shaped cooperatively, the exchange of ideas, instruction, experience and sometimes scolding for not listening carefully must have become imperative. Gestures, sounds and slowly, words began to be formed. Sharing one's learning with others is done not just through oral or textual language but also artistically. Feelings became art. When feelings had to be understood even without explicit articulation, one needed to develop intuition (Gupta, 2016).

Through the use of transdiscipline<sup>4</sup>, tools have been developed, an example are tools used by Raumstrategien (Spatial strategies) a German Master of Arts- programme that emerged from the vision of an artistic and urban design practice that acts on city space and explicitly promotes interdisciplinarity. One of these tools is senses mapping [Figure 1], a tool that combines observation, field immersion, sensory ethnography and graphic thinking, the aim of this tool is to develop intuition and capture a holistic view for first stages of field research.



[Figure 1] Senses mapping. Developed at PULI 002 project workshop. 2018

An insight— related to this topic— to remark is that analogue tools are more efficient at collective projects, because there is no need of a previous technological training, nevertheless, this does not eliminate the support of the latter, since they can be more rigorous and may strengthen the process from designers role.

We must imagine how we might create highly flexible, constantly evolving systems in which any exchange between participants is an opportunity for empathy, insight, innovation, and implementation. Every interaction is a small opportunity to make that exchange more valuable and meaningful for all participants (Brown, 2009) and, therefore, an iteration towards collective improvement.

Empathy or, the feeling that you understand and share another person's experiences and emotions, has become one of the top must-have soft skills for success in workplaces. Although contrary to the traditional competitive environment that has been the culture of many workplaces, empathy is unarguably necessary to create teamwork and collaboration. Empathetic people are more likely keep an open mind to others' ideas. As a consequence, empathetic leaders will also ignite creativity and innovation.

It is important to emphasize that deep empathy in the context of the design attitude is not simply a tool, an off-the-shelf methodology or a quick-fix consumer observation. It is a deeply held belief and an embedded practice that runs through the core of how projects are carried out and how decisions are made (Michelewski, 2016), empathy stands at the basis of collaboration.

### 3.2. Collaboration

Collaboration is a system of beliefs embedded into the culture, the minds, the tools of a (design) team to yield better work more effectively (Brown, 2013). Multiple perspectives will obviously offer several possibilities to enhance any process.

<sup>3</sup> Related to sharing the global knowledge and the global responsibility (Swäbisch Gmünd, Cumulus working papers, 2007).

<sup>4</sup> Transdisciplinarity connotes a research strategy that crosses many disciplinary boundaries to create a holistic approach. It applies to research efforts focused on problems that cross the boundaries of two or more disciplines.

In different parts of the world, despite the efforts made to exclude certain sections of society from access to collective pool of knowledge, there has been a tradition to share knowledge openly (Gupta, 2016). Actually, there is an increasing interest of people to (re)discover the power of collaboration to augment their capabilities, and how this (re)discovery gives rise to new forms of organization and new artifacts on which they base enabling solutions (Manzini, 2015).

Nowadays grassroots organizations are becoming more open and flexible, consisting of differently motivated people: they are evolving into collaborative organizations. Larger groups of people are thus being asked to cultivate their design capacity, and becoming more competent in doing it. That is, they are adopting a design mode that can be defined as diffuse and competent design (Gupta, 2016). In fact they are not only proposing unprecedented solutions to complex problems, but are also generating new ideas (new ideas of time, place, relationships, and work) that are the cultural dimension of the actions they have taken to live and produce in more a sustainable way (Manzini, 2015).

An interesting concept aligned with these transformations is collective intelligence, which can be understood as a group of cognitive attributes that are shared by a collectivity and that allow to diminish uncertainty towards a problem or respond to the need of innovation through a series of practices.

According to Levy (1999), collective intelligence :

- c). is distributed everywhere so it is not exclusive of one particular type of knowledge or sector;
- d). is valued constantly so ignorance or contempt of other knowledge requires constant recognition and appropriation;
- e). is coordinated in real time which implies constant adjustments of communication supported by all kinds of technologies, allowing collectivities and individuals to coordinate interactions; and
- f). allows effective mobilization of competences on each of its members recognizing them on its widest diversity.

This is relevant as it emphasizes collaboration to benefit and empower the collectivity rather than individuals.

Empowerment is defined as where people, organizations and communities have control over their affairs (Rapoport, 1987), one of its attributes to take into account is that communities seeking to empower themselves can build active citizen participation by welcoming it, creating valuable roles for each person to play, actively reaching out to build inclusive participation, and creating and supporting meaningful volunteer opportunities (Sanoff, 2006).

#### 4. CONCLUSIONS

Society becomes a laboratory and a communitarian organization that testifies in favor of vernacular culture linked to the present and to its constant transformation where ideas and practices emerge as knowledge; this represents the inclusion of daily ways of doing and thinking to design ideation.

Recognizing generative design means its democratization, since it also recognizes daily and empirical practices through which people give their own meaning to the world, to things, ideas and actions that are found far from a passive consumption, and that prefigure the recognition of knowledge that exceeds disciplinary conception.

The design has opened gaps, and has become a shared informed language among stakeholders involved in projects to develop. For the latter, we must use the joint generative capacity, in order to build and push beyond these languages in common, to increase ownership, cultivate empathy and exterminate indifference among communities.

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## **SUSTAINABILITY AND DEMOCRACY WIDESPREAD COLLABORATIVE DESIGN INTELLIGENCE**

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### **ABSTRACT**

The transition towards a sustainable society is a long, wide, contradictory learning process that involves the whole society. In this framework, the paper introduces and discusses these main ideas: (1) democracy, by its very nature, is the political regime in which learning processes can happen at best. (2) The search for a democratic regime converges with the one for distributed socio-technical systems. (3) To be conceived and put into practice distributed systems require the existence of widespread collaborative design intelligence. (4) Design experts can support all this bringing in the process co-design tools and visions.

Key words: transition, democracy, design, distributed systems

## INTRODUCTION

Should a sustainable society also be democratic? Should a genuinely democratic society also be sustainable? Can design help in connecting the search for sustainability with that of democracy (and vice versa)?

I will try to answer these questions by articulating some ideas that derive from my experience as a designer and researcher in the field of social innovation for sustainability. This practice brought me to recognize the existence, and the growing role in a connected fast-changing society, of *diffuse design* (practiced by different social actors - Manzini, 2015) and their interactions with the design experts (those who have been formed as professional designers and/or researchers in the field of design). Of course, to understand these interactions, and enhance their potentiality, the profile of the design experts must be updated considering how it changed in the past two decades - Buchanan, 1992; Cross, 2011; Brown, 2008).

What I intend to support with this article is that, together, design experts and other design-oriented actors can create competent and collaborative networks (the designing coalitions – Manzini, 2017), capable of taking steps towards sustainability and, at the same time, regenerating democracy. And vice versa<sup>1</sup>.

However, before tackling this issue, in order to reduce the risk of misunderstanding, it is useful to focus on two terms that form the basis of what will then be proposed. They are: transition and democracy. Obviously these terms refer to complex topics on which the discussion is still open (and on which there is a boundless literature<sup>9</sup>). Therefore here I will report only few points, just to make clear how in this article they will be interpreted.

## TRANSITION (TOWARDS SUSTAINABILITY)

We are already living in transition phase: the XXI Century sees all of us catapulted into a risky, turbulent and complex reality to be understood as a mesh of long lasting crises (the crisis of all the XX Century social, cultural and economic models. My main reference here are: Stiglitz, 2015; Chomsky, 2016; Harvey, 2017) and/or as a broad contradictory transition towards a new form of society. Hopefully, a sustainable one (see, among the many possible references: Irwin, 2015; Eriksen, 2016; Manzini, E., M'Rithaa, 2016).

Given all that, contemporary society can be seen as a huge future-building laboratory where everything that belonged to the mainstream way of thinking and doing in the XX Century is changing and will change: from everyday life and the very idea of wellbeing, to the large socio-technical eco-systems in which they exist. The problem to be asked is: where these changes will lead us? We all hope to be lead to a sustainable society. But, unfortunately, this is not the only possibility: on-going changes can also lead to ruinous disasters or forms of environmental sustainability that are fragile, incomplete and unacceptable in their social and political dimension.

Therefore, the first clarification I have to make is this: from now on, I will use the term “transition” in the sense of a systemic evolution towards sustainability. But, it should be remembered that this is only a possibility: an outcome to be made concrete with our collective design action. And it is precisely on this emerging wide demand for design that I think a second clarification is necessary: the transition we are talking about refers to a highly complex system. More precisely, to an ecosystem whose complexity cannot be reduced. Thus, in fact, this transition cannot be imagined and directed by a single subjectivity, however powerful it may be. In other words, transition requires design action, but there is not and there cannot be an omniscient and super-powerful entity to guide it. Therefore, it must be seen as a social learning process driven by a very special form of collective intelligence: widespread design intelligence integrating the contribution of both diffuse and expert design. And here the theme of democracy comes into play.

## DEMOCRACY (A REGIME CAPABLE OF LEARNING)

By saying “democracy” I mean a political regime characterized by a balance of powers between institutions and by the dual tension towards the values of freedom and equality. A complex political system that, in fact, would be best defined as an ecosystem (Spadam Allegretti, 2016): a democratic ecosystem in which different forms of democracy coexist (traditionally we have had representative, direct, council-based and participatory democracy; today, other forms are emerging - Kataja, 2017; Simon, Bass, Boelman, Mulgan, 2017).

The problem is that for several reasons, at the moment, in many parts of the world this whole democratic ecosystem has been hit by a deep crisis and/or is under attack. One of the arguments to criticize democracy is intertwined closely with the theme of transition (on design and democracy in the transition phase, see for instance: Bonisiepe, 2006; DiSalvo, 2010; Margolin, 2012; Ehn, Nilsson, Topgaard, 2014; Manzini 2018).

By its very nature, democracy is the terrain of consensus building and commoning, both time-consuming processes. It is also the place of conflicts and mediation, and thus of time-wasting, if time is considered only in terms of technocratic efficiency.

Given that, nowadays, it seems to many that this intrinsic viscosity of democracy is in stark contrast to the urgency of the issues we must and will have to deal with, and therefore with that of the seemingly urgent need to make

<sup>1</sup> This paper background is more extensively proposed in two books: Ezio Manzini, *Design, When Everybody Designs* (Cambridge, MA: MIT Press, 2015) and Ezio Manzini, *Politics of the Everyday* (London: Bloomsbury, 2019).

strong, rapid decisions. This is giving rise to growing support for authoritarian forms that in the name of efficiency are prepared to sacrifice the fundamental principles of liberty, equality and the balance of powers.

In my opinion, these proposals, and the way of seeing things from which they derive, are wrong. And this not only for ethical reasons, but also for a very practical motivation: in the transition to sustainability, the authoritarian choices do not work. In fact, they do not create resilient societies, they do not release available social resources and, finally, they do not learn from experience. On the contrary, democracy can do that.

First of all because, accepting and cultivating diversity, it is able to bring out alternatives in moments of need, acting as a resilient system. At the same time, because it is by nature open and tolerant, it can liberate the creativity, skills and, at the end of the day, the project-making ability with which human beings are endowed (Dewey, 1903, Donolo, 1992; Manzini, 2018). Furthermore, and for the same reasons, it can enhance their ability to weigh their experiences and, when confronted with evidence and/or convincing arguments, to change their idea, or produce a new one and thus create knowledge. In other words, a well-functioning democratic regime is as an environment where ideas and experiences of small groups can develop and be transformed into values and behaviors shared by the whole community. In turn, these shared values and behaviors can become common goods thanks to which new ideas, new projects and new democratic practices can emerge and flourish.

Because of this, democracy is not only a neutral tool for social conversation. It is also a regime capable of learning. And, doing so, capable of creating the widespread design intelligence needed to support and orient the social learning process we are talking about here.

Therefore, given the urgency of accelerating the transition, there is no doubt that something must be quickly done. But, in my opinion, there are no technological and authoritarian shortcuts. What needs to be done is to regenerate democracy and its way of functioning by conceiving and implementing democratic experiments (Kataja, 2017; Binder, Brandt, Ehn, and Halse, 2015; Bertolotti, Tassinari, 2017), which should be, at the same time experiments of sustainable ways of living.

## **DISTRIBUTED SYSTEMS FOR A REGENERATIVE SOCIETY**

After many years of research and experience on the subject of sustainability, many issues are still quite open. However, some others seem sufficiently consolidated. In my opinion, the first of these is the following: sustainable societies can be many and varied, but all must be based on socio-technical systems capable of being resilient and symbiotic with the natural ecosystems in which they are located. To move in this direction, a paradigm shift must take place in the way these systems are conceived and the direction we try to make them evolve.

In fact, it is necessary to pass from the centralized hierarchical systems prevailing today, to distributed systems: socio-technical systems consisting of a network of interconnected, but relatively autonomous elements (Murray, 2009; Biggs, Ryan, Wisman, 2010; Diez, 2018). And it is necessary to move on from the search for pure economic efficiency (on the basis of which a socio-technical system seems to evolve positively even when this implies unsustainable consumption of environmental and social resources), in the search of eco-systemic improvements (which, by combining socio-technical systems with the natural ones, guarantee the quality of the first, the regeneration of the latter, and the resilience of the whole).

It must be underlined that the distributed systems of which I speak here are far away from the repetition of the autarkic models of the past (the quasi-closed local economies of the villages). They are, in fact, virtuous applications of the current scientific and technological possibilities: digital networks and higher connectivity; miniaturized mechanical devices and new manufacturing possibilities; renewable energies and intelligent grids; ecological solutions deriving from physical, biological, agrarian sciences advancement. Finally, but not less important, distributed systems are also the result of the social innovations that have characterized the last decades (Murray, Caulier Grice, Mulgan, 2010), proposing radically new ways of thinking and doing (to which we can more precisely refer with the expression transformative social innovation - Transit, 2017).

Given that, if we observe reality carefully with all its contradictions, we can see that dominant as the centralized system model still is, there are also powerful counter tendencies: renewable energies, which are strongly inclined towards distributed systems by their very nature, are the most evident example (Vezzoli, Ceschin, 2018). Food networks, with the diffusion of their locally based production and consumption systems, are another one (Meroni 2018). The makers' movement and the new digital craftsman are experimenting the potentialities of distributed manufacturing (Diez, 2018, Maffei, 2013). Several examples worldwide show us the possibility of creating symbiosis between natural and sociotechnical systems, developing bioregional projects (Thackara, 2015). All these cases prove the practical feasibility of distributed systems and indicate their convergence with the idea of regenerative economy: an economic system that is inherently sustainable because, instead of consuming environmental resources, it regenerates them.

For my part, on other occasions (Manzini, 2010), I have talked amply about these systems and the scenario deriving from them (which I called the SLOC scenario, where SLOC stands for Small, Open, Local, Connected): a scenario in which the socio-technical systems, being distributed systems, can optimize the use of local resources, reduce the intensity of transport (of people and raw materials, semi-finished and finished products), locally create forms of industrial ecology and apply the principles of circular and regenerative economy in a non-trivial way, creating symbiotic relationships with the natural ecosystems in which they are found.

It follows that precisely because these systems redistribute complexity in their nodes (Murray, 2009), they can cultivate diversity and a (relative) autonomy of their different parts. And, for this same reason, they also behave as resilient systems (as opposed to centralized and hierarchical systems that, by their very nature, are intrinsically fragile). Finally, by operating in this way, distributed systems also produce favourable contexts for the regeneration of democracy.

### **DISTRIBUTED POWER FOR A PARTICIPATIVE DEMOCRACY**

If democracy means also that people should have power to decide what to do, there must be themes on which they can take decisions, and arenas in which this can happen. That is, they should understand them, know what to do and how, have the capability and power to implement what they have decided. The pre-condition for this to happen is that the systems with which they interact have (also) a local dimension.

This is exactly what happens with distributed systems. In fact, they offer different social actors the opportunity to focus on common goals and form decision-making and project-centered networks (Latour, Weibel 2015; Ehn, 20008). Doing so, i.e. in returning a certain quota of power to local communities, they generate opportunities for democracy regeneration, at its deepest roots. For example: local agricultural-food networks that connect citizens and farmers, as in the case of community-supported agriculture; local production chains that connect farmers, producers and processors, distributors and consumers of some food products; energy networks in which groups of users and technicians are associated for the production of renewable energy; local associations for the water in which the inhabitants of the same water catchment create a coalition for an optimal use of the waters. The examples could continue, but let's stop here.

If, how and how distributed systems will mature and spread, and if, how they will contribute to the regeneration of democracy, it will depend on a combination of factors. Among these, the most crucial will be the attitude, choices and abilities of potentially involved people.

### **WIDESPREAD DESIGN INTELLIGENCE**

The development of distributed systems is certainly a huge field of activity for design, both diffuse and expert. It is a matter of co-designing and co-developing a new generation of products, services, communication systems, suitable spaces, and different types of distributed infrastructures. For this to happen, a large number of people should recognize their value (and the one of the sustainable and democratic society they make possible), be motivated by this recognition and, most importantly, be able to play their part using at best their design capabilities.

In the face of all this there is also a new role of design experts. Beyond conceiving and developing products, services and infrastructures for these distributed systems, they should also help other social actors in building shared images on what to do and how. And, from here, in forming collaborative and competent coalitions capable to make them real.

The by now long experience in the field of design for social innovation and co-design can help by making numerous tools available for triggering, supporting and orienting these widespread co-design processes. These tools should be brought to a wider public, making them more accessible and easier to use, and hopefully become part of the normal basic culture of citizens (see, for instance: Hillgren, Seravalli, Emilson 2011; Selloni, 2017). In addition, since every design activity is not only a question of tools, but also of ideas, values, knowledge, critical sense and creativity, it is necessary to develop some basic competence along these lines too. In other words, people also need cultural tools that enable them to recognize the current problems and opportunities, and to imagine possible futures (other than those normally proposed). Therefore, it seems to me that collaborating to weave these competent networks is today the main task of the designers.

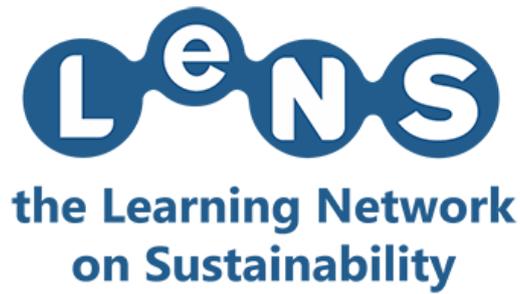
Indeed, these networks, of which today we observe the first signs, indicate the emergence of the widespread design intelligence that has been proposed at the beginning of this article, speaking of transition as a social learning process.

Of course, today they are still the expression of active minorities. But their current status should not discourage: collaboration, expertise and design skills, which are ultimately the most important resources for creating a sustainable and democratic world, are potentially abundant. What needs to be done is to co-create an environment in which this potential can be translated into reality. Which is possible, but, unfortunately, not so simple.

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## **UTSTAL: HEADING HEARTS AND JOINING COMMUNITIES**

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### **ABSTRACT**

Utstal is a service system within Zotut'ha, a community based on permaculture located in the town of Sotuta, located in the jungle area of the state of Yucatan, southern Mexico. It seeks to generate income and the union of communities through a service that helps people heal heart wounds created after a love break, through a series of specific activities of the place and that help generate a bond between the communities and the visitor.

Key Words: Communities, Service, Human Centered.

## WHAT?

In 2017, we will carry out a service system that involves a community and a locality with the visitors in order to generate economic means that help to maintain the internal activities of the community.

## WHO AND WHERE?

### **The town of Sotuta and the community of Zutut'ha**

**Sotuta:** Sotuta is populated in the center of the state of Yucatan, southeast of Mexico. It has approximately 5000 inhabitants. Although most of its economy is local, some of its inhabitants are engaged in the sale of honey melipona (which is obtained from the melipona bee, the endemic species and the difference of traditional beekeeping, there are no bee farms and The properties of honey The only information that is given in the same type The help of the rapid healing of wounds and the healing of diseases of the liver and kidneys, the sale of handicrafts and agriculture, although this one is very limited to the characteristics of the area where you can have long periods of sequence. The area is recognized by visitors for its large number of cenotes and be surrounded by jungle.

**Zutut-ha:** It is located approximately 30 minutes from the town of Sotuta. It includes an estate of several hectares where the community coexists. Although its population is very minimal (2 to 3 people), it has a large population within social networks. His community system is based on Permaculture. (Permaculture is born from the need to create communities and self-sustainable ecosystems, which means a social, economic, political and ecological benefit of the place). learn or apply new learned methods of permaculture.

The monetary resources for the maintenance of the community are born from the voluntary contributions of the visitors and some contributions from the private sector. Although research has been sufficient to sustain the community so far, the lack of economic support has slowed the growth of long-term projects.

## WHY?

Although it has the economic resources to continue with the community of Zututha, the lack of time and spaces for the realization of new activities, economic growth and self-sufficiency of this. That is why we seek a way to obtain economic income in the community without spoiling the daily work of this.

## HOW?

We generate a System-Service that helps to attract people with interests in the learning of permaculture, the nature and the knowledge of the Sotuta population, generating a fraternal bond between Zututha and Sotuta in which the two parties' benefit.

## VISITOR PROFILE

Tourism in Zutut'ha was invasive. That's why we looked for it not to be a tourism. We look for the profile of our end user to be special. We think of many alternatives and thanks to a series of talks and talks that reach our final user.

## FINAL USER

Person older than 23 years with economic solvency. He lives and works in the city and recently he has had a loving relationship that has prevented him from carrying out a life with the tranquility with which normally. Find a place to help you heal your love break and at the same time learn from yourself to overcome it.

## FINAL ANSWER

### **Utstal**

Utstal, which in Mayan means sanitation, is the name of our system-service that consists in helping the visitor to know himself in order to achieve a sanitation faster than the rupture of a love relationship. It is a means of "spiritual retreat" in the community of Zututha and that, in collaboration with residents of Sotuta, a closed system of aid is generated and not only for a part. The system is divided into several phases where the end of this is sought, you see an improvement in the internal health of the visitor.

### **First step: Trip**

The trip corresponds to the visitor's part, but the moment it arrives or arrives at the bus station of the city of Mérida, it is time to be sent to a representative of the community. Will use in some subsequent activities.

### **Welcome Kit**

The kit consists of a stuffed toy made by the residents of Sotuta. The mascot of the service was created in order to generate empathy between the visitor and the place. The mascot is called MELVI and it is a Melipona bee (an

endemic bee from the stingless area, which is why it is incapable of harming anyone, hence the philosophy of the workshop, where no harm will be caused to anyone. generates honey melipona, where some of its characteristics were mentioned previously), a booklet of activities, shirt, hat, keychain and jar of honey melipona.

When all the members of the retreat get together, they proceed to the transportation to the community of Sotuta where they are received by inhabitants and they are offered typical food of the region. In the afternoon a first encounter with the community of Zutut'ha is generated and a small introduction to permaculture is given. At night the first healing activity is performed: Letter to myself. The letter consists of writing how they feel, why they are there, what they hope to heal, and why they want to heal. It is a completely personal letter and helps to contact the retreat. Afterwards, we go to the campfire where people can write everything they have not dared to say or feel on paper. At the end of the activity they commit to throwing it to a bonfire in order to get rid of that grudge forever.

### **Second day**

With the help of members of the community, there is a morning yoga class followed by a walk through the caves of the region where you will have some time alone for internal reflection. Although all the participants will be in the same place, it is important that they look for a time alone to be able to feel themselves. After the activity in the caves we went to a moment of fun with the visit to the cenotes where you can get in free or cross practice slackline with advice from members of the community.

By belonging for a moment to the community, visitors will also be part of their own activities so they will be taken to the fields to harvest some fruits and vegetables so that, among all, the food consumed that day will be prepared. This activity will help the group's integration and to meet new people within the retreat. In the afternoon they will have free time of exploration, either alone or in a group and, at night, with the help of people attending the workshops held in the town, a sensory theater play will be presented in the darkness where the attendees will have to be focused on themselves to be able to attend to what happens outside of them.

### **Third day**

In the morning, there will be a walk along the path that connects Zutut'ha with Sotuta to explore endemic birds. A quick bird photography course will be given and a manual of birds that can be found along the way will be delivered. Upon arrival in the town, they will be welcomed by beekeepers who will teach the process of obtaining melipona honey, its properties and its cultural importance in the region. Later they will be given an express workshop of growing vegetables in small spaces looking for what they learned to replicate in their places of origin. At the end of the workshop, you will go on a guided tour of the town counting the uses and customs, as well as the legends of the place. This will help reactivate the interest of the transmission of customs with all the inhabitants. At the end of the tour you will visit a workshop of artisans in the area and a demonstration of honey melipona collection. In the afternoon, there is a return to Zutut'ha where a handbook of follow-up of the retreat will be given where advice of what to do in case of not feeling well, who to ask for help or what to do in spare time is added. The final activity of the retreat is to write another "Letter to myself" explaining how they feel after having attended the retreat and what changed with the activities they did.

### **What are we looking for?**

We seek to obtain monetary resources in the community of Zutut'ha without interfering with the normal activities of the community, in addition to further interweave the ties that exist between the community and the town of Sotuta, seeking the generation of joint activities that are beneficial for both parties in the same proportion, generating jobs, social cohesion and cultural transmission not only between them, but also with visitors. In addition, we seek that people with an emotional blip can overcome it in the friendliest way with the help of unique and unrepeatable activities.

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## **SUSTAINABLE DESIGN AND AESTHETICS IN THE SOFT SCIENCE AGE**

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### **ABSTRACT**

The research analyses the new aesthetic sensibility that arises with sustainable project, in order to answer more specifically the following questions: what influence does the culture of sustainability have on the aesthetics of contemporary design? What are the future directions of the design project in relation to the possible declinations of the relationship between ecology/aesthetics/technology?

The post-Darwinian idea of evolutionary pluralism influences sustainable design, with significant implications in our times from the point of view of the variety of methods, technologies and aesthetic parameters (Ceruti, 1986). The idea of a one-best-way project is extraneous to the logic of design for sustainability. Eco-sustainable design is expressed above all as a variety of strategies, an open codification of ways to travel and experiment through the project. The contribution investigates the relationship between sustainable design, aesthetics and technological imagery, to arrive at a critical analysis of a series of design aesthetics in a context such as Anthropocene.

Key words: Aesthetic; Sustainability; Contemporary Design; Anthropocene.

## 1. A LIGHTER WORLD, WITH A DEEPER MATERIALITY

The “product in its environment” is the study unit of sustainable design, an articulated and changing scenario according to the point of view we take and that makes impossible any monological approach to the aesthetic dimension, implying a plurality of paradigms. The general question we can ask ourselves is: what awareness of the reality of nature is now widespread among designers and in society? At the same time, which imaginary of nature, explicitly or partially unconsciously, leads the work of a designer?

Sustainable design is based on a culture, both technical and humanistic, that refers to specific imaginaries linked to the artificial and to nature. This reserve of imaginaries, partly explicit and partly accumulated in a subliminal dimension, triggers its inventive energy starting from the emerging conditions of our post-industrial age. An age strongly characterized by the emergence of two “sweet sciences”, the living sciences and the information and telecommunication sciences (Serres, 2016), which influence our perception of the future in a positive way.

The alliance and conjugation of these two different sciences brings with it the double promise of a lighter world on the one hand, and a world with a deeper materiality on the other. We are able to demonstrate and explain this affirmation by observing concretely in the field what the world of contemporary design is doing.

In the industrialised West, Nature is increasingly being proposed as a “commodity” to be purchased, in some cases at a high price and to be used in special privileged places. Any experience, any item can find its own form in a heteronomic way, in other words if it is considered and sold as a commodity. The beach, the trees, the healthy food, the clean air - Nature in different shapes and packaging - is now offered to us, in the version of “product” or “experience” to buy: the access to natural “oases”; the travel and the stay; the guided tours; the organic food; the ecological products for personal care or home. Nature becomes a “surplus” that the object or experience can contain. The adherence to this model supposes that we perceive our environment as contaminated, and we are constantly looking for ideals “natural islands” that remove us from this condition. In fact, the most compelling attempt is to transform ourselves, our own body in the first place - and the surrounding environment immediately afterwards - into an “island”, a reality as uncontaminated as possible. But this happens in an age like ours, called from a geological point of view Anthropocene and that reveals an over-exploited planet where there are no paradisiacal islands or unpolluted places because they are subtracted from the human alteration.

At the same time, nature should not be seen as a playground for the weekend, a guided educational trail, a place to organize safe and sterilized visits, a corner increasingly narrow and remote to be searched when possible, as if it were, paradoxically, yet another artificial spectacle. Nature is not ahead or around us, but simply we are the Nature: it is the only reality we have and of which we are constitutively part. (Henderson, 2018). On the basis of what has been illustrated, we understand the cultural value of the eco-sustainable project, the scientific breakthrough of which it is the result and its essential contribution to the construction of the future. Introducing the concept of the product life cycle analysis (LCA), which seems more like a technical methodology, the time-dimension of the project comes into play. (Vezzoli 2016). At the roots of the method there is a slow maturation of the culture of design, which has adopted the principles of the sciences of complexity (Morin 1987, Bocchi & Ceruti, 1985). The product is interpreted as a system that exchanges matter and energy with the environment at every stage, in every moment. We can do no other than prefigure the ways in which this reciprocal transformation object/environment takes place in a context of “compatibility of transformations”. In other words, our project should encourage the liveability and the coevolution between natural and artificial systems. F.L.R.

## 2. CONFLICTING VISIONS

To understand our idea of nature, it is useful to confront ourselves with significant cultural moments to highlight, for example, some conflicting visions with which Modernity has thought of nature and technology. Henri David Thoreau (1817-1862) hated gardens. In the forests of Maine he saw a remote virgin nature. The view of the top of Mount Ktaadn inspired him to write in *The Maine Woods*: “This was that hearth of which we have heard, made out of Chaos and Old Night. Here was no man’s garden, but the unhandseled globe. It was not lawn, nor pasture, nor mead, no woodland, nor lea, nor arable, nor waste-land. It was the fresh and the natural surface of the planet Earth, as it was made for ever and ever.” (cit in Weiss, 1998, p. 85). As writes Allen S. Weiss, “The geometric garden was in particular anathema for him, as he explains in his essay *Walking* (originally entitled ‘The wild’)” in according with New England Transcendentalism, Thoreau believed that there exists a metaphysical need for communion with nature, a need in opposition to the nascent commercialism of American culture and social conformity (Weiss, 1998).

A direct access to truth and beauty, with the experience of the nature: it’s important to highlight the emergence of the myth of untouched nature which arises at the moment of its decline. A holistic vision man-nature never considered in terms of picturesque, aestheticized scenery. It arises precisely when the fracture caused by the advent of industrial society technology is exacerbated. On the contrary, the movement that will most decisively declare war on the “moonlight”, on the “flowers”, on the beauty and poetry of nature, i.e. Futurism, is emblematic. As Fedele Azari writes in 1924, “Flowers in general represent a stonework in our mechanical and synthesized modernity”. An ideology which, by encouraging a break with the past and the nature, sees the human body tending to integrate itself with the technology and the machine.

These visions of nature represent opposite poles around which the relationship between design, nature and technology, dense of unresolved points, will be articulated throughout the twentieth century and up to nowadays.

The nostalgia for a primordial nature on the one hand, and the break with the natural element and the exaltation of the machinic world on the other: two visions that only a cultural development that sees together the ecological turn and the technological transition of the post-industrial can overcome. Beyond specific interpretations and trends, a world of objects emerges today which is the result of a deep analysis and vision. An experimentation with a clear sense of a sustainable use of natural resources and technologies and that is able to freely combine the ecological paradigm with an advanced scientific imagination. We can understand the variety of aesthetics of contemporary design in their relationship between ecology/technology/nature by looking at them in that vast territory that concretely exists between the Thoreau's vision and the futurist vision. What is this territory made of?

Today, we are witnessing a new technical revolution that breaks away from hard sciences and technologies destructive for the environment; a technical revolution that arrives at the life and earth sciences and at the information sciences, playing a decisive role (Serres, 2016). The culture of the project, heavily invested by these changes, interprets and relaunches from its point of view the themes and future prospects, opening up day by day. Technologies are an extension of the human being, they can be light and impalpable toward the hi-tech. Materials, too, are sometimes increasingly impalpable and thin or, on the contrary, they can sometimes be "dirty" or "waste". They are invented starting from new logics, not necessarily of perfection, but of real sustainability.

The nostalgia for an uncontaminated world and the unconditional trust in technology as a synonym for progress are temporally distant from us, we clearly perceive them in their extremism with no way out. But if instead we read them together and not as antithetical, there are no strangers in their underlying utopia. We have many more ways today to imagine new conjugations and balances between technology and nature, to propose non-destructive relationships. Above all, we have solid scientific bases that allow us to experiment in a concrete way a coevolution between the artificial and the nature. This basic paradigm is intercepted now by the contemporary design through a plurality of research and aesthetics. F.L.R.

### 3. LIVING IN THE ANTHROPOCENE

The Anthropocene, whose neologism derives from the union between "anthropos" and "holocene", concerns the geological era in which we are now immersed. It is a term coined in the 1980s by biologist Eugene Stoermer and later adopted by Nobel Prize winner for chemistry Paul Crutzen in his book *Welcome to the Anthropocene* and indicates a period where the invasive impact of human civilization on the planet is such as to cause irreversible transformations.

The atmosphere is overheating, the glaciers are melting, the waters of the sea are rising, many animal and plant species are beginning to disappear or to be at risk of extinction: the effect of human industrialization has reached such a magnitude as to change the balance of nature. The changes in the chemical-physical characteristics of the earth, generated by this impact, are leading to a different ecosystem, semi-artificial, because built and remodeled by nature and man together. As it has always done, nature responds to external attacks by defending itself, and through this act of protection and survival, it evolves.

Far from being considered only a theory, Anthropocene is now configured from a scientific point of view in a precise way, through the structure of a biosystem given by the coexistence of nature and artifice. As described by the philosopher Donna Haraway in her essay *Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin*, we are now in a completely atypical situation: "The Anthropocene marks severe discontinuities; what comes after will not be like what came before. (...) Right now, the earth is full of refugees, human and not, without refuge. So, I think a big new name, actually more than one name, is warranted. Thus, Anthropocene, Plantationocene, and Capitalocene. (...) We need stories (and theories) that are just big enough to gather up the complexities and keep the edges open and greedy for surprising new and old connections." (Haraway, 2015).

The pervasive impact of human activities is intertwined with the industriousness of nature, creating, layer by layer, a series of substances and minerals, unknown before. In an article in the *Mineralogical Journal*, Robert Hazen, Edward Grew and other geologists describe the spontaneous creation of new minerals, including simonkolleite, andersonite, tinnunculite, all substances defined as anthropogenic. From a geological point of view, the study states that the generation of these 208 new minerals is mainly due to three stratigraphic markers: the presence of chemical compounds in the rock; the transformation of the rock surface based on mining activity; the redistribution of natural minerals by humans.

This discovery, together with others similar studies, has revolutionized the way of thinking and reworking the new materials and it is configured as one of the most current aesthetic and conceptual research. On the other hand, the aesthetics of neomaterialism, and of a materiality that is no longer shiny and perfect from a formal point of view, is in line with current research in the field of the most speculative design.

Among the ongoing projects, *Craft in the Anthropocene* by Yesenia Thibault-Picazo represents an important case study for having been able to mix a material research, a deep study of future scenarios, the photography and an audio-visual storytelling. The project is based on the creation and visualization of minerals derived from the accumulation of common materials of our time, such as plastic, aluminum, steel, concrete, glass, textiles, bones. The materials created thus become the starting point for reflection for an imaginary future of artificial substances, extractable from the subsoil and potentially intended as new resources. Among the objects created, a pestle, a mortar

and a vase become the design devices around which Anthropocene manifests itself, since the materials used really derive from the action of this new era. The materials chosen correspond to a bone marble resulting from the 2001 disaster in Cumbria in north-west England, a PPC (Pacific Plastic Crust) - a particular type of polymer originating from pollution of the Pacific Ocean [Figure 1] -, and an aluminum resulting from the ecological disaster of a factory on the Thames in London. In this perspective, reversed to the common approach to an environmental disaster, one of the possible directions concerns the adoption of the changes taking place in the environment, as they are, without having to restore nature to an original degree. Along this perspective, Shahar Livne reworks polymeric waste, reformulating it into a new clay compound. Plastic, from an iconic element of the disposable civilization, turns into something precious and rare, adequate to reshape unique and collectible objects, through the invention of a new material - Lithoplast - that look at the primordial while being technological, and that, through a techno-philosophical contamination, invite to a critical thought on the interaction between man and nature.

Our identities, which derive from the landscape, change in the precise moment in which the landscape is transformed. What happens inside the man with the disappearance of seas, soils, animals and plants? How can the designer intervene in preserving this memory and in keeping constant the remembrance of a natural territory that has now vanished? Through a series of maps, 3D scansions, photographs and 3D models of various kinds of glaciers and landscapes, now extinct, Xandra van der Eijk's research moves on the borderline between design, art and political denunciation. The Retreat project, like the other works of the Dutch designer, challenges the concept of time that passes, transforms and modifies, through the study and the creation of a series of objects that clearly reveal what climate change is causing. [Figure 2]

A design for sustainability that uses nature itself as a reflective mirror to denounce its state of criticality and courageously reveals the most worrying issues. Another example is represented by the exhibition Post Fossil. Excavating 21st Century Creation, by Lidewij Edelkoort (2011, Design Museum Holon) that describes apocalyptic scenarios, through fake paleontological findings. The matter of the fossil becomes the expedient from which everything starts up again, re-imagining new worlds. The raw material is re-processed, fire becomes an instrument to construct objects as in the past: there is a return to natural imperfection, to the roughness of surfaces and substances used. C.S.



[Figure 1-2] Yesenia Thibault-Picazo, *Craft in the Anthropocene*, 2013. Xandra van der Eijk, *Retreat*, 2018.

#### 4. BIOLOGICAL AND E-WASTE: APPROACHES TO THE SUSTAINABLE PROJECT

The gap between nature and technique is dissolving in the current state of techno-biological convergence. In the book *Biophilia + Technophilia*, Jon Bailey - on a time line that goes from 1600 until reaching a future projection to 2050 - places biology and technology on a parallel track. It emerges that from 2000 onwards, these two fields began to cross and evolve together. "We are currently at a time where our technology is increasingly becoming more biological (...) the revolution created by computational processing has given us insight into the creation of artificial life, biological system, neural networks, and explanations into the biological world which remained unknown to mankind until now. As technology catches up with biological and technological aspirations, this merger will likely increase in momentum arriving at a synthesis within the foreseeable future." (Bailey, 2010).

In relation to sustainability themes, technology now collaborates with nature in an integrated way, through a manufacturing modality corresponding to the logics of the natural world. Towards a shared horizon between biological and digital, in the designer's laboratory organic materials, experimental prototypes, texts, digital tools and images coexist, in a logic of transparent syncretism that dialogues with nature and interprets sustainability from a point of view of a living organism.

The particular mixture between the worlds of design and natural sciences is also due to a tangible increase in the practices of Do It Yourself Biology and the interest in a series of experiments in the fields of synthetic biology and future bio-materiality. The process of democratization of science has found its natural driving force in numerous laboratories and bio-based fablab that, joined by the network in a viral process, share knowledge about tools and protocols related to the bio-design practices. Beyond this expanding network, a series of research and exhibition cen-

ters emerges, including the Laboral in Portugal, the Science Gallery in Scotland, Symbiotica in Australia, the Kapelica Gallery in Poland, as well as different collectives that pursue the same objectives.

Concepts of the nature such as self-assembly and self-organizing propose new visions and aesthetic scenarios. They lead to conceive the product as able to regenerate and modify itself autonomously toward a new sense of materiality, new hybrid technologies and unprecedented living forms. Among the possible interests, the skin, intended as a receptive and reactive membrane, is one of the most interesting themes for the relationships between man and the artificial environment, through the creation of fabrics, connected devices, clothes. Among the designers working in this direction, there are Catts & Zurr, Officina Corpuscoli, Eric Klarenbeek, Mike Thompson and Steve Pike.

With the Victimless Project, as instance, Oron Catts & Ionat Zurr envisage the cultivation of artificial leathers from the replication of animal cells and tissues, in order to denounce and pose a political reflection on the exploitation of animals and the toxic production of leather. Again, referring to the creation of a new textile material for the fashion and furniture industry, Naja Ryde Ankarfeldt and Suzanne Lee work with a particular type of microbial cellulose, a biological substance derived from the cultivation of bacteria and capable of growing autonomously. Through a special treatment of production, drying and cleaning, Lee adopts microbial cellulose as her stylistic signature, creating a real company called Biocouture, while Ankarfeldt has developed and built a machine, Microbial Skin, for a hypothetical self-production in large quantities and in leveled layers. Focused on a new vision of organic fashion, “Biocouture is the world’s first biocreative design consultancy. We work in the now, near and far future to help brands to imagine their biodesigned future. From microorganisms like bacteria, fungi and algae to cellulose, chitin and protein fibers like silk, we’re exploring Nature’s sustainable materials for future consumer products.” (Lee, 2012) [Figure 3]



[Figure 3] Suzanne Lee, *BioCouture*, 2010.



[Figure 4] *FormaFantasma, Ore Streams*, 2015.

Materials with organic aesthetics, sophisticated and transmedial narratives: the designer’s work embraces several expressive fields, collaborating with figures belonging to very different areas of the project. However, each foray into the biological world is never completely separated from the digital world.

In parallel with bio-design practices, a series of researches are being carried out concerning the recovery of digital waste and its re-elaboration in the form of new objects or materials. Design builds an anthropic landscape that is increasingly integrated with the digital world, through body extensions, prothesis, electronic devices and post digital objects. In the project *Ore Streams*, commissioned by the NGV Triennial of the National Gallery of Victoria in Melbourne, Formafantasma design a collection made from the scraps of the digital industry, where computer plates, emptied cases and molten metals are converted and reassembled into tables, desks and office furniture. The project is thought towards a future where the metallurgy industry has changed, adopting as its raw material the waste resulting from its own programmed obsolescence. [Figure 4] The theme of e-waste and the reuse of materials for the transmission of digital bits is currently one of less explored but most promising areas for contemporary design. The possibility to treat metals and electronic components for their material importance, not technological, restores the value to the material and, trying to reprocess it, it brings it back to the zero degree of its genesis. C.S.

## 5. SUSTAINABLE DESIGN AND NEW AESTHETICS TRENDS

It seems utopian to think that the project can, by itself, take on the restoration of a natural ecosystem. Rather, it can intervene in an incisive way through a divergent thought capable of rethinking the world of production in a new vision that is totally integrated with nature. Thanks to its ability to illustrate complex problems in a tangible way, not only through the production of objects, but also through an activity of visualization and narration of topics, the discipline of the project can be the most suitable tool for a collective awareness. The idea of placing the Anthropocene as a catalyst concept of a design practice, unfolds today both in an intellectual research and in a very concrete one. In this perspective, the alliance of life and earth sciences with digital and computer sciences can be decisive for a transition to a sustainable development, with the aim of strengthening a relationship between man, nature and

technology based on livability and co-evolution. The research trends and the aesthetics identified are different traces that together, however, build an already clear path.

The strategies of eco-sustainability are just as plural as are the aesthetics that now affect the design project. As we have seen through the design examples, today very different aesthetic visions coexist and inform experimentation: the logic of biomimicry draws from nature schemes in which form and technique find new identifications; an inspiration to the sensory dimension of nature signals our deep sense of belonging to it; in the staging through the design of an ancient nature, an imaginative paleontology puts us before our eyes our deepest history; the very strength of the language of design becomes a crucial tool to give strength to social denunciation; an aesthetic of technology that, far from the machinic world, finds on the one hand in the languages of biotechnology expressive forms, on the other hand in the languages of digital a sweet version of the technical power; the research on materials, which re-examines and redesigns them with the eye of the scientist but also of the designer, able to give value to the most humble as to the most sophisticated; the acceptance of waste, the broken, the dirt and residue as a concrete and scientific starting point for the project, the basis for an aesthetic conception far from the aseptic nature of the rationalist object.

It is no coincidence that the exhibition Broken Nature - inaugurated on March 1, 2019 at the Triennale Design Museum in Milan - is based on this complex and moving scenario. A scenario where the differences in scale of the project, from that of the object to the planetary scale, lose importance compared to the fundamental dimensions of the sciences of biology and communication: time and information. F.L.R.

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*F. La Rocca is the author of the following paragraphs: 1, 2, 5.*

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## **THE SOCIAL CONSTRUCTION OF ENVIRONMENTAL CRISIS AND REFLECTIONS ON THE SUSTAINABILITY DEBATE**

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### **ABSTRACT**

The purpose of this paper is to introduce sustainability, as a concept that emerges as a critical response to the inconsistencies of the social and economic structures, as models that destabilize and accelerate the destruction of the environment in which they exist.

The analysis of the so-called social and environmental crisis is thought from an epistemological point of view and this opens up the debate about the complex emergence of the term.

## 1. INTRODUCTION

Along with the environmental crisis we are experiencing today, social conflicts are also becoming more acute. Depletion and pollution of natural resources worsen social inequalities, such as poverty, the clash between cultures, violence, food insecurity, gender equity and so on.

The question arises. How did we get here? Several authors specialized in social ecology, such as Daniel Wahl (2005), David Orr (2002), Enrique Leff (2004) agree that the origin of this environmental crisis is a dilemma of knowledge: the conceptual basis of our thought has built an unsustainable world.

## 2. SUBMITTING PAPER

The critical phenomena of the contemporary reality have made us consider, above all, our way of understanding life: an imperative arises that we cannot continue acting in the world as we have done so far. The theoretical means that have emerged to overcome this crisis are diverse, but something is clear, is necessary to reconceptualize the paradigms of knowledge that govern us by opening up to a dialogue of knowledge, that is, a holistic thinking that recognizes different visions about the understanding of life.

In terms of epistemology, it is referred to conceptual lenses by which our vision of the world is filtered (Leff, E. 2004). Reality is approached from the understanding provided by sciences, as structures which have been internalized and adopted as absolute structures to get to know, because that is their intention, to institutionalize a way of seeing reality as true. However, these ways of approaching knowledge are cultural constructions that provide referential frameworks, related to a specific view of reality.

To inquire about the way in which cultural context determines our rationality, we might say that we are determined through daily experience. This experience with the outside forms our way of thinking, understanding and valuing reality. Pierre Bordieu (2010) founded that the ways of acting, thinking and feeling are originated by the position that a person occupies in the social structure. In few words, our rationality is the reflection of the world views, social practices, moral values and legal norms of the society in which we live.

The subject is subjected to the structures which determines it. The structure is internalized but at the same time the subject also in its act is structuring reality, somehow is perpetuating what it's been learned. These patterns describe the normalization of an epoch, expresses a collectivity oriented towards certain ends, established prohibitions and encouraged the actions of men, directing them towards contemplation, war, commerce, industry, or the protection of the environment. Thus different 'cultural rationalities' and 'social temperaments' have emerged throughout history (Leff, E. 2011).

Is in the modern era when sciences and the use of reason, are established as the means of true knowledge to emancipate human spirit from the tutelage of religion.

Science validates knowledge through the scientific method. There was a fragmentation of reality, humanity separated from nature, was an idea reinforced from philosophy itself. Hence, there is a definite separation between man as a subject and nature as an object. Nature is reified, and as such, it is disposed as things at our necessity, living beings are transformed into things, for example, a tree into paper, and a cow into a hamburger. Not only dominate but to own, that is the relationship we keep with the things of the world, such as property rights.

The social sciences adopted the methodological principles of the natural sciences and applied them to the research of the social fact. On one hand culture is studied ignoring the interrelations with the environment where the effects of established rationality are discharged. And on the other, there is a pretense to objectify, to impose absolutes on social reality so to impose a criterion of rationality.

Our scientific relationship with nature focused on learning how we could control nature and the social sciences were in charge of knowing man to dominate him. The Social Sciences exacerbated what is marginal and pathological to their conception of a normality imposed to maintain a certain social order (Foucault, M. 2003).

Development and progress concepts were strengthened, thanks to the support of scientific knowledge, based on society evolution and improvement thanks to accumulative process of knowledge. That is, scientific paradigms evolve from previous knowledge, in such a way that a rationalist concept of progress emerges. The "modern" is superior to the old because knowledge is the mean to ground the true (Calinescu, M., 1987). However, Michel Foucault (2003) reflects that these forms are only an episteme, a frame of knowing according to the determined "truth" imposed from a power. Knowledge works like a filter that validate beliefs, which are justified as true by a social group.

Then, progress of societies is supported by the advances of scientific knowledge and its technological expansion. Development summarizes the idea of the domain of nature, everything that separates us from nature and places us in front of human constructions.

The economic model based on these precepts was coupled with a previous mercantilist tradition as the way to obtain profits. Accumulation was also applied in the economy: the reproduction of capital in the short term based on a productive rationality and consumption, having as source of wealth natural resources and labor force exploitation. A competitive and individualistic logic is implied, if some may have more and accumulate, there will be others who in return have less.

The accelerated dynamic of the unlimited economic growth of capital has progressively depleted natural re-

sources, ignoring the regenerative cycles of nature. An exhaustive policy of resources consumption predominates, therefore, capitalism paradoxically destroys its own bases, so is an unsustainable device, it cannot perpetuate itself infinitely.

The effects of environmental crisis has been undeniable around the world and from the UN, recognizes the evidence that nature has limits and that it is urgent to modify the economic order to dominate the ecological consequences of this development (Our Common Future: Brundtland Report, ONU 20 March 1987).

Sustainable development seeks to balance, economic and social development with the protection of the environment. However, this development has been commonly interpreted as a greening of the productive means. The urgency of a profound change on human behavior and its relationship between human groups and nature does not arise. It is maintained that economic growth is the mean to create an atmosphere through which everyone can increase their productive capacity.

Contradiction lies in the concept of Sustainability, since its ecological principles, transferred to the social scale would suppose the complete refoundation of cultural system. The problem is not scientific nor technical, but fundamentally sociopolitical and ethical. The discourse of sustainable development has been manipulated in such a way that the process of appropriation of nature is justified, while aiming to achieve the illusion of a paradigm shift to weaken the tension between economic growth and environmental sustainability.

Since the acknowledgment of contemporary crisis, the environmental knowledge, constitutes itself with the purpose of deconstructing scientific paradigms of modern rationality. It arises as a reaction within, in such a way that the term sustainability did not exist before in any other culture, because it was not necessary.

In Michel Serres "The Natural Contract" (1991) the author reflects that cultures emerged saved from the war thanks to the establishment of a social contract, which is an agreement between two or more wills to create or transmit rights and obligations. This has made possible integrate ourselves into collectiveness, and in the same way, there should be a natural contract that must be established with the world. The way in which we act in nature is similar to that of a parasite, confuses use with abuse, lives from but at the same time harms its host, the parasite appropriates everything to remain without anything. A pact that leads us to dominate our domain, because unregulated this turns against us. It is necessary that a certain justice take place in the exchange, and to guarantee it, a contract is necessary. Nature from being a mere object is now conceived as a subject of rights.

Given the emergence of an unprecedented fact in history: the limit imposed by nature to the economic and social order, an answer is the emergence of an awareness of environmental complexity as a guideline for human intervention in the natural order (Leff, E. 2004). The term sustainability, comes from the study of living beings and refers to the ability of biological systems to conserve diversity and productivity over time (Capra, F. 1997).

This awareness of a complex and interrelated world with limited resources is contradicted by the objectives of accumulation of capital. On one hand, the official definition of "sustainable development" raises the possibility of guiding economic growth in such a way that environmental costs are calculated within the equation, but does not suggests that the economic system should adopt ecological and social sustainability conditions. Such an ambition would imply a change of attitude, not having more than we need, and taking just the necessary. Productivity shouldn't compromise the stability of the ecosystem. Up to now, there are still obstacles to its deep understanding; which are nothing more than strategies of power that block or activate social action, and lead in such a way to continue with the rationality already established.

Environmental Rationality appeals to an awareness of human actions within their environment, sustained by the evidence that there is nothing more legitimate than our dependence on certain conditions of nature for life survival. This rupture with capitalist rationality makes possible coming up with other ways of facing poverty. According to Leff (2011), communities that has been excluded from development, must go through a self-recognition process as a social group and its territory. Then decide where they want to direct their future and determine the means theoretical and practical to go for it. In other words, there is a self-management of the ecological and socio-cultural system, so communities can strengthen their productive potential.

A source of sustainable productivity, might come from coupling cultural needs with appropriate technology. The concept of appropriate technology arises from the need of a technological application that coordinates traditional knowledge with scientific, according to human and ecological resources of a community.

Another definition alternative to Brundtland's sustainability "The guarantee that natural and cultural base will persist indefinitely and an equitable distribution of resources and access to them will be established between individuals, social groups, human generations and the rest of living beings" (Astier, M., Masera, O. R., & Miyashi, G., 2008).

The latter presupposes not only that ecological, technological and cultural productivity will always be constrained to the conditions of the environment. But unlike the official sustainability concept, contemplates the right of cultural continuity. A posture of this kind acquires ethical dimensions about respect for life and justice, since it proposes points of view on how we should act to ensure the survival of living beings. That is why sustainability is stated as a meta concept, a dynamic concept subjected to cultural relativity, this would mean that the aspirations among human societies are not the same and can vary from culture to culture, recognizing that any of these forms are totally equal and valid in their context.

Sustainability is then a dynamic concept that is interpreted from the different circumstances of human societies. The conception of a totalitarian discourse that leads humanity towards a sustainable transition is not possible,

the commitment on the establishment of a rationality that directs ethical values about an ideal relationship of the human being with nature, is a process that each society must resolve to ensure their well-being. This point of view contemplates the dialectical tension among cultures: there will be different points of departure through which Sustainability is understood.

Sustainability is utopian, it is not a fixed and achievable goal, rather it is a process that is in continuous interpretation and construction by a learning community on how to participate appropriately within the natural order. In any case these will be unrepeatable practices, since the rationality that shapes them, is limited by the perspective of a community. The concept of nature is thought based on the ethical, epistemological and ontological principles.

“In the medium and long term, a whole world must be redesigned, which was already designed from the hypothesis of indefinite growth and the irrelevance of the natural substrate ... It is necessary to mobilize the potential of the technique, to reveal new possibilities. The necessary redesign of the artificial environment can lead to new qualities” (Manzini, E. 1992). The design process is linked with the transition towards sustainability, when he indicates the world must be redesigned through technique, we can go for the design intervention, through which scenarios may be provided of another qualities. The design of objects is not enough, but to think about expanding design’s intervention to the environmental scale. To achieve this, a commence would be to set a platform of values in the design exercise, that may allow projects where users can adopt another dynamics towards sustainable attitudes. Design for sustainability would materialize through infrastructures, but more deeply would be expressed in interactions of communities, in their lifestyles and cultures.

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## **DESIGN FOR HUMAN FLOURISHING: PERCEPTUAL MAPPING OF DIFFERENT DESIGN APPROACHES TOWARDS HAPPINESS AND WELL-BEING**

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### **ABSTRACT**

This paper seeks to categorize and organize some of the existing approaches to happiness and well-being in design, by means of a perceptual map of definitions, approaches and tools found in recent literature, in order to guide possible applications towards social innovation and positive behavioral change. By the use of conceptual mapping, we aim to create an initial frame of reference which could lead towards a better discussion of the impact of design in the quality of life of users of products and services, and possibly guide design choices in projects that wish to consider both objective and subjective well-being of the user as project parameters. From this perspective, it may be possible to develop products and services which can impact directly on interpersonal relationships and on values systems, in positive and more sustainable ways.

Key Words: Positive Design, Well-being, Social Innovation, Sustainability

## 1. INTRODUCTION

In recent years the interest in discussing happiness and well-being has raised considerably, with a significant increase in the amount of publications with these terms in their titles or as one of their main topics. While this has been taking place in a variety of areas, the terms have been often mentioned in Design, but many times with different or interchangeable meanings, ranging from life satisfaction to hedonistic joy, with concepts that originate from a wide variety of sources, from cognitive psychology to the social sciences. The purpose of this paper is to propose an initial organizational scheme of different approaches to happiness and well-being in design, as a starting point for a deeper discussion on possible design choices in projects that aim at contributing towards the users positive emotions, as well as whether designers should intentionally take these dimensions into consideration when designing products and services. In order to achieve that, six different understandings of happiness or well-being will be examined in part 2, so that relevant categories can be defined for the creation and analysis of a perceptual map in part 3.

## 2. RECENT USES OF THE TERMS “HAPPINESS” AND “WELL BEING” IN DESIGN LITERATURE

The terms happiness and well-being are terms associated with a variety of meanings, with basic concepts which come from different areas, such as the Arts, Economics, Literature, Philosophy, Psychology, and Social Science, as well as changing cultural definitions, constantly being reinterpreted by people in their daily lives. Some of the authors and designers who have recently discussed such concepts from a design perspective base their ideas in sometimes very different foundations. For this reason a topological organization of a few concepts may be of great use as a starting point to clarify the discussion.

### 2.1. Donald Norman – Emotional Design

In his book “Emotional Design”, Donald Norman approaches emotions from the point of view of the usability field, borrowing concepts from cognitive psychology and cognitive science, defining emotion as the ‘*conscious experience of affect, complete with attribution of its cause and identification of its object*’ (Norman, 2004). He describes positive emotions – such as happiness, fun, pleasure, joy and excitement – as ‘critical to learning, curiosity, and creative thought’, and makes an argument for a connection between the aesthetics in product design and people feeling good. Norman also describes emotions as the result of processes in three levels of the brain: the *visceral level*, responsible for quick judgements; the *behavioral level*, the level of most human behavior; and the *reflective level*, where conscious thought and reflection take place. In a simplified scheme, the three levels are related to three forms of design, concerned with different aspects of a product:

- *Visceral design*, concerned with physical features, such as look, feel and sound;
- *Behavioral design*, relates to the pleasure and effectiveness of use, being concerned with function, understandability, usability, and physical feel;
- *Reflective design*, involving self-image, personal satisfaction, memories, and also the meaning of products.

All three aspects appeal to different kinds of positive emotions which could be associated with some concept of happiness, well-being or satisfaction.

### 2.2. Ezio Manzini – Sustainable Design

In a series of lectures on Sustainable Design in 2007, Ezio Manzini described well-being as a social construct, and situates the western idea of well-being as originated in the Industrial Revolution; currently as a dynamic set of articulated visions, all sharing one common characteristic, which is the association of the idea of well-being to an ever greater availability of products and services (Manzini, 2008). Later, in his book “Design when Everybody Designs”, Manzini describes the modern idea of well-being as ‘*liberation from the weight of everyday activities, where your own skills and capabilities are replaced by a growing series of products and services to be purchased on the market and received from the state*’ (Manzini, 2015). Manzini derives his understanding of well-being from a historical approach, and seems to be concerned with this construct within a socioeconomic perspective.

### 2.3. Stefan Sagmeister – Happiness by design

In his 2004 TED Talk, Austrian graphic Designer Stefan Sagmeister describes happiness in a few different ways: the first from a consumer’s point of view (being happy while experiencing design), and describes a memory of his youth, riding a motorcycle listening to music on a Sony Walkman – a moment of pleasure made possible by design objects; the second way in which he describes happiness is from a designer’s standpoint, being happy while designing, a concept that relates to satisfaction and flow (Sagmeister, 2004). Sagmeister also talks about a third point of view, that of design as a tool to evoke happiness, describing whimsical and clever jokes that evoke surprise and fun. Sagmeister uses the term in a broad manner, ranging from pleasure to satisfaction and intellectual surprise and amusement, taking into account a great number of subjective experiences which can be made possible by design.

### 2.4. Ingrid Fetell Lee – The Aesthetics of Joy

Brooklyn-based designer Ingrid Fetell Lee, founder of “The Aesthetics of Joy” is concerned with empowering people to ‘find more joy in their daily life’. In a 2018 TED Talk (LEE, 2018), she notes how sometimes the terms joy and happiness are used interchangeably, describing joy as ‘*an intense, momentary experience of positive emotion – one that makes us smile and laugh and feel like we want to jump up and down (...) it’s different than happiness, which measures*

*how good you feel over time. Joy is about feeling good in the moment, right now.* Lee claims that through Aesthetics one can arouse the senses in a transformational way, including not only beauty, but aspects of objects which are whimsical, surprising or stunning (LEE, 2016)

### 2.5. Marc Steen – Design-for-Wellbeing

Marc Steen, Senior research Scientist at TNO (an independent organization for applied scientific research in the Netherlands) describes Design-for-Wellbeing (DfW) as an approach to bring positive social change and to promote people's well-being, that includes social design and socially responsive design, and is different from the traditional problem-focused design process. Steen claims that although consumption does not necessarily create well-being, products *'can enable people to engage in meaningful and fulfilling activities—especially if these activities involve using and developing one's talents and skills, contributing to a greater goal, creating and nurturing relationships with people one cares about, or improving one's health'*. Steen goes on to present two different views on well-being: the Aristotelian idea of *flourishing*, which can be described as the *eudaimonic* perspective; and the Epicurean idea of pursuing pleasure-giving activities and avoidance of pain, which constitutes the *hedonic* approach. On one side, the *eudaimonic* perspective involves the cultivation of virtues, engagement and meaningful lives, while, on the hedonic approach – even though the term has become known only for the maximization of pleasure and escape from pain – it also valued simplicity, *'as well as fostering social relations, economic and psychological independence and resilience, and contemplation and reflection'* (Steen, 2016). Steen claims that DfW should be examined from an *eudaimonic* perspective, arguing that traditional design already addresses hedonic well-being (by means of usability); and that DfW can address the notion of flourishing by improving external conditions and people's resources, creating virtuous feedback loops:

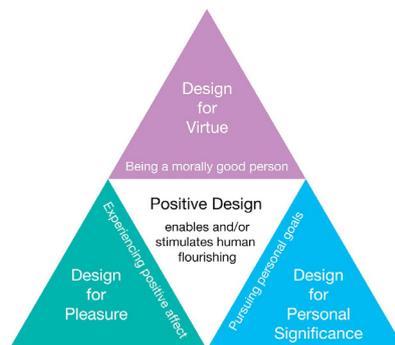
DfW projects can aim to improve external conditions in many different ways—for example, by proposing policies that promote active participation of minority groups in local politics or by placing garbage bins in the shape of basketball hoops in public spaces to nudge people toward throwing their garbage into these bins. They also can aim to improve personal resources by, for example, creating prostheses for people who are missing parts of their body or creating programs for soldiers to train them in emotional resilience.

Moreover, a DfW project takes into account that people can have very different motivations, abilities, needs, and preferences—and different ideas about what would constitute the good life for them. A DfW project would therefore stay clear from prescribing specific behaviors, which would limit people's freedom. Rather, a DfW project would aim to create opportunities for people to use technologies in different ways and for different purposes, thus accounting for diversity and promoting people's freedom and flourishing (Steen, 2016)

### 2.6. Pieter Desmet and Anna Pohlmeier – Positive Design:

Delft TU Design professors, Pieter Desmet and Anna Pohlmeier proposed a framework for Positive Design, an approach which would unite three different components of subjective well-being into one approach, which would enable and stimulate human flourishing:

- Design for virtue (being a morally good person);
- Design for personal significance (pursuing personal goals);
- Design for pleasure (experiencing positive effect).



[Figure 1]: Positive Design Framework (Source: Desmet and Pohlmeier, 2013)

In their work, Desmet and Pohlmeier cite definitions of flourishing, from different authors<sup>1</sup>:

- 'being in the high end of the subjective well-being spectrum' (Huppert et al., 2009);
- 'optimal human functioning and living to one's full potential' (Ryan & Deci, 2001);
- 'having a sense of meaning, engagement, interest, and purpose in life' (Seligman, 2002).

Desmet and Pohlmeier also offer us their own definition of human flourishing: *"People who flourish are developing as individuals, live their lives to their fullest potential, and act in the best interests of society"* (Desmet and Pohlmeier, 2013). According to them, Positive Design is a form of design which explicitly aims at human flourishing, and is defined by five characteristics: it should be possibility-driven, strive for balance, accommodate a personal fit, promote active user involvement and offer the means for long-term impact.

<sup>1</sup> The definitions cited in this paragraph are (apud Desmet and Pohlmeier, 2013).

The use of the term ‘positive’ is due to an intentional reference to Positive Psychology, as described by Seligman & Csikszentmihalyi in 2000, as well as a reference to a Positive, possibility-oriented approach, as described by Desmet & Hassenzahl, in 2012 (Desmet and Pohlmeier, 2013).

In 2011, Desmet and Pohlmeier established the Delft Institute of Positive Design (DIOPD) at Delft University of Technology (TU Delft), in the Netherlands – defining its mission in the following manner: “*To initiate and stimulate the development of knowledge that supports designers in their attempts to design for happiness, for human flourishing.*”, arguing that the increase in material wealth witnessed since the Industrial Revolution did not ‘*seem to result in an equal increase in subjective well-being... in contrast with the aspirations of many designers and design students to make a positive contribution with their designs to the individual user, and to society in general.*’ (DIOPD, 2011)

The Positive Design Reference Guide, published by Delft TU in 2015, refers to different sources, both in Psychology and Design in order to understand happiness; In the fundamentals borrowed from Psychology, there are various concepts, such as determinants of happiness and happiness-enhancing activities, as described by Lyubomirsky, Sheldon and Schkade in 2007, Csikszentmihalyi’s Flow Theory, Concepts of Hedonism and Eudaimonia and the Hedonic Treadmill, Appraisal Theory, Russell’s Circumplex Model of Affect, Maslow’s Hierarchy of Needs, Ryan and Deci’s Self-Determination Theory, Seligman’s Well-being Theory (PERMA) and the Character Strengths and Virtues Classification (CVS), as well as Ryff’s Dimensions of Psychological Well-being. From Design, the Guide incorporates frameworks, models and tools from different authors, that take into account Norman’s levels of Design, as well as other categories that separate aesthetic, meaningful and emotional aspects of the user experience, or include new values such as virtue, pleasure, choice, gifts and personal significance. The research from DIOPD seems to be the most complete research currently available on the subject.

### 3. CONSTRUCTION OF THE PERCEPTUAL MAP

#### 3.1. Martin Seligman’s Well-being Theory

In order to operationalize the notion of Well-being and avoid a monistic construct, psychologist Martin Seligman (Seligman, 2011) defines well-being as constituted of five elements which can be measured independently and are pursued for their own sake, while contributing in a specific way to overall well-being. The five elements are:

- Positive emotion: the “pleasant life”, subjective aspect of happiness, including variables such as pleasure, comfort, warmth, and relating to the present.
- Engagement: also a subjective aspect of the experience, encompassing notions such as the feeling of time stopping, of being completely absorbed by a task and losing self-consciousness. It can only be referred to retrospectively, not in the moment it is experienced.
- Meaning: an element with both subjective and objective components, referring to how meaningful an experience is to the individual, but it can also be measured in an objective manner, using logic and history.
- Accomplishment: the pursuit of mastery and achievements for their own sake, it’s an element which can be measured objectively.
- Positive relationships: with both subjective and objective components, it refers to the presence of quality relationships in someone’s life.

Seligman argues for the importance of having a theory which does not limit itself to the subjective experience of positive emotion, but which can also address objective aspects; he makes a proposition which could be applied to design approaches in very interesting ways:

Public policy aimed only at subjective well-being is vulnerable to the Brave New World caricature in which the government promotes happiness simply by drugging the population with a euphoriant called “soma.” Just as we choose how to live by plural criteria, and not just to maximize happiness, truly useful measures of well-being for public policy will need to be a dashboard of both subjective and objective measurements of positive emotion engagement, meaning, good relationships, and positive accomplishment. (Seligman, 2011)

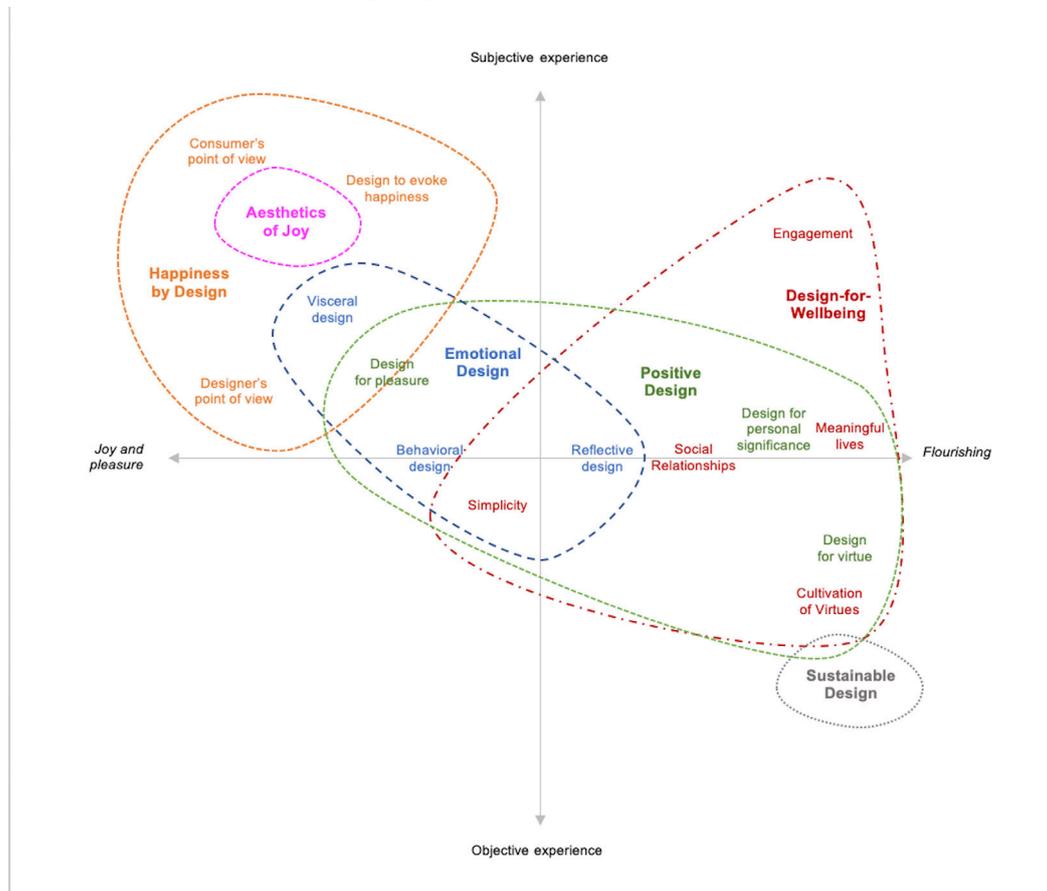
Defining the goal of Positive Psychology as measuring and building human flourishing, Seligman proposes that well-being be measured so that it can be applied to public policies, so that we can ask ourselves questions such as “*How much will building this new school rather than this park increase flourishing?*”. If we extend this notion to design choices, as already indicated by Desmet and Pohlmeier, Positive Psychology could be a powerful tool in order to understand how to create solutions which not only make people feel aesthetic pleasure or are easy to use, but to create design solutions which can improve overall quality of life.

#### 3.2. The choice of axes for the perceptual map

From the analysis of the six approaches described above, a few concepts which could constitute interesting axes for the topological mapping begin to emerge:

- Theoretical Base: Cognitive Psychology vs. Philosophy vs. Social Sciences;
- Quality: Eudaimonism vs. Hedonism, meaning: joy vs. life satisfaction;
- Meaning: Pleasure vs. flourishing;
- Cognition: Visceral vs. behavioral vs. rational/reflective;

- Perception: Pleasurable experience vs. pleasurable state;
  - Timeframe: In the moment vs. In the memory (past) or in predictions (future);
  - Nature of the experience: objective well-being vs. subjective well-being;
  - From these possible oppositions, and considering Seligman's proposition, two axes were derived, considering the different understanding of the idea of happiness and well-being:
  - The meaning of happiness: flourishing (including meaning, relationships, achievement and accomplishments) vs. joy and pleasure;
  - The perspective of the user: objective vs. subjective experience.
- With those axes in mind, the following diagram was constructed:



[Figure 2] Conceptual map of design approaches towards happiness and well-being

The perceptual map allows us to better understand differences between approaches and to make more appropriate comparisons between them. It makes evident that the time perspective is likely to influence the idea of happiness one is referring to: if the design is focused on more objective experiences, they seem to value more long term aspects such as overall life satisfaction, while those which value positive emotion in the moment seem to rely more on the subjective experience of use.

On the joy and pleasure side of the map are situated the approaches which are more focused on the aesthetic dimension of design, giving a strong value to the artistic and creative aspects. On the flourishing side of the map, approaches seem to be more aware of the social role of design, as well as its capacity to generate meaning. Both sides appear to value the functionality and ease of the user experience. Some of the approaches, such as positive design and Design-for-Wellbeing, seem to be very promising in trying to integrate the objective and subjective experiences that a product can provide to the individual or group of people using their solutions.

## 5. CONCLUSION:

In this paper, six different approaches of design centered on the idea of “happiness” and “well-being” were examined. From the descriptions, a few categories were extracted in order to constitute axes for the creation of a perceptual map. Taking into consideration the theory of Well-being from Positive Psychology, the categories “joy and pleasure vs. flourishing” and “objective experience vs. subjective experience” were chosen to be positioned on the axes. Finally, the six different approaches were positioned on the map, indicating their approach to the criteria which create well-being for the user.

From the map, one can observe that there are approaches which lean more to an experience of joy, surprise and amusement in the moment of use; while on the opposite side of the diagram there are approaches which focus more on the overall improvement of quality of life, considering variables such as meaning, virtues, and relationships. If we take Seligman's proposi-

tion to use de elements of well-being in order to make better public policy, and apply it to the design of Social Innovation, the positive impact of solutions on people's lives can be intentionally designed and measured, generating better solutions which go beyond conventional design approaches.

This map was created using approaches which specifically mention or focus on aspects of happiness and well-being. It provides us with a better notion of the impact that design can have on well-being and the kind of experiences which could be measured, whether they are subjective or objective, and if their greater impact is in the short or long term. As a next step, other design methodologies could be examined using the chosen axes, in order to either discuss their impact on well-being, as well as derive improvements which could generate results with a more positive impact on users and society.

At a time when design solutions are being scaled to millions of users very rapidly, and are present in our everyday experiences, it becomes very important to reconfigure our design tools and methods, in regards to their impact on people's happiness and well-being. As well as social innovations, social networks and services could be designed in a more conscientious manner, and be measured for their positive impact on society as a whole.

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## **USING EMOTIONAL DURABILITY FOR SUSTAINABLE PACKAGING DESIGN PRACTICE BASED ON USAGE SCENARIO**

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### **ABSTRACT**

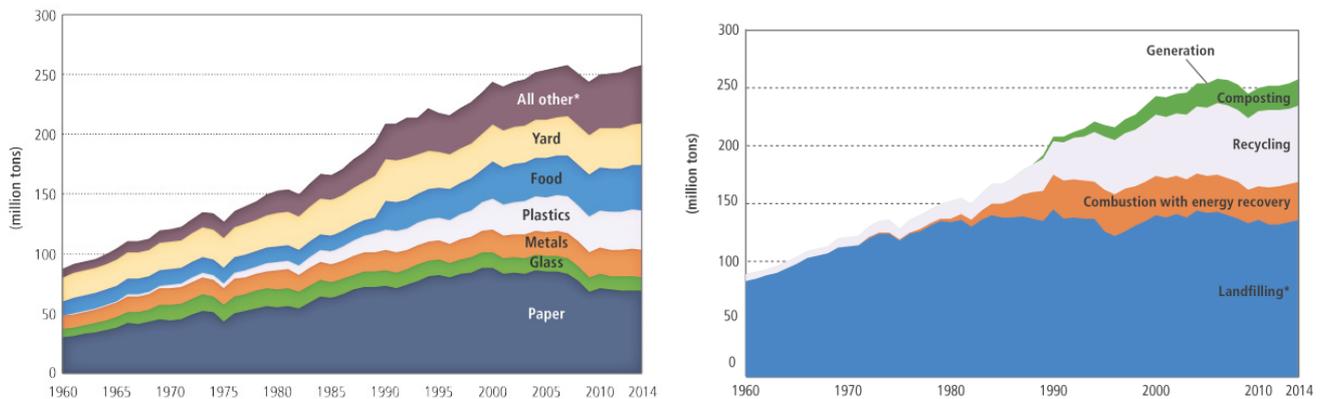
Every day consumers acting replacement purchases online or offline are causing a negative impact on the environment. Enterprises and designers realized the increasingly importance of applying sustainable packaging. This study is aimed at applying the 'emotional durable design' strategy in packaging design practice of Children's Robot DIY Kit, so that the packaging would provide users with additional functions and be reused in a sustainable way. The lecture surveys about emotional durability and reusable packaging cases analysis were both presented in this paper. Additionally, through the observation and interview about the usage scenario of DIY robot kit, the potential needs of children players were found out. Finally, the packaging of robot kit was designed in an emotionally durable way. Giving the ability for user to transform packaging into funny props by hand-made, the product packaging became reusable and promoted experience for product usage.

Key Words: Emotionally durable design, Sustainable Packaging, Usage scenario

## 1. INTRODUCTION

### 1.1. Research background and purposes

As a report from EPA (Environmental Protection Agency, US), which talked about current status of garbage disposal, until 2014, recycling rate for other paper and paperboard packaging paper is merely 26% and paper material is the most generated material per year. Plastic packaging is even as low as 15% [1]. However, most of the generated materials are just landfilled or combusted to energy recovery, which means that a large amount of packaging are wasted and probably used just one time.



[Figure 1] Types and completion of generated materials  
(Refer to: *Advancing Sustainable Materials Management: 2014 Tables and Figures 2016*)

Despite that several design principle or strategies have been suggested for creating sustainable products, emotionally durable design is still not widely promoted in practice. Companies care more about their revenues rather than retarding customers' high-frequent replacement purchases. With increasing competition between packaging production enterprises and development of packaging manufacture and printing technology, the packaging of product is promoted to be more attractive and more prolonged for usage life.

In this paper a literature study surrounding emotionally durable design was reviewed and previous cases analysis are presented that were used as initial explorations of emotionally durable design in case practice afterwards. The final design practice was focused on a packaging of DIY robot kit for children to ensure the findings were pertinent to more packaging design situations.

### 1.2. Process and method of research

The process of this study was mainly set as literature review, case analysis, demand survey and design deliver. Firstly, through the literature review about emotional durable design and cases analysis of life-prolonged packaging, the design pattern and characteristics of the emotional durable packaging were concluded for practical applications afterwards. Secondly, by observing the usage scenarios of DIY robot Kit and interviewing with user and producer, user's potential needs were extracted. During the final step of design deliver, combined with the needs of using additional props under playing scenario and emotional durable design strategy, solution of usage-life-prolonged and multi-functional packaging was proposed.

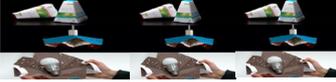
## 2. LITERATURE REVIEW ABOUT 'EMOTIONALLY DURABLE DESIGN'

Researchers in the field of sustainability mentioned that the end of product lifespan is not all caused by technical issues, but mainly psychological obsolescence. [2] Thus, emotionally durable design is purposed as a genre of sustainable design strategy for enhancing the durability of the relationship built between users and products, aiming at reducing consumption and waste. In order to achieve emotionally durability, several design guidelines have been purposed by relevant researchers.

The five qualities of emotional durability [3] were purposed to be used during design practice, which includes involvement, adapt to the user's identity, animacy, and evoke memories and rewarding. A six-point experiential framework was distilled to deal with the occurred issues when practicing product designers design and develop greater emotional longevity in products. [4] Among this framework, Product attachment was first brought forward as the strength of the emotional bond consumer experience with a specific product, which is designed by creating emotional experience such as self-expression, group affiliation, memories and pleasure, and stimulates sustainable consumption. [5]

Briefly, emotionally durable design is not merely contributed in reduction of over-consumption or waste, it elevates the product design process to an expansive and holistic design paradigm, which is emotion-centred and service-oriented.

### 3. CASES ANALYSIS OF LIFE-PROLONGED PACKAGING DESIGN

	Design cases	Description
1		<p>“Never Wasted” shopping bag <sup>[6]</sup> designed by Happy McGarrybowen can be used and reused in 28 different ways, which would keep the customers engaged and excite them long after they’ve left the store.</p>
2		<p>The packaging of mug was designed as coaster box, which can be disassembled and reused as a coaster after the end of packaging function.</p>
3		<p>This packaging designed for light bulb can be reused as lampshades as well as increasing the value of the commodity itself.</p>
4		<p>The paper packaging designed for clothes can be folded as hanger through several steps which were printed on the packaging.</p>
5		<p>The knife produced in Victorinox Company <sup>[7]</sup> was packaged by wooden box which can be reused conveniently as a chopping board.</p>
6		<p>The object called “Dream ball” consists of a cylindrical container for the delivery of aid packaging, can be made into a football by children in developing countries.</p>
7		<p>The packaging of Joco cup was designed to be reusable as a fresh coffee keeper, a pen holder, piggy bank or a snazzy drink bottle holder, and the instructions of reusing were printed on cap.</p>

[Table 1] Title of Example Table

From life-prolonged packaging cases, 3 design rules can be summarized. Firstly, the packaging is functionally complementary to the usage experience of product. In order to be better realization of product function, the packaging is designed to be reusable and multi-functional according to product’s usage scenarios. As the third case above, the bulb packaging can be unfolded and used as a lampshade in period of bulb using. Secondly, involving in transforming the being-wasted packaging is a vital factor for implementing the reusability and upgraded longevity of packaging. Users can disassemble, cut, reorganize, assemble and fold the packaging according to the indications printed on it. The indications use dotted lines or a simple production process, so that users know how to transform packaging into useful and new functional product. ‘Never Waste Bag’ is one of the cases that can be cut and reshaped as practical or funny items such as calendar, bookmark, pen container, ruler, dice, etc. As the conceptual explanation of emotionally durable design, the process of making items by customers themselves would enhance the emotional attachment between user and packaging, and the exciting shopping experience maintains through reusing of items made from shopping bag. Finally, the packaging could be designed to be cognizable for its eco-friendly brand and image by modelling shape or printing sign and pattern. The sustainable packaging encourages users to perceive and form sustainable behaviours and provide users with sustainable life style. For example, the packaging of Joco cup was designed to be reusable as various functional containers and its usage instructions were printed inside the cap, in order to encourage consumers to continually use the packaging. Thus, the survey about users’ demands based on product usage scenario is necessary to be conducted before final design. In this way, the redesigned function of packaging can better help users using product, and bond the prolonging pleasure experience with reused packaging rather than throwing away.

### 4. DEMAND SURVEY BASED ON USAGE SCENARIO

In this paper, the DIY Robot Kit is targeted at normal children aged from 6 to 12, who are with characteristics of creative, energetic and curiosity for new things. Besides, this age of children is also the best period to improve their manual ability. Users can use the components of DIY Robot Kit to build robots, which can recognize walking paths through photoelectric sensor. Through interviews, the purchasers’ opinions on the appearance and quality of the current packaging and enterprise need for packaging were obtained as following. The interviewed purchasers were Children’s parents. According to interview results, purchasers and enterprise tend to consider with usage of the packaging.

Opinions from Purchasers	<ol style="list-style-type: none"> <li>1. Sometimes, the packaging was directly discarded, because it takes up a lot of space at home and useless. Sometimes the packaging will be reused.</li> <li>2. As a creative and educative toy for children, the usage or appearance of packaging lacks interesting and creativity.</li> <li>3. From the perspective of brand, there is no obvious difference from other products on the market.</li> </ol>
Opinions from Enterprise	It is necessary to highlight the brand image of the enterprise through packaging while showing the product characteristics to the purchasers.

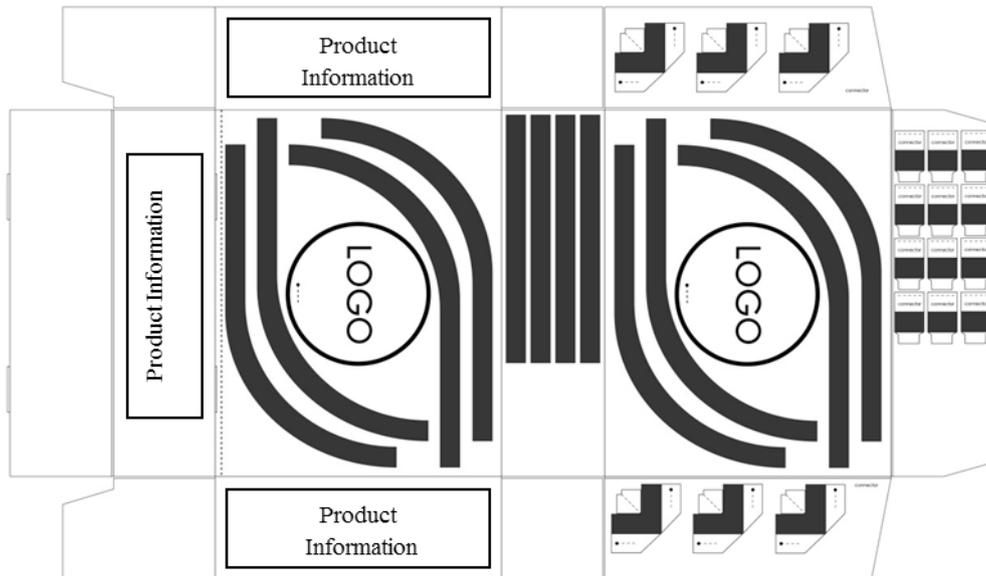
[Figure 2] Results of interview

Observing the usage scenario of DIY Robot Kit, we found that some additional props would be needed to assist the realization of product functions. For example, if a robot was to realize the function of path recognition, it would need a road map with black tracks on the ground for sensor to identify.



[Figure 3] Product usage scenario

5. PACKAGING DESIGN FOR CHILDREN DIY ROBOT KIT



[Figure 4] Packaging design of Children DIY Robot Kit

According to the previous demand survey, the concept of emotional durability was appropriately applied in this project. Product designer brought forward the idea of “Props + Packaging” for DIY Robot Kit. As for the tentative ideas, according to the cutting line of the outer packaging printing, users can involve in cutting the packaging box and reforming it as the props that would be needed in the product usage scenario, and its unfolded drawing is shown as figure 4.

## 6. CONCLUSION

This research introduced the concept of emotionally durable design and conducted practical application in packaging design, which was bound to users' needs in usage scenario. The invention of props not only connected the improvement of children users' hands-on ability to usage scenario, but also increased the durability of packaging emotionally instead of throwing away. Additionally, the involvement of reforming the packaging into props strengthened the connection between handmade props and users, and also prolonged the service life of packaging.

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## THE VALORIZATION OF INDIGENOUS CULTURE THROUGH UPCYCLING

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### ABSTRACT

The current model of consumption is one of the main reasons for the social and environmental problems that our society has been passing through. Currently, according to Manzini (2008) and Abreu (2016) the best answers for these issues are local actions, made by people who are directly affected by them. The designer, as a holistic professional, can become the facilitating agent who helps (through good projects, products or services) propagates these local answers. The present project is based on that. It aims to valorise and revitalize braiding knowledge of Kaingang Indigenous culture, through experimentations and development of fashion products using and resignifying textile waste (Upcycling) through native braid used in their basketry. The concept of Co-design (AGUAS, 2012) was widely used in the work with the artisans occurred. The result from this work showed that with the practice of co-creation it is motivating in the sense of including the indigenous community in the work with the university and they are being part of the results.

Key Words: Cultural Sustainability; Co-design; Social Innovation

## 1. INTRODUCTION

In today's consumer society, the search for products focused on sustainable, as well as the quest for trade and fair production goes against the global market and its need for ephemerality and exaggerated consumption. Within the fashion industry, due to high market demand, plus the large-scale ephemeral production, generate, just in Brazil, 175 tons of textile waste each year. The idealized type of lifestyle sold to all as "perfect" provokes cultural homogenization, which leads to marginalization and devaluation of traditional cultures and their modes of production.

Authors from several knowledge areas (Cavalcante 2014; D'ambrosio 2013; Engler, Freitas, Montenegro, Krucken 2010; Manzini 2008; LOPES, Schulte 2008) already point to a change in thinking and consumption, including the product and fashion production that spread and serve as an example for others locals answers. The designer is the professional who seeks to develop a holistic view over any and every project, having an ability to adapt to the sustainability guidelines and social responsibility. It can give profound value and concept to the product or service. The designer can be a very important part of this change (Manzini, 2008).

In the South of Brazil, one of the most present autochthonous cultures is the Kaingang Indigenous People. They have a millenarian knowledge and, therefore, a very rich culture and artefacts full of meanings and values (Cavalcante, 2014; Ribeiro, 1989). According to Manzini (2008) and his concept of Social Innovation and Local Solutions (Abrue, 2016), these communities can have the main answers to the actual problems. "Saving" and maintaining cultural communities is also considered "sustainability" by the ONU. Thus, this research sought to give a positive response to the problem of textile waste and environmental wastage through co-design and valorisation of local knowledge.

Through this article, we intend to show the possibilities that were open to work in favour of the local market and cultural valuation of the Kaingang from Mococa and its community. Showing the possibilities and results of the joint work realized under the concept of co-design and positive environmental response for textile waste in the city of Londrina. When we disseminate an idea or concept through some product or service, the more it become known, the more people recognize it and give it right value (Nogueira, 2007).

## 2. METHODOLOGICAL PROCEDURES

Concepts as cultural sustainability, co-design, co-creation, social design and etnodesign were used to support this work for this theoretical background research. As a qualitative research, according to Flick (2004, pg.20) the following steps were performed: appropriability of methods and theories; recognition and analysis from multiple perspectives; the researcher and reflexivity research; and the variety of approaches and methods. During the research, 8 female artisans from Mococa participated in the study. The field research of the different braided baskets techniques and "Grafismos" had everything documented. 8 meetings occurred from April to July 2018. The Co-design method (AGUAS, 2012) was applied during all the processes. One of the limitations that happened was the transportation to reach the community, which caused fewer visits than original planned in the schedule. At each visit, activities were developed to test the possibilities of using textile waste; to answer the questions that the artisans brought; to check out the strengths and weakness of the process; to prepare content for the next meeting. Photos and written notes were used to document the work to be used latter in the development of some possible products.

The Project was under the "Termo de Consentimento Livre e Esclarecido (TCLE)", "Ethics Comitee Model in Research Involving Humans" from the State University of Londrina. The TCLE was presented and authorized by the head of the Indigenous Community of Mococa.

## 3. DEVELOPMENT

At the first visit, on April 27th, was developed a conversation with the artisans for the presentation of the Project. For that, and for better understanding by them, it was taken to them 6 strips of reassemble fabric along a book from Berta Ribeiro (1989) that had illustrations of different braiding techniques of indigenous from the Communities of Northern Brazil. Upon seeing the material, one of the two artisans who first talk to the researcher started braiding with the fabric.



[Figure 1] From the left to the right: "Trançado Cruzado Fechado" "Hexagonal" and "Umbigo Asterisco Fechado", realized in Oxford tissue using Ribeiro's nomenclature (Bennemann, 2018)

From this very first visit, it was possible to conclude the technique potential from the artisans to develop their craft in a different type of material than they are used to work. This was the first positive sign to the project. Along with this confirmation, it was also very clear that something was needed to keep the strips together for transportation, a fact considered on the second visit. In this second time, different types of fabrics were also presented, some with finishing and some not. Also, to tie the strips, other types of tissue waste, cut into small squares, were used to be on the bottom of the strips. The strips were fixed by a simple sewn hand, presented by the researcher, which was quickly learned. This way, what it is known as “tissue panels” was developed.



[Figure 2] From left to right: “Trançado Sarjado” using contrast with colors in knitted fabric (Font: Bennemann, 2018)

With the photo above it is easy to see that the contrast with the colors shows the “grafismos”, so important expression of this ethnicity. Each of them is full of concepts and meanings, they carry the beliefs and background from the Kaingangs (Cavalcante, 2014). Because of this, it was very important to ask each time which could be shown in the photos, work with, or even ask what color they would prefer to make the next “panels”, since some could contain religious significance.

In this second visit, 8 artisans participated in the activities. The women responded better when they could see and participate in the activity than when only theoretical visits were offered. So, an interesting fact was that during that visit, the tissue offered was over. The concept of using textile waste provided from used clothing were presented to them in the first visit and reminded during this second one. Surprisingly, this concept (upcycling) was understood very fast by them and soon the problem with the tissue happened, one of them came back with 2 pants e 1 t-shirt that was no longer used to cut and make new strips for the activity. This attitude showed one more positive view of the project and the possibility of future developments that responds to the environmental textile waste and local and autochthonous communities.



[Figure 3] Geometrization Process, for the “Cultural Upcycling”. (Font: BENNEMANN, 2018)

During the third visit it was clear that the women responded better when they could also see the results from the activities: possible products. Let it be explained that this work intended to experiment and seek new answers for the textile waste and find new ways to Kaingang culture to be valued and recognized by other people through different possibilities of products, always respecting their culture, wishes and opinions. All the “products” that were developed during this research were given back to them at the end. Only used to answer the main objective and for results boards and comparisons, not with economics purposes.

The following photos are from these “panels” made by the women during the third visit. With sewing hand techniques, a small bag project was made. The other photos show more possibilities also developed in the university, with other panels from the following visits and used to make the final project of graduation.



[Figure 4] Possibilities for the Kaingang Basket Braided technique (BENNEMANN, 2018).

#### 4.RESULTS

In a very clear way, it was possible through this research field and experimentation in group, be sure about what colour they liked more in their “graphics” and preference to use red and black colours. Colours that resemble the natural ones, those used in their baskets. Strip with finalization was better than one without it, flat fabrics are easier to work with than the knitted ones, and other considerations that this research allowed us to have and were synthesized in a comparison board as a result from this work.

The results from the activities also showed very well the technical potential of women in working with different tissues. Following the Social Design and Cultural Revitalization and Valorisation concepts that, according to Cavalcante (2014) and Manzini (2008) consists in the process and methods suitable for the implementation or creation of something new to determined human group, always relying on cultural elements of each distinct group, and also the Etnodesign, based on the cultural studies and their different knowledge to be revitalized, searching to apply techniques and methods with the objective to value one community or ethnic knowledge through dissemination (NOGUEIRA, 2007), which, in this work, occurred through the development of some fashion products and redesignation of textile wastes.

With these results yet was possible to think about the continuation and economic glimpse that it is possible to perform with the community, always respecting their wishes and culture.

#### 5.FINAL CONSIDERATIONS

The results lead to a relevant possibility of work and social innovation with the artisans from Mococa. The following studies aim to the capacitation and production of some products to future selling it is written and in course to happen, with the market plan for them already done and new possibilities too.

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## **CLOTHING LANDSCAPES: INTERDISCIPLINARY MAPMAKING METHODS FOR A RELATIONAL UNDERSTANDING OF FASHION BEHAVIOURS AND PLACE**

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### **ABSTRACT**

In this paper, 'Residencies' is described; a suite of research methods designed to meet the urgent methodological needs of a new wave of fashion and sustainability discourse focused on societal and structural change. An interdisciplinary approach drawn from cultural geography, art and design aims to chart complex and often overlooked dynamics of clothing behaviours as they take place in everyday life, intricately linked to the context they take place in.

Effective transformation towards sustainability in fashion has been limited by the dominance of technocentric approaches, disconnected from the social context of people's lives or the realities of planetary boundaries. In line with a growing international move to re-prioritise social and human concerns in sustainable development work, Residencies offers potential new ways to identify and visualise social patterns, material flows and interactions. It is not within the scope of this paper to discuss applications and findings, but rather to share methods to enable future research outcomes identifying potentials for systemic transformation.

Keywords: design research methods, fashion, behaviour change, sustainability

## 1. BACKGROUND

Fashion's role in the unfolding environmental and human crisis is increasingly acknowledged. Mass-produced garments negatively impact the environment as part of ever growing industrial and sociocultural systems reliant on the overuse of resources, energy, pollution and waste (Fletcher & Tham, 2015). And while there has been a significant increase in activity to try to address this, it has been dominated by eco-efficient or technocentric approaches, such as replacing less environmentally friendly fabrics with better ones, or reducing waste and pollution in the production or disposal of clothing.

However, there is an emergent movement in the area of fashion sustainability which strongly critiques such approaches, finding that they have only succeeded in making *individual* products less damaging, not in reversing overall impacts (Ehrenfeld 2015; Fletcher, 2017; Greenpeace 2017; Grose, 2015; Klepp & Tobiasson, 2017; Thackara, 2015; Thorpe, 2012). They find that such measures ultimately fail elements because they do not seek to alter the systems they are built into –of unchecked growth, waste and inequity. What is required is a radical restructuring towards systems that embrace planetary limits. This indicates a need for a methodology targeted towards greater understanding of how to better satisfy physical and psychological needs though a sustainable (smaller) social metabolism (Ehrenfeld, 2004; Prádanos, 2018, Thorpe, 2015).

This opens up a large territory of required research, drawing on perspectives of economics, cultural studies, sociology and psychology which have so far been largely outside or on the margins of academic work on sustainable fashion. In this way fashion follows critical movements in other design disciplines oriented towards society and the public realm. This 'social turn' has been characterised by design researchers adapting methods from the social sciences which are useful for building relational rather than reductive knowledge. These are methods adept at investigating complex organic systems of society and culture (Keshavarz & Mazé, 2013; Sangiorgi & Scott, 2015). Because design offers great capacity as a creative platform for a convergence of science, technology and the arts, it has shown to be well suited to sustainability investigations that call for such an interdisciplinary approach. (McMahon and Bhamra, 2015). However, currently the overlap between such approaches and fashion sustainability is a small emergent area in need of development (Fletcher & Klepp, 2017). Examples that do exist includes Emma Rigby's research into laundering habits (2016), Amy Twigger-Holroyd's study of amateur fashion making and re-working (2013), Jonnet Middleton's on mending (2015), Kate Fletcher's emphasis on *use* (2016a), Dilys Williams' work on design thinking and community engagement (Williams, 2018), as well as more established studies from anthropology into consumption clothing habits (Klepp & Laitala, 2015). These projects all share a relational perspective and more specifically, they all use ethnographic approaches to make detailed and nuanced observations contextualised within the locations and relationships where clothing activities take place.

Activity	Type of Data	Documentation
1. Make a basic geographic description	Statistical Historical Geologic Other	Notes
2. Walking observation including ethnographic observation and field notes	Observational (mix of qualitative and counting)	Field notes Smartphone photographs Sketches Map collages
3. Additional 'slow noticing': observations made using manual focus film camera, life drawing and ambiance collections using all 5 senses	Observational (visual, sensory and explicitly subjective)	Analogue photographs Drawings Notes Audio recordings
4. Informal interviews with the public using design probe: 'Clothing Practice Cards'	Hybrid questionnaire/hybrid casual interview	Field notes Clothing practice card responses
5. Place-based wardrobe audits and interviews	Counting In-depth interview	Audio recording and transcription Schematic (filled in) Photographs of selected garments
6. Creative drawing and mapmaking including participative workshops	Creative Participative	Sketches, collages, drawings Final drawings, maps Maps made at workshops

[Table 1] Six methods used in conjunction to document the fashion activities and behaviours of a place

This paper describes my contribution to the development of methods in this area with specific inclusion of observational drawing and mapping practices used to map relational activity. The original Residencies methods were developed in collaboration with Eleanor Snare (Toth-Fejel & Snare, forthcoming) and are part of my ongoing doctoral research project, Fashion-in-Residence<sup>1</sup>. They have been tested in a number of locations in the UK but most recently in an area 2 km<sup>2</sup> in Shoreditch, East London. It is outside the scope of this paper to describe how they have been applied or subsequent outcomes.

<sup>1</sup> See more at <http://www.katelyntothfejel.com/#/fashioninresidence/>

## 2. DEVELOPMENT OF METHODS FOR DIFFERENT PERCEPTIONS

The Residencies methods listed in Table 1 are designed to be used in combination as a ‘bricoleur’; an investigation made from different angles using interlinked methods (Denzin & Lincoln, 2005). In this section I describe a number of ways these methods are designed to foster different perceptions of fashion, useful for countering dominant (and incomplete) perceptions of fashion activity where it is defined as industrial, globalized, commercial, inherently unsustainable (Fletcher, 2016).

These methods gather data using a mixture of observations, interviews and creative activities conducted within a small area. This is modelled on the approach, developed by Kate Fletcher’s Fashion Ecology project, of laying a quadrat to make detailed fashion observations within a tightly-bound geographic area (2018). In ecology and geography this method is used to measure the populations of species within a delineated place, from which the findings about the larger system may be extrapolated (Montello & Sutton, 2013). In the context of fashion, it is useful for supporting a shift in perception –away from the dominance of globalised viewpoints. Identifying local social or relational aspects of fashion (rather than for instance commercial activities which are far more visible), requires devices for ‘seeing’ differently. Sociologists François Dépelteau and Christopher Powell note that relational analysis always requires the ‘re-casting’ of perception through the use of different modes of observation and orientation in this world (Eacott, 2018: 33). I have found that the task of documenting the full spectrum of fashion behaviours, at close range within a given area, makes seemingly marginal or inconsequential activities more visible. It is therefore potentially a useful tool for the identifying emergent patterns and potential seeds of sustainable social change present in already existing behaviours (Shove, 2010).

The interdisciplinary mix of art and science methods built into Residencies is another way of responding to the difficulty of working with everyday behaviours. By its nature, information about the social dynamics and relationships which underlie clothing activities exists below the surface and is difficult to identify. In sociology this has been described as the difficulty of accounting for the richness of real-life experience and ‘the complex ways in which the senses are tangled with other forms of experience or ways of knowing’ (Mason & Davies, 2009: 587 in Heath et al., 2018: 715). This also makes a challenge for the communication of findings; potentials for social change, disconnected actions and emergent patterns are not simple occurrences to communicate (Alberti, et al., 2003). To address these issues, the strengths of art and design to make sense of difficult to describe dimensions of the human condition and surrounding world are called on; things like nuance, empathy and others not reducible to language (Cole & Knowles, 2008). Specifically, visual drawing and other observational art processes are included in Residencies, in conjunction with methods from ethnography (i.e. wardrobe audits) and design (i.e. cultural probes). These methods share an aptitude for an investigation of fashion tuned to the relational landscape of social patterns, material flows and interactions.

## 3. ART AND DESIGN MAPPING

Everyday lived experiences can be described as fluid, embodied and improvisatory in nature (Given, 2008: 536) and the challenge of observing, analyzing and communicating fashion in ways which stay true to these qualities is central to this research. The final and most experimental item on the list of Residencies methods is the use of creative drawing and mapmaking.<sup>2</sup> The remainder of this paper is a discussion of this component, informed by a range of disciplinary perspectives. Creative mapmaking activities assist at 3 different stages of the research process: observation, analysis and culmination of findings. For example, a slowed down form of visual observations is achieved in the fieldwork by photographing the area using a manual focus film camera. Detailed maps of the clothing resources of an area aid in the analysis of the fashion landscape. And maps made in cooperation with local residents communicate a social understanding of the area in a way that no written description could. In this way, visual outputs also speak in a language not restricted to academic audiences (Bjerck, 2017).

Following movements for post-discipline research in the arts (Eisner, 2008) and non-textual approaches in the social sciences (Heath et al, 2018), drawing is one of many creative practices being re-examined as a useful research tool. (Denzin & Lincoln, 2005). Even so, Sue Heath et al. note that drawing methods are only sparsely used by contemporary social scientists, despite the fact that many academic disciplines (such as anthropology) ‘have illustrious histories of observational sketching as a tool for investigation in the field’ (2018: 714). They describe the year-long collaboration between an observational artist and researchers from the Morgan Centre for Research into Everyday Lives which led them to conclude that observational sketching generates ‘a refreshingly different form of visual data which has considerable potential to be used as a complement to other methods, including as a participatory method and as a useful tool for thinking’ (2018: 718).

In seeking to document a ‘landscape’ of behaviours taking place within an area, mapping from the traditions of cultural geography and art maps are important reference points. In these disciplines, conventional conceptions of maps as neutral scientific records have given way to understanding all maps as a form of language, inbuilt with representations of power and narrative (Barnes, 2011; Harley, 1989). And since early in the last century maps made

<sup>2</sup> See the paper, ‘Residencies’: mixed methods research investigating fashion through place’ for detailed description the rest of the Residencies methods (Toth-Fejel and Snare, forthcoming).

by the likes of the Situationists as well as cultural geographers have been given the capacity to communicate marginal and more nuanced subject matter including social behaviours and everyday practice (Barnes, 2011). Graphic designer Alison Barnes uses maps in her work and notes that maps are a potent medium because they are not simply fixed representations of places, but something to be used –so the map represents also a practice, or multiple ways of interacting with place (Barnes, 2011: 42). It also means that the making and using of maps offer many possibilities for participative research methods. Mapping and drawing offer ways to document and experiment with conceptions of human activity linked to places that goes beyond textual or objective representations (Banis & Shobe, 2015).



[Figure 1] Three Shirts from One Wardrobe

In developing a method for mapping the everyday, Social Practice Theory offers this research a further way of identifying and understanding social change through its emphasis on practice (Shove et al, 2012). Many of the same authors making the case for systems level change in fashion also call on practice theory to research patterns of culture and behaviour (see Fletcher, 2017; Thackara, 2015; Klepp & Tobiasson, 2017). In seeking to effectively merge ethnographic and arts based investigations over the last year, practice theory (particularly by Reckwitz, 2002; Giddens, 1984; Shove et al., 2012) have proved to have great potential for guiding the way that content for the maps is identified and analysed. This guidance further addresses the challenge already discussed, of identifying and documenting difficult to see clothing activities and dynamics. For instance Reckwitz's descriptions of practices as constellations of elements including the body, mind, things and knowledge, have provided a framework for interrogating what little evidence there is of alternative fashion practices. Multi-layered design questions and conversation prompts based on Reckwitz's reconceptions of these different categories have helped to overcome the common problem that participants in this research rarely have the language to readily to talk about clothing practices and sustainability in relation to everyday rituals and place. They have helped support a systematic way of digging deeper into people's motivations and consequently provided rich content for the maps.

Figures 1 is an image of work in progress, created using the methods described in this section. It has been made using words recorded during a wardrobe audit and interview of one individual in Shoreditch. This is not a final outputs but included here to give one visual for what one of the Fashion-in-Residence drawings look like so far.<sup>3</sup>

#### 4. CONCLUSION

The 'Residencies' methods described in this paper function as suite of creative and ethnographic research methods designed to better understand relational fashion behaviours in specific geographic locations. These interdisciplinary methods have been developed to help populate the new territory marked out by a new wave of fashion and sustainability discourse oriented towards radical change and social contexts (Ehrenfeld, 2008; Fletcher & Klepp, 2017; Thorpe, 2012). They build on others' development of hybrid methods from the social sciences, art and design; enabling simultaneous, different ways of perceiving and interpreting social landscapes including that of fashion (Barnes, 2011; Fletcher, 2018; Heath et al., 2018). They explore the potential for novel forms of drawing and mapping practices informed by ethnography and social practice theory to better understand and communicate certain difficult to describe dimensions of the human condition and surrounding world. Residencies will be of interest to those seeking new methods for a building a relational understanding fashion and sustainability or ways to integrate creative and socially engaged practices.

<sup>3</sup> To see additional drawings and maps from this project, including maps of fashion practices and participatively made maps, see <http://www.katelynthfejel.com/#/mapping/>

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## **INTEGRATION OF ART OF HOSTING METHODOLOGIES AND PRINCIPLES INTO THE SOCIAL INNOVATION LAB PRACTICE: A CASE STUDY FROM A SOCIAL AND PUBLIC INNOVATION LAB IN NEW BRUNSWICK, CANADA**

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Evoke by Design

### **ABSTRACT**

In September 2017 the first multi-year standing lab undertaken by NouLAB was launched on the topic of Economic Immigration. Along with more traditional Social Innovation Lab methodologies such as design thinking, systemic design and Social Labs structures as defined by Hassan (2014), Jones (2014), and Westley et al. (2015), NouLAB employed the participatory practices of the Art of Hosting and Harvesting Conversations that Matter (AoH) to design and facilitate lab sessions.

The Economic Immigration Lab (EIL) has run for 18 months, and two full cycles. NouLAB has identified linkages between the AoH approach and the systemic principles of design. Of specific interest is how multi-stakeholder participants' learning and capacity is effectively enabled by the practice of holding space, encouraging an atmosphere of psychological safety, experimentation, learning, and addressing root causes of problems.

keywords: Social Innovation Labs, Art of Hosting, Participatory Practices, Public Sector Innovation, Systemic Design

## 1. INTRODUCTION

Social Innovation Labs (Labs) are inherently transdisciplinary. They borrow methods and tools from design thinking, systems thinking, participatory practice, policy development, human centered design and more (Binder & Brandt, 2008; Bason, 2014; Gryszkiewicz, Lykourantzou & Tuukka, 2016). Sometimes called Public Sector Innovation Labs, i-Labs, or Social Labs — these forums for multi-stakeholder engagement have gained popularity in the public sector worldwide with a burgeoning number of these labs in Canada (Tonurist, Kattel & Lember, 2015, 2017; Westley et al., 2015; McGann, Blomkamp, & Lewis, 2018). The exact approach varies and is highly dependent on the skills and experiences of the individuals running the lab process. This paper is an investigation into the methods of facilitation for Social Innovation Lab processes and specifically, how the suite of participatory practices, the Art of Hosting and Harvesting Conversations that Matter (AoH) played out in a lab on Economic Immigration in the province of New Brunswick, Canada.

As Social Innovation Labs have evolved and progressed over the past decade, there are a few ‘must-have’ features. As described by Hassan (2014), Social Labs are experimental, multi-sectoral and systemic. Labs are facilitated processes and these three factors are satisfied through designed engagements. There has been work on building a codified practice of facilitation but experience and practice are essential to guiding stakeholders through a meaningful and fruitful co-creation process (Vorberg, Bekkers & Tummers, 2014; Aguirre, Agudelo & Romm, 2017). In the policy realms where Public Sector Innovation Labs are employed, the issues are complex and, according to the Cynefin decision-making framework, the most appropriate response is to probe, sense and then respond (Kurtz & Snowden, 2003). As the tools created to accomplish this task and facilitate increasingly higher orders of complexity have been taken up in policy creation, including Systemic Design practices (Considine, Alexander & Lewis, 2014; Jones, 2014; Ryan, 2014), the question arises of who is equipped to deal with the organisationally emergent qualities of facilitating through this complexity (van Alstyne & Logan, 2007; Lichtenstein, 2014). The work of Quick and Sandfort (2014) identifies that the practice of deliberation in policy creation can be effectively ingrained in facilitators through training in the Art of Hosting and Harvesting Conversations that Matter, a suite of participatory practices that facilitates new ways of working through the complex challenges of our time. The AoH practice shifts the locus of direction from facilitators to participants, more effectively tapping into the innate knowledge and wisdom of the participants, while providing workshop tools to work in collaborative spaces, enabling and enhancing effective creation of system interventions.

The authors of this paper come to the Social Innovation Lab space through careers in nonprofit management, fundraising and a shared experience of a Masters programme in Strategic Leadership towards Sustainability, awarded by the Blekinge Institute of Technology. Their other combined experience is that of the Art of Hosting, being ‘hosts’, or facilitators of the process, and participants. As such, while planning the Economic Immigration Lab (EIL) processes and practices that come from Art of Hosting were deeply integrated into the all aspects of the workshop experience. At the time of the lab, both authors were employed by NouLAB – New Brunswick’s Social and Public Innovation Lab as the Lab Manager and Knowledge Manager.

## 2. THE ECONOMIC IMMIGRATION LAB: A RESPONSE TO THE IMMIGRATION CHALLENGE IN NEW BRUNSWICK

The Economic Immigration Lab began out of an identified need between the New Brunswick Multicultural Council and the New Brunswick Business Council to address a lack of immigration and retention of immigrants in the province. New Brunswick was expected to have the worst economic growth out of the ten provinces in Canada in 2018 (Jones, 2018). Exacerbating this economic trend is the fact that there will be fewer workers to fill the unfilled jobs. According to the New Brunswick government’s population growth strategy, there will be 60,000 job openings to be filled between 2018-2023. This, coupled with the expected 110,200 exits from the workforce from now until 2026, has led the province to look to international immigration as a source for ready-to-hire workers (NBjobs.ca, 2017; The Public Policy Forum, 2018). In response to this, and in coordination with the Atlantic Immigration Pilot Program (AIPP), the EIL was launched in September of 2017 as a crucible for ideas on increasing immigration to the province and for sustainable results-oriented action. NouLAB functions as an authorising environment for the work of delving into the root causes of problems and securing support for working in a truly multi-sectoral fashion (Bason, 2013). Looking to Jones and van Patter (2009) the EIL is firmly situated in Design 4.0 with societal transformation as an objective. To achieve this, government policy makers are imbedded on teams with representatives from the private sector, non-profit sector, academia, government and immigrants to New Brunswick, with the purpose of achieving requisite variety for systemic change to occur (Jones, 2014). This has resulted in new and deeper policy interventions that aim at the root of the problem rather than symptomatic responses.

## 3. THE ART OF HOSTING AND HARVESTING CONVERSATIONS THAT MATTER

The Art of Hosting and Harvesting Conversations that Matter is a set of participatory practices that enable groups to navigate complex challenges and create spaces for people to come together in different ways (artofhosting.org, 2019). These participatory practices are predicated on the idea that we collectively have the resources and wisdom to solve the complex challenges we face, if we provide the time and space for that wisdom to emerge (Jones 2003;

Sandfort, Stuber & Quick, 2012). AoH processes such as Open Space Technology and World Cafe, give space for the self-organisation and participation necessary to enable “increase[d] awareness, incentives and social motivation to accelerate learning behaviors” (Jones, 2014, p. 120). AoH assumes that our knowledge of and about the world is dependent on our position in society, and it places the practitioner within a larger community of practice, supporting collaborative innovation, including multiple sectors in the design process (Bommert, 2010; Torfing, 2019; Sandfort, Stuber & Quick, 2012). AoH fosters a community of practice whereby facilitators actively support and share with one another. This is especially important because “systemic social innovation and transformation processes do not occur due to the activities of only a single leader or ‘hero-preneur’; rather, it is through distributed agency” of stakeholders within the system (Considine, Alexander & Lewis, 2014; Moore, Olsson, Nilsson, Rose, & Westley, 2018, p. 1).

In the lexicon of Art of Hosting, ‘hosts’ play the role of designers/facilitators as they are known in more traditional lab-speak. Hosts legitimise the wisdom of the collective (Quick & Sandfort, 2014) and serve the function of creating a container for dialogue to occur (Isaacs, 1999), pushing participants to their learning edge (Holman, Devane & Cady, 2007) and hold space for emergence to be possible (Senge, 1990) before converging too quickly on solutions without hearing from all participants in the group (Kaner, 2014). The intentionality of design is paramount to the way hosts operate (Ryan, 2014). Hosts sense the needs of the group and are responsive to provide intervention when needed with the aim of empowering people to contribute with their whole selves to the issue at hand. The philosophy behind the hosting concept is very much akin to the philosophy of Christakis & Bausch (2006) that all participants are designers themselves (Jones, 2014).

The Art of Hosting connects deeply to individual values and belief systems as essential elements to work with in order to enact change. Connecting this theory to design literature, Valkenburg & Dorst (1998) also note that the individual or biographical vantage point has as much influence on design as the context or the problem being addressed. Allowing and encouraging products or policy development to align with purpose of individual value systems gives strength and longevity to projects, especially in their nascent stages when long-term commitment and funding has yet to be secured (Jones, 2014).

#### **4. LEARNING FROM EIGHTEEN MONTHS IN: CHANGE HAPPENS AT THE LEVEL OF RELATIONSHIPS**

The Economic Immigration Lab was established as a three-year project. After eighteen months, and two cycles, the following constitute some of our observations. When looking at the change within the immigration system in New Brunswick, our theory of how systems change is deceptively simple – it’s essentially this: Systems change happens at the level of relationships – with the Self and others. Those new relationships, through dialogue, action and reflection, hold emergent potential for change which could not be foreseen. Both relationships and their by-products (emergent change) ripple out into networks within the system, eventually resulting in a tipping point of systemic change (Lichtenstein, 2014). In other words, our theory of change is a combination of these two aphorisms: “The success of an intervention depends on the interior condition of the intervenor” (Bill O’Brien, quoted in Scharmer & Kaufer, 2010), and “Change happens at the speed of trust” (Covey & Merrill, 2006).

We are not alone in this conclusion. According to Drimie, Hamann, Manderson, & Mlondobozi (2018, p. 2) in *Creating transformative spaces for dialogue and action: reflecting on the experience of the Southern Africa Food Lab*, “social innovations emerge from new ideas supported by new relationships and new commitments emerging from within transformative spaces that lead to action in the system.” Looking to systemic design principles, self-organization and requisite variety are fulfilled through the creation of these new relationships amongst groups selected from their diversity in power, age, department, sector and life experience (Jones, 2014). This was the case in the first cycle of the Economic Immigration Lab, where a month long process of interviewing more than 70 applicants led to the selection of 54 participants on the basis of those factors.

The polarisation of factious groups in any complex challenge means that simply applying design thinking will not have the desired impact of creating systemic change. Instead, we need tools that help us to be in conversation with one another, help us to really listen to one another, help us into a co-creative state with one another. Therefore, bringing people into new types of relationship with themselves and one another, encouraging horizontal structures that have inclusion, diversity, equity and access as central pillars, and giving intentional space for people to get in touch with their true Selves and their Work is just as important – if not more important – than the actual tools we use (Newman, Bloom & Knobe, 2014).

‘Creating a container’ is a term taken from the Art of Hosting, which unsurprisingly, uses the tenets of hosting to reimagine collaborative spaces. Imagine you invited someone over for a meal. You would endeavour to be welcoming, to make them feel safe and comfortable and valued. You might set the scene with beautiful objects or art or candles. You would listen attentively to your guest, you would honour their boundaries, and you would show them respect by behaving authentically and in allegiance with your values. Why then, do we abandon these principles in the workplace?

At NouLAB, creating the container means holding the lab in spaces that are beautiful and accessible. It means checking-in in circle (Baldwin & Linnea, 2010). It means spending a lot of time up front on getting to know one another, as people, apart from the work we are gathered to do. It means listening deeply. It means honouring each

person with the opportunity for equal voice. It means acknowledging the expertise, the privilege and the power in the room. It means care for the community and ourselves. It means showing up as facilitators and modelling authenticity, vulnerability, comradeship and failure.

#### **4.1 Results of creating a Container**

The outcomes of creating a good container can be hard to measure but in the case of the EIL, 100% of lab participants agree or strongly agree that they had the opportunity to meet and work with compelling people (NouLAB, 2018). Policy creators were face to face with stakeholders of the problem they were working on - sometimes for the first time. Government workers who were in charge of designing policy that impacted immigrants to New Brunswick were in conversation with immigrants to New Brunswick and learning from their experiences in order to design better policy - collaboratively. Immigrants to the province were hearing first-hand about the limitations of the business and political structures and realising that the challenges they had faced when immigrating to New Brunswick were systemic, rather than personal. When interviewed, 93% of lab participants agreed that their understanding of both the newcomer and employer experience had increased and 95% of participants were happy to have been able to analyze opportunities and barriers to immigrant attraction and retention within New Brunswick in order to prototype new paths forward (NouLAB, 2018).

Furthermore, being in the lab and experiencing work in a different way rejuvenates lab participants. One participant raved: "I have worked in government for 10 years and needed new wind in my sails, and this lab gave me that". Another participant said: "On a personal level it was a profound experience, and very gratifying". Yet another participant explained that it had helped their entire portfolio, saying, "it allowed my other work to accelerate. I feel satisfied that I have a map and a destination, but still discovering the exact terrain and vehicle" (NouLAB, 2018).

Participants cite the atmosphere created by the hosting team, the encouragement to show up in new ways, the opportunities to engage with people holding different perspectives on the issue, and the space to reflect on how personal values and beliefs impact their vantage point and therefore understanding of the system. Systems change relies on those on either side of power to come into relationship with one another and, in so doing, begin to transform their understanding of the system as a whole, their part in it, and the leverage points for action available to them (Torfing, 2019). It would appear that the most meaningful and revolutionary aspect of the lab is simply bringing folks with different lived experience, different understandings of the challenge and different capacities to interact with the system into conversation with one another. After all, "one cannot expect entire systems to radically shift if one cannot practice and embody a microversion of this in one's conversations with everyday colleagues" (Moore, Olsson, Nilsson, Rose, & Westley, 2018, p. 9).

As evidenced by its name, the Art of Hosting and Harvesting Conversations that Matter is a set of engagement tools to facilitate participatory and democratic conversation. It is ultimately an attempt to provide the best circumstances for dialogue to happen. "Dialogue is inherently relational," (Drimie, Hamann, Manderson, & Mlondobozi, 2018, p. 2) and it both deepens and widens over time. At its most basic level, there is knowledge exchange, but methodologies that use dialogue build empathy and connection between participants, which contributes to their desire to find solutions that work for everyone (Senge, Scharmer, Jaworski, & Flowers, 2005).

Art of Hosting practices are designed to be customisable, responsive and emergent instead of being "oriented to a method of set 'best practices'" (Sandfort, Stuber & Quick, 2012, p. 5). As facilitators, we work collaboratively, intuitively and with the expectation that the participants in our programmes will co-create them with us also. This is another principle from the Art of Hosting, where "there are no explicit leaders who command authority; rather [a focus on] creating learning experiences (Sandfort, Stuber & Quick, 2012, p. 3). We check in with participants every day, ask them how they're doing and what they need. And their answers influence our design of the next day - or the next few hours. We've thrown out plans because we have heard that that is not what participants need. Giving participants agency over their experience, invites a new structure of working, where collective intelligence, self-organization, continuous adaptation, and feedback coordination are possible because of the readiness of hosts to make changes and assess situations in real time (Jones, 2014).

#### **4.2 A Co-created World Café – Tools for Self-organization**

In the first cycle of the Economic Immigration Lab, we opened with a World Café that asked: When we invite people to live and work in NB, what are we inviting them into? What came out of this World Cafe question was a churning up of some of the deep-seated racism in New Brunswick. It was an opportunity to discuss what it means to be a newcomer in NB, which for some, was shocking. It became very apparent that the time allotted to these conversations wasn't enough, and so the design was altered for the next day to include an Open Space Technology session with the question: What conversations do you need to be having now?

During this session, participants took the opportunity to discuss the experience of being a newcomer through economic, cultural and gendered lenses. Observing the room, the level of attention was palpable. Everyone was leaning in. These conversations were so important for opening up a level of authenticity and vulnerability that influenced the prototypes they tackled and the way they related to one another in the days and weeks to come. Facilitators heard from participants that this session directly impacted how they felt they could show up in the lab and resulted in at least two people choosing prototype topics and teams that they felt called to on a personal level, as opposed to the ones that they might naturally have joined because of an alignment with their work.

It may seem inconsequential – but when the facilitators show up in a different way, it breaks the traditional, hierarchical power dynamic that exists – the one that gives certain people with certain voices more power than others. By sitting in circle to collectively hear and resolve the issue, we invite perspective from everyone – equally.

“The invitation to participate in a community – of co-learners and co-producers of knowledge – also reflects hosting’s distinctive and democratizing philosophies about deliberation and design, namely that all people in the room have wisdom, that deliberation enables the sharing of knowledge, that facilitators and others aim to decentre the authority of their position and expertise in the room and that participants coproduce deliberative policy processes as well as decisions” (Quick & Sandfort, 2014, p. 317).

#### **4.3 Disruptive Potential: Understanding the System and Self in New Ways**

These practices don’t only serve in times of conflict, but throughout the process. By addressing dynamics of identity, power and privilege, we are furthering our disruptive potential towards systems change (Quick & Sandfort, 2014). Furthermore, “at the heart of the disruptive process of social innovation lies a need for a type of institutional reflexivity; that is, the capacity to see, interrogate, and reimagine the taken-for-granted structures that sustain current systems and people–planet relationships” (Moore, Olsson, Nilsson, Rose, & Westley, 2018, p. 3).

Indeed, this is the case for one of the lab teams now prototyping a streamlined process to allow employers and potential employees to navigate the government services they need to meet the requirements for hiring and being hired in New Brunswick. Team members from Immigration, Refugees and Citizenship Canada (IRCC) - the national governing body for immigration in Canada, Post-Secondary Training, Education and Labour, J. D. Irving Ltd. (the province’s largest private employer) and Practical Human Resources Services Inc. came together across the national/provincial governmental divide, the public/private sector divide, and with newcomers to the province in order to flesh out the immigration process as it is experienced by immigrants, employers wishing to hire immigrants and the governing institutions for immigration. With this deeper and broader understanding of the system as a whole, the team was able to identify leverage points - or opportunities - for new policy development. Currently, the team, in collaboration with the provincial and federal governments, is prototyping a Concierge Service that will help immigrants and employers navigate the immigration system, as well as track their experiences in order that those learnings be used to inform further policy changes down the line.

The learning from this prototype is scalable throughout New Brunswick, as employers and employees currently have no resource, or are forced to rely on private concierge services to aid their recruitment efforts, which is not an option for many small and medium enterprises in the province. And, with IRCC involved in this prototype, the learning could have impact on a national scale.

## **5. CONCLUSION**

In conclusion, the Economic Immigration Lab turned out to be more than just a space to prototype solutions to the immigration challenges New Brunswick faces. By using Art of Hosting practices, the team at NouLAB managed to: create a container which enabled participants to show up in their work and relationships to one another in new and deeper ways; harness Systemic Design principles, enabling self-organization, feedback coordination, continuous adaptation, requisite variety, appreciating complexity; establish a precedent for co-creation which gave participants agency over their experience and thus over the subsequent work and prototypes that were developed in the lab; encouraged a transformation of identity, relationships, and dynamics of power and privilege, thereby allowing for a reflexivity in the system not otherwise possible.

These features are consistent with Transformative Learning Theory (Mezirow, 1997), and “the importance of transforming perspectives by undertaking a critical assessment of epistemic, sociocultural, or psychological assumptions; examining one’s self, including feelings, roles, and competencies; exploring and provisionally trying new roles, relationships, and actions; acquiring new knowledge and skills; and building competence and confidence in new roles and relationships” (Moore, Olsson, Nilsson, Rose, & Westley, 2018, p. 5).

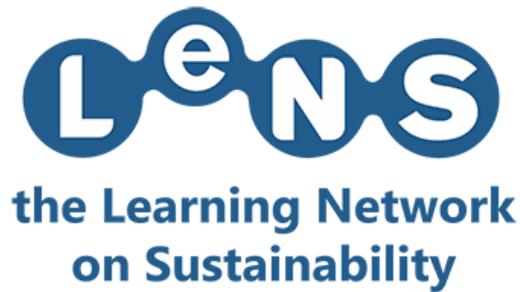
While not explicit in the field of Social Innovation Labs, we contend that the transformative experiences of coming together in conversation in new ways, reorganising traditional hierarchies into distributed horizontal leadership approaches, and co-creating the structure as well as content of the lab in order to increase the self-reflexivity of the system accounts for the performance and success of the lab thus far. The methodologies and principles within the suite of the Art of Hosting and Harvesting Conversations that Matter, gave structure and guidance to be able to offer these transformative elements to lab participants.

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## **DESIGN AS DEMOCRACY: THE DEMOCRATIC POTENTIAL OF DESIGN**

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### **ABSTRACT**

The present article proposes to investigate possible futures for the design through a proximal and dialogical approach between design and democracy. In this way, we begin with the letter “Stand Up for Democracy”, written by Manzini and Margolin. Thus we seek to understand the foundations of the concept of Design as Democracy, proposed by the mentioned authors. We seek a relationship between the structures of democratic models and design practices. For these reasons, we have opened up a dialogue on codesign as a possible methodological alternative for a democratic design, more comprehensive, horizontal and open for all. Providing a fertile ground where collective creativity can be used as a form of collaboration and solving common problems is mirrored in design as democracy. For this resonates with the creation of a more inclusive and sustainable world for the future generation.

Keywords: Design as Democracy; Citizen participation; Codesign and sustainable; Possible Future of Design, Common by Design.

## 1. INTRODUCTION

Design is a complex activity that influences and is influenced by multiple interests among the different social groups that participate in its process, being therefore an activity that is not neutral in relation to social and political issues.

Different authors deal with the social function of design and the performance of the designer as an agent of social transformation. Gert Selle (1973) relied on the Critical Theory of the Frankfurt School to discuss affirmative action for Design, involving ideology and utopia. Tomás Maldonado (1972) observed the environmental degradation caused by the industrial consumer society and dealt with the projectual hope, the need for the designer to act with autonomy and social conscience. Bonsiepe (1978, 1986 and 2006) since the 1970s has observed the problems of technological and industrial dependence of the “peripheral countries” vis-a-vis the “center countries” and has reflected the relationship between design and democracy in the sense of seeking autonomy through design. Frascara (2000) emphasized the importance of approaching design with the area of social sciences for the development of actions geared more towards social benefits than commercial interests. Manzini (2008) has debated the importance of sustainability in the development of design actions and has been pointing the potential of social innovation, new social organizations based on collaboration networks, as a way to change the current paradigm of industrial production.

These theoretical approaches deal with articulations that broaden and deepen what is meant by “project activity” as well as the role of the designer in the university, in the city, and in society as a whole. Recently, Ezio Manzini and Victor Margolin at a Chicago’s Conference wrote an open letter to the Design community calling for a lift for democracy. The authors believe that the design community should take a stand, speak and act to defend democracy as a core value of society, this attitude must happen by recognizing the strong possible convergence between democracy and design.

From this point of view, the present article intends to investigate possible futures for the design starting from a proximal and dialogical approach between design and democracy. The aim is to connect design concepts to democratic practice, in order to broaden the field of work and design research. Besides being a way for designers to position themselves politically in the complex scenario of fragility of democracy that we live in the contemporary world. At first we try to understand what the foundations of the concept of Design as Democracy, proposed by the mentioned authors. For this, we seek a relation in democratic models, as they are their structures of operation and their relations with the practice of design. From the relationship and articulation of these structures with the design we open a dialogue on codesign as a methodological alternative, for a design as democracy, so that it is more democratic, horizontal and open.

Finally, the purpose of this article is not to exhaust the theme but to open up ways for this relationship to strengthen in order to widen the frontiers of knowledge in the field of design.

## 2. DEVELOPMENT

The theories and practices of design have gone through new design spheres in search of improvement of human, environmental and economic factors, that is: they involve issues that go beyond simple project action and their interrelations condition and constantly redefine the way of understanding the design. This transforming and flexible feature of design makes the foundational fields of knowledge of its practice change according to the nature of the problem being treated.

In this way, we recognize the challenge of establishing new paradigms for the creation and use of design knowledge that is more democratic and encompasses the complexity present in the contemporary world.

### 2.1 DESIGN IN THE COMPLEX SCENARIO OF DEMOCRACY

The contemporary political and democratic scenario is extremely complex, at the same time that capitalism has invaded our lives by capturing our subjectivities and our cognitive so fiercely that it also dominates and encompasses even the forms of resistance created against it. Moreover, the high levels of rejection of the traditional politics of representation by parties, leaders and institutions - largely linked to problems of corruption and misappropriation - have led to a global delegitimization of the model of representation, called to be corrected or even replaced by formulas of direct citizen participation (Crozier, Huntington e Watanuki, 1975, Pharr e Putnam, 2000). Today, with the Internet and social networks, citizens feel more politically active, providing for the inclusion of different actors in civil society, making it possible for autonomous and horizontal actions to be established for political demands.

This participatory growth is very broad and ranges from organic reforms that seek to give more weight to the militants in the decisions on programs, alliances or internal leadership, to new forms of participation in the local space, such as participatory budgets or citizen consultations, which can be extended without great costs at local levels through referendums or formulas of electronic democracy (MOTOS, 2018).

The discussion of key concepts to democratic theory - participation, equality, legitimacy, self-government, dissent and freedoms - permeates the understanding of these contemporary forms of expression. It also goes through the productions of affections, how dissent manifests itself, how the public scene is handled, and the current forms of sharing are essential if democratic theory itself is to be renewed and can deal with current political problems. Design is connected to all this complexity by its strong context of social interaction and by being linked more and more to

the production of subjectivity, that is, the projection of visualities and spatialities that interfere in our ways of living, of relating and to constitute ourselves as a society.

Manzini and Margolin (2017), insert design in this context of discourse on the direction of democracy by launching a letter / call to the design community to engage politically and actively in the maintenance of democracy through actions involving theory and practice of design. In this text, the authors emphasize that the development of democratic forms and processes has always involved design and must continue to do so, being a moment of construction of possible futures, through design, able to conceive, develop and connect new possibilities for democracy and well-being, resisting the growth of negative forces that have attacked democratic processes.

In addition, they draw a parallel between design and democracy, based on four aspects, namely:

- Design of democracy – improving the democratic processes and institutions on which democracy is built;
- Design for democracy – enable more people to participate in the democratic process, especially through the use of technology;
- Design in democracy – building access, openness and transparency in institutions so as to ensure equality and justice;
- Design as democracy – the practice of participatory design so that diverse actors can shape our present and future worlds in a fair and inclusive way.

With the exercise of opening a field of dialogue between democracy and design, this article focuses on understanding the relations contained in the fourth proposal of convergence between design and democracy, presented by the authors. The intention is to open channels of conversation between these two fields of knowledge without the pretension of exhausting the theme. Therefore, we propose a dialectical relationship between the structures of democratic models and the practice of design.

## 2.2 DESIGN AS DEMOCRACY, BUT WHAT DEMOCRACY?

Democratic actions take place in the public sphere, that is, in a plural space as an arena of mediation of communicational dialogical processes, with articulations, opinions and reflexive reconstructions of moral and normative values that guide social coexistence. Therefore, if democracy is thought of as a way of life based on the notions of equality and self-government, it can be understood as the collective effort to build a shared world from just conditions. This effort is realized every day in the meeting of singularities for the texture of a common experience.

However, it is necessary to develop critical, hybrid, horizontal and living forms of knowledge production, which are essential for the production of emancipatory and democratic solutions in contemporary times. Whether they come from design or from any other area of knowledge. As a way to better understand the concept of design as democracy, as presented by Manzini and Margolin (2017), we search through the models of democracy, understand their structures and what relationships are possible in both theory and practice of design. The models of democracy can be understood as an “idealized theoretical construct to reveal and explain the key elements of a democratic form and its underlying structure of relationships” (Held, 2007.p.25). Thus the models of democracy present us with possible types, that is: abstractions that allow us to capture the characteristics and normative practices that distinguish a democratic proposal from its alternatives.

## 2.3 AGONISTIC MODEL OF DEMOCRACY

Mouffe (2005) proposes the idea of the agonistic model, based on the acceptance of dissent within the democratic process, a point that is opposed in the democratic model as we know it, would be a deliberative democracy. The democratic process of the deliberative type requires that the participants not only be free and equal, but also “reasonable”, because democracy is understood as a system of social and political arrangements, capable of connecting the exercise of power to the free exercise of reason between equals. By “reasonable” it is understood that the participants in democracy seek to defend and criticize institutions and programs in terms of considerations that others, as free and equal, are right to accept, given the fact of reasonable pluralism.

That is, adherence to liberal democracy would be like a kind of rational agreement that would close the door to the possibility of contestation in the search for a final rational solution. Mouffe (2005) considers that it should really be at stake would be the constitution of a set of practices that make possible the creation of democratic citizens and not a question of rational justification, but of the availability of democratic forms, individuality and subjectivity. In this sense, the aim is not to eliminate the existing differences in the public sphere in order to have a rational consensus of equality, but to mobilize these different energies for the sake of democratic purposes.

If we accept, however, that power relations are constitutive of the social, then the main question for democratic politics is not how to eliminate power, but how to constitute forms of power more compatible with democratic values (Mouffe, 2005, p.19). Understanding the constitutive nature of power implies abandoning the ideal of a democratic society as a perfect, harmonious, or transparent institution. To understand how the pluralism of the agonistic process and the relations of power form the social, the author proposes a distinction between “politics” and “the political.” The first would be a set of practices, discourses, institutions that seek to establish an order of human coexistence, that is, structures that guarantee governmentality - The second would be the antagonism inherent in human

relationships that emerge different types of social relations, that is, condition of society, in constant opposition and debate, materialized in acts of resistance and confrontation.

The author Carl DiSalvo (2012) using these distinctions of Mouffe (2005), inserts the design in this agenda creating a distinction between “Design for Politics”, that involved with issues that involve the modes of governmentality, and “Political Design”, whose goal is to create dissent. From this analysis we can also distinguish the design that is used as a tool by politicians, and one that has a more democratic and plural character where their practices generate constant reformulation generates more just and inclusive worlds. Therefore, it is possible to create a parallel and convergence of the agonistic model of democracy with the development of a “Political Design” and a practice of “Design as Democracy”. Being the Political Design a form of positioning where the political potential would be placed before the questions presented to it, in order to always leave a space so that the subjectivities can be considered in the challenges before them.

Design as Democracy can then be seen as a political act through the practice of actions, mechanisms, and tools for the creation of spaces of experimentation of subjectivities. An example of this would be the possibility to include people in decision-making processes, in the creation and management of the process of developing proposals for problem solving in conjunction with communities aimed at improving the quality of life of citizens. In addition, Design as a democracy would be linked to practices that break paradigms of production and consumption, that go towards a design that sustainably exploits natural resources and materials available, seeks new productive aspects and values symbolic diversity and cultural. More democratic practices allow for the creation of new products, new values, new scenarios, where the concept of project covers the interaction between society, production, real demands and local development.

#### **2.4 CODESIGN AS POSSIBILITY OF DESIGN AS DEMOCRACY**

The evolution of the thought of the performance of the design, through a creation developed for the user has changed to a new perspective of co-creation, this has altered the design practice scenario, as well as the emergence of new domains of collective creativity.

The creation of possible futures through design necessarily passes through a regeneration of environmental and social capital breaking with old ways of life, production and consumption, opening up to new possibilities for everyday interactions between humans and their artifacts.

The creation of a space where collective creativity can be used for collaboration and problem solving, involving all, easily connects with design as democracy as proposed by Manzini and Margolin, because it is in resonance with the creation of new worlds more inclusive and sustainable.

In this sense, codesign, as a methodology, integrates into these scenarios of possible future creations through design, since codesign is based precisely on the idea of including people with different voices for collaboration within the design process in building common and collective solutions. “Designing with others” is a methodology that proposes a more democratic, open and innovative design process that has been finding space in different projects and actions, especially in what concerns public participation and social innovation.

In the perspective of democracy models, codesign would be in tune with the agonistic model because its characteristics are complex but basically take into account the other - in all its levels of affections, passions, perceptions, subjectivity and dissent - as part of process of social life. By including the other in its actions, the codesign “as a design approach” can potentially create new possibilities and new values, but requires a new set of skills and an underlying philosophical approach by designers (Fuad-Luke, 2009, p 147).

The codesign actions involve collaborations with a high degree of confidence, are social services in which the end users are actively involved, assuming the role of codesigners and co-producers of the service (Cipolla, 2004). The challenge of codesign is to fit the design together with the other authoring tools into the process of collaboration and co-creation, so that it is not possible to identify a single authorship in this process.

Codesign is present in the experiments of democratic design, that is, in the development of a service, a process of collective construction that involves issues related to cities and regions, the conquest of more rights for its residents, among other possibilities.

The democratic process of codesign places the design within a set of actions involving the individual and society in order to find solutions to diverse problems. More specifically, the challenge is to integrate codesign methods and tools into these processes in order to improve the effective participation of citizens and society as a whole, thus enabling more people to contribute to transforming their needs in search of a better future.

However, there is a critical point in the use of codesign methodologies, which is their relationship to the time of results. The actions that involve codesign generally take a longer time to reach a good result, than could possibly be done using traditional solutions. Perhaps, this happens because the codesign initiatives take into account the individualities within the collective, that is, they consider the subjectivities of each participant to reach a collective agreement and more democratic in relation to the natural stages of the project which are: analysis of the problem, proposal for execution and immediate application of possible solutions.

A possible way to maintain the collective and collaborative way of acting in design is to promote a new thinking about the accelerated pace of our lives and the revision of the contemporary lifestyle.

### 3. FINAL CONSIDERATIONS

With regard to democracy, the act of inclusion, even dissent, as part of the democratic process strengthens its structures and makes them more comprehensive. In terms of design as democracy, practices that seek to include citizens as trainers and thinkers of this process also create a more democratic bias for design and strengthens the possibilities of citizen participation.

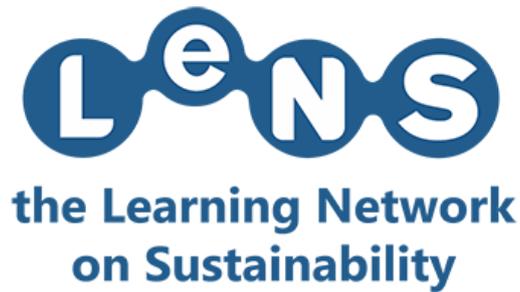
Facing this, linking democracy and codesign considerably broadens the scope of the design activity. This integration expands its scope of action through new formats, models and methodologies that present themselves as more creative and integrative. In this way, it is possible to allow different social actors to propose new paths with subjectivities and affections, with consensus and even dissent, promoting different ways of democratically occupying the public scene and common shares.

However, this process is essential to strengthen design as an important area of knowledge within applied social disciplines. In this context, using codesign as an instrument of democratic participation is not seen here as a passive process that provides voices to individuals, but rather to generate effective proposals through collective actions through design. The collaborative practice, through codesign, opens space for design to act as a mediator of the processes of structural changes in contemporary society that go well beyond the management of interaction models and collective collaboration processes.

As a conclusion, the perception of design as a democracy still includes in its practices more horizontal forms of social participation that, when potentialized by co-creation, make the whole process a model for conceiving, developing and connecting new possibilities for democracy and for design itself.

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## **REGENERATIVE FOOD SERVING SYSTEM FOR A SUSTAINABLE UNIVERSITY CAMPUS LIFESTYLE: A SOCIAL AND BEHAVIOURAL STUDY**

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### **ABSTRACT.**

Students and staff consume a staggering amount of food packaging daily with short lifespans lasting a few minutes before being thrown away. The paper created a regenerative system to improve university campuses' sustainable lifestyles in Egypt, focusing on the German University in Cairo (GUC) as a case study. The GUC is self-sufficient where services and products are produced on campus. However, attention is not given to packaging of food served. Therefore, the paper's main focus is on the system of serving food at the GUC with the aim of implementing the outcome on other campuses. The outcome targets youth who tend to follow trends easier and faster and lifestyles in universities will positively influence society. This research used behavioural studies on participants studying and working at the GUC to gain information about packages consumed daily. The system improves sustainability by reducing carbon emissions, money spent on packages, and landfill space.

Key Words: Food Packaging, Egypt, Sustainable Campus, Regenerative System.

## 1. INTRODUCTION

Workspaces including universities are home to materials with plenty of waste created each year. Campuses are a place where students and staff members eat several meals a day including their frequent drinks of water and coffee. Each time someone on campus buys something it comes in a pre-packaged container that normally lives for only a few minutes before it is thrown away. By developing campus waste management systems, universities in Egypt can begin the trend of sustainability which can improve not only the campus but the students' homes as well.

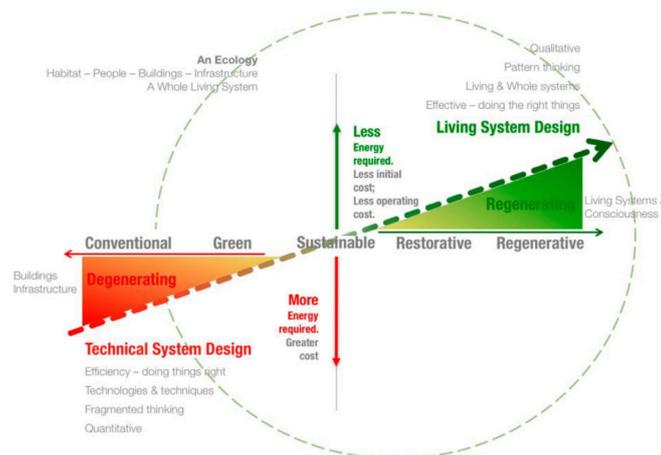
According to Ball and Taleb, the 72 million people living in Egypt produce at least 17 million tons of municipal solid waste a year (Ball & Taleb, 2011). The goal of this paper is to reduce and recycle municipal solid waste produced by university campuses in Egypt through the development of a regenerative food packaging system. By developing campus waste management systems, universities can begin the trend of sustainability which can improve not only the campus but the students' homes to influence society positively. The study will focus on the German University in Cairo as a case study, with the aim of implementing the study's outcome on other campuses.

## 2. REGENERATIVE SYSTEMS

### 2.1. Defining Regenerative systems

It is now apparent that action needs to be taken to solve our ongoing environmental issues. Sustainable systems maintain themselves to indefinitely sustain life support system that maintain human lives (Goodland, 1995). These systems are also known as maintaining themselves biologically, socially, or economically (Pearson, 2007). However, according to Reed, extreme changes must be created to achieve significant improvements (Reed, 2007).

Regenerative systems are developed using living systems to solve problems and involves interaction between several systems. According to Mang, the word regenerate involves a desire to improve, creating a new spirit, and energy going back to its origin. Designers are now being challenged to develop sustainable communities as a united system (Mang, 2001). It is a method that moves from thinking about reducing damage to understanding human's roles in service to finally regenerating new life, as shown in Figure 1. Regeneration understands healthy living systems that constantly produce new life sources. This is based on the thinking that humans evolve within systems and should be part of reviving and regenerating inside their own systems (Sheffer, 2017).



[Figure 1] Regenerative System Design according to Bill Reed, Regenes 2000-2016

## 3. CAIRO CAMPUS LIFESTYLE

### 3.1. Taboos in the Egyptian culture

Over packaging is not only a problem of one university but of the whole country. Egypt lacks a system that incorporates sustainable approaches. The Egyptian culture believes that more is better where it is considered impolite or taboo to show off your food, therefore, more packaging is used to protect food. On the other hand, in different Egyptian societies, people tend to be shy of reusable products and using their own utensils in public. Behavioural norms are also a factor when it comes to the waste that is produced in Egypt. While buying something from a shop, the cashier will always insist on giving a plastic container or bag, as a sign of generosity. Culturally, it is impolite to refuse these types of generousities or if they are refused they can be misunderstood.

### 3.2. Youth in Egypt

Egyptians are influenced by trends due to Egypt's the high population of youth who tend to follow trends easier and faster. In that case, introducing trends would be convincing and sustainable trends can be successful in the Egyptian culture. The Egyptian population consists of a large percentage of youth which will allow the study to address a large majority of the population by targeting universities.

According to Buckner, higher education in Egypt is the largest in the region where 2.4 million students were

found enrolled in post-secondary institutes or universities between 2009 and 2010 (Buckner, 2013). Choosing youth as a main user of the waste management system proposed will benefit our research because younger users are more likely to follow trends and to adapt to sustainable systems.

**4. EATING CYCLE ON CAMPUS: THE CASE OF THE GERMAN UNIVERSITY IN CAIRO (GUC)**

The German University in Cairo is a self-sufficient university where most of its services and products including food products are produced on campus. Sandwiches, beverages, lunch, desserts and snacks are cooked, produced and packed in the GUC kitchen. However, not much attention is given to the packaging of the food served. The American University in Cairo’s Carbon Footprint report found 25% of solid waste produced by the university end up in landfills (Office of Sustainability, 2017). This backs up the need for establishing a reusable food packaging system.

**4.1. Food Preparation and Packaging**

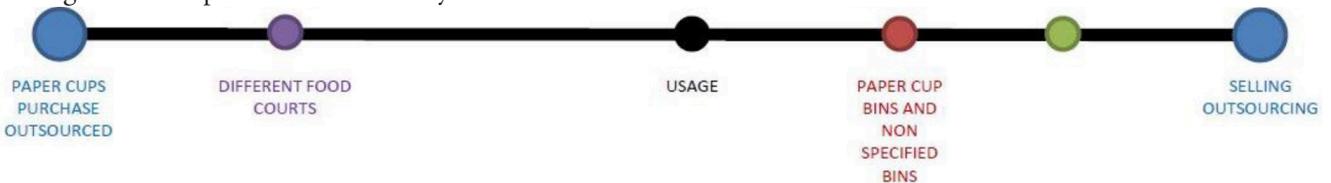
At the GUC, food is prepared by chefs at a central kitchen where it is then packaged securely and moved to different locations across campus. The packages used include cling film, cardboard plates, foam plates, paper cups, and plastic cutlery. Consumers buy the meals which are further packed into plastic bags to easily carry. The meals are consumed on campus usually within one hour of purchase. Water dispensers are provided by the university with regular changes of large water dispenser bottles as well as plastic water cups. Annually, the GUC uses 130,000 paper cups, 12,000 plastic cups, 130,000 plastic forks, 750,000 plastic spoons, and 45,000 plates (Waheba, 2017).

**4.2. Consumption on campus**

According to a survey conducted with 75 participants ranging from ages 16 to 34 who are students and staff members of the GUC, 27% rarely bring their own food from home and 79% sometimes, usually or always buy food from campus. However, 65% of the participants prefer homemade food rather than fast food or food served on campus. 69% of participants do not reuse their food packaging. It was also found that the majority of the participants would use sustainable alternative for all food packages provided at the GUC and 84% would participate in tasks to help recycle package waste. Therefore, it was found that there is potential in introducing a sustainable system where people on campus are willing and keen on finding alternatives and improvements to the current system.

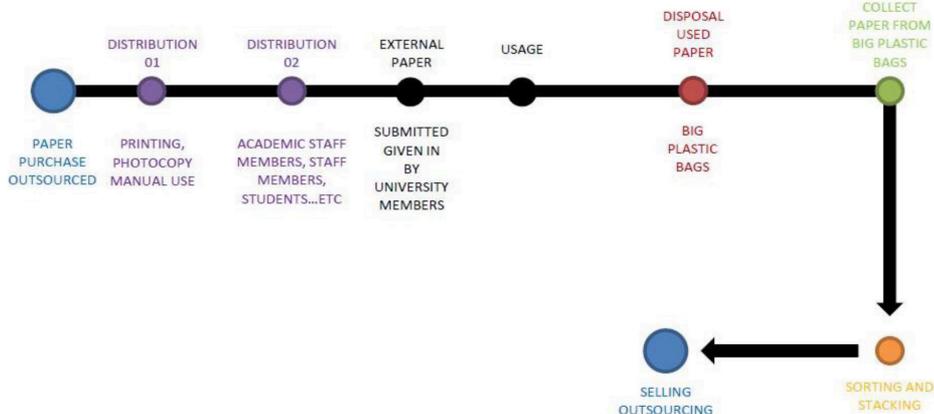
**4.3. Current Systems at the German University in Cairo**

The current situation of waste at the German University in Cairo can be shown in Figures 2 and 3. As most of universities and academic entities, huge amounts of paper are used and wasted. The use of paper goes in many different directions: exams, assignments, office work, etc. Paper purchase comes in many different forms and is distributed through different parts of the university.



[Figure 2] The Current System for the GUC’s Paper cups

Figure 2 shows the university’s current cup process as follows: paper cups are purchased from an outsourced manufacturer, then distributed through different parts on campus (cafeterias and coffee shops). After usage, paper cups are disposed in bins that are not specified to paper cups but are placed near by the coffee shop and cafeteria outlet. Afterwards, they are collected by the housekeeping department to be sold with the other collected garbage.



[Figure 3] Current Paper System at the German University in Cairo

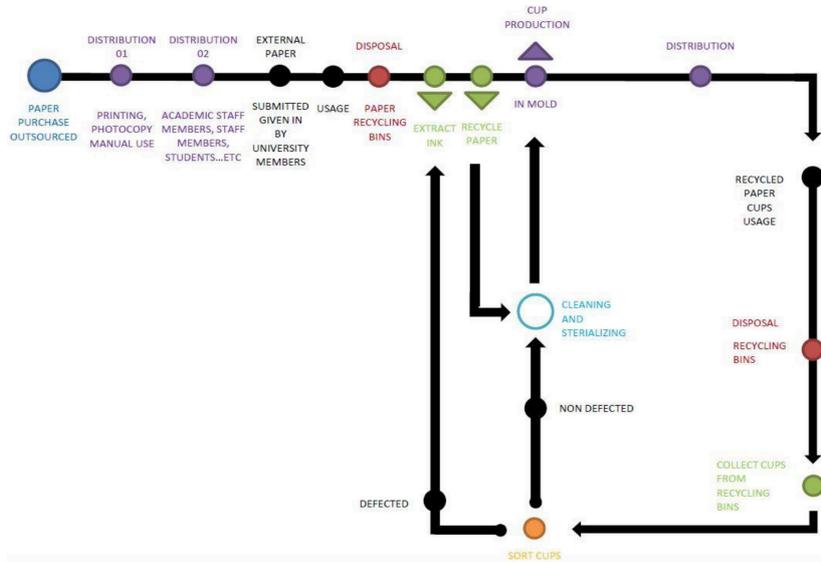
Paper does not only stop by the purchase of the university, it also comes from the students who submit their assignments and projects on campus. The campus becomes home to many paper from different areas. The waste of paper on campus is managed as follows: paper is purchased, then it goes to printing, photocopied or is manually used. Afterwards, it is distributed to different parties for use (academics, staff members, students, etc.). Paper is

disposed in big plastic bags in large quantities (for example, exam papers, assignment papers, projects). Used paper is removed by the house keeping department and transferred to a place where all paper is collected for sorting and stacking in order to be sold to paper traders.

**5. PROPOSED REGENERATIVE PACKAGING SYSTEM**

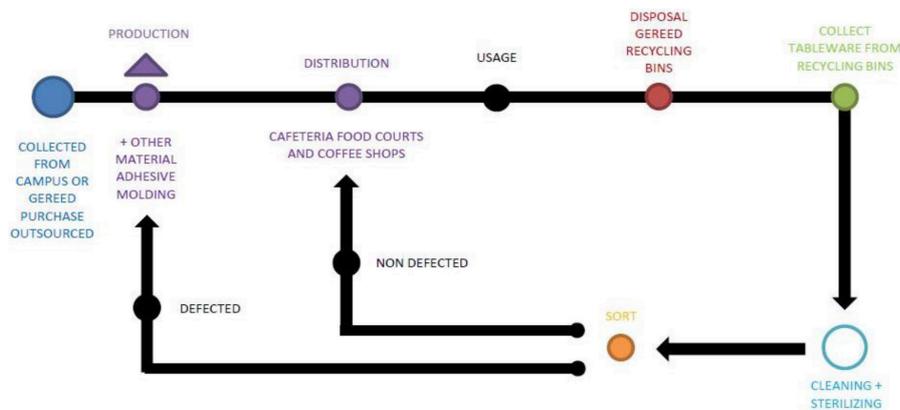
Based on our research findings, a proposed paper recycling system was developed (Figure 40 to create a regenerative system within campus paper consumption to achieve a minimum waste rate. In this system, the start is the same; paper is purchased in different quantities and printed on for different purposes. After usage, paper recycling bins are placed near every printer, office, copy centres and classroom. This will make collecting used paper waste easier for the house keeping department. Paper waste is then transferred to a spot where ink is extracted from the paper to be reused as writing ink. Paper will be shredded, recycled, and sterilized. After sterilizing, paper goes to production by pressing it into moulds to form the paper cups shape. Consequently, paper cups will be distributed to different places on campus like the cafeterias, and the coffee shops. After using the cups, they will be disposed in the cups recycling bins and the loop will continue again to go for sorting to two

different categories; the defected and non-defected cups. Defected cups go to recycling and moulding again, then to the cleaning station and sterilizing. However, the non-defected go directly to the cleaning and sterilizing station, then to be remoulded again.



[Figure 4] Regenerative Paper system for cup production at the university

Another system was developed for a long-term approach to incorporate reusable options for the university. For this approach, Gereed is used which is a material extracted from the leaves of Palm Trees and is renewed annually with approximately 965 tons are wasted every year in Egypt. The material is available in Egypt profusely as well as on campus where all exhaust leaves are thrown away with no use. The material can be made into boxes, planks, or curved and is a local renewable material (Eldeeb, 2017).



[Figure 5] Regenerative system for the development of reusable options made from Gereed

As shown Figure 5, the first step to produce the tableware is to collect Gereed from the university premises or outsource it externally. The material is grinded and an organic adhesive is added to hold the material together in the mould. The final products are then distributed to cafeterias, food courts and coffee shops where university members are to use the products as a replacement to plastic products. After usage, the tableware is disposed in specified bins

with clear signs for Gereed tableware. Tableware is collected by the housekeeping department from the specified bins. The tableware is transferred to be cleaned and sterilized and sorted to two different categories; non-defected and defected products. Non-defected products are directly transferred and distributed to the cafeterias, food courts and coffee shops. Defected products go back to reproduction, by grinding and moulding.

## 6. CONCLUSION

To conclude, an opportunity for enhancing the system of the university campus of the German University in Cairo was proposed by introducing a regenerative packaging system, by using both approaches, a recyclable products and reusable products. The systems address key elements of the existing processes to make use of every single part. They aim to reuse and regenerate different sources and materials already used on campus and introduced the reuse of the immense amount of wasted paper on campus to produce paper cups for everyday use on campus. Moreover, another regenerative system for reusable products using Gereed which comes from Palm tree leaves. Therefore, by following these systems the university will become more self-reliant and will reduce waste outcomes as well as be more cost efficient. The system targets student as trend setters to establish a new way of perceiving food and service in Egyptian culture. Once this environmentally friendly “trend” starts on campus other students and university members will also follow the trend.

## 7. FUTURE RECOMMENDATIONS

It is recommended that further testing be developed using the proposed systems to understand the behavioral acceptance of people towards applying these systems into their daily lives. It is also suggested that the systems and regenerative studies be applied in other universities across Egypt to further reduce and manage municipal waste. Further regenerative systems can be developed to incorporate other materials that are wasted on campuses and implementing the approach can be factored into the system of other workplaces in Egypt.

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## **DESIGNING FURNITURE BASED ON STUDENT'S LIFESTYLE AND MERGING WITH A SUSTAINABLE CAMPUS**

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### **ABSTRACT**

In this paper, we discuss the potential of an emerging form of sustainable design product as a solution to the space constraint problems caused by bulky furnitures. This study presents how students perceive the interior design from convenience and usability aspect for efficient space management. A quantitative research method was chosen to conduct a survey to execute the data analysis. Based on the results delivered from the survey, a series of interviews were scheduled with hostel authorities, architects, material vendors, and carpenters. A detailed analysis was conducted on the re-usability of materials from existing furniture with the addition of sustainable material alternatives in place of costly and not environment-friendly materials. The aim of this study is to discuss the step-by-step approach in design process while developing a new product and provide more defoliated area with ergonomically designed sustainable furniture and theoretically verify its credibility from the furniture design perspective.

Keywords: Design Process, Transformable furniture design - Hybrid Bed Model, Sustainable Materials, Space efficiency

## 1. INTRODUCTION

Every inch counts when living in a confined space [9] and so the use of transformable furniture has taken the market by storm over the past few years. Zhou and Chen in their paper “Computers and Graphics” have briefly elaborated the need for convertible furnitures [9]. Transformable space saving furniture is a revolution and innovation [7]. The versatile nature of this furniture in storing it in a compact form facilitates the better utilization of space. This space efficiency has fascinated the designers worldwide.

However, due to its intricate transitions, many designers have collaborated with skilled professionals to get acknowledged with the mechanical structures and properties of different materials to make the furniture both aesthetic and functional [7].

Ideation by sketching on paper has been replaced by 3D modeling on software. Therefore, computer-assisted furniture design systems have attracted a lot of attention in the area of computer graphics for decades [9]. The software modeled graphics well anticipated the design, leading to the creation of furniture with superior usability characteristics.

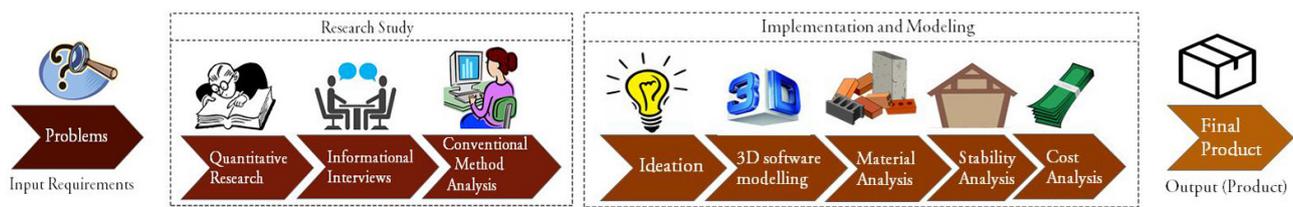
Thus, in this paper, we support the argument by Zhou, Jie, and Xuejin Chen on “Convertible Furniture Design” about the potential of an emerging form of sustainable design product as a solution to the space constraint problems caused by numerous bulky furnitures [9].

Thus, our perspective in this paper will make two contributions:

- i. Emphasize on the design procedure for the development of a new design.
- ii. Propose a new furniture design for efficient space management.

## 2. DESIGN PROCESS

Design-based implementation research can help [5] find a better solution without neglecting any structural, technical, material and financial aspect of the design. The design process is shown in figure 2.



[Figure 2] A step-by-step approach from a raw unfurnished input problem to a functional and aesthetically appealing output via an orderly approach of a design process

### 2.1. Research:

The first step toward developing a design-based implementation research is a systematic form of inquiry to comprehend the problems faced by existing furniture designs [5]. A quantitative research method was chosen with a survey as a form to execute the data analysis. The questionnaire was delivered through an intramail system of IIT Gandhinagar's current students and nearly 70 respondents participated in the survey. The inferential analysis was employed to interpret the collected data. Its results implied that there were great concerns related to space allocation in the room after housing the basic requirement of furniture (chair + table + bed). Nearly 70% of the students were unhappy either with their perspectives towards movement or storage space in the room.

### 2.2. Problem Statement:

#### i. Space Constraint:

The standard furniture sizes together lead to a shortage of space due to which there was space constraint for additional appliances or households like water cooler, plant pot, shoe-rack etc.

#### ii. Scantiness of shelves

Organization of personalized daily use items was rather difficult with no handy shelves or drawers.

#### iii. Difficult to dig out dust from the interiors

The dust allergic students and the cleaning staffs found it strenuous to clean the corners and the interiors of the rooms, lifting the heavy, immovable and bulky furnitures to reach the interiors, especially when things kept falling down.

### 2.3. Informational Collection and Conventional Method Analysis:

To understand the real issues associated with the existing furniture, types of materials and processes used, a series of interviews were scheduled with hostel authorities, architects, material vendors and carpenters. As a part of our design research activities, we designed a survey form comprising a questionnaire and conducted a survey within the students' community. Also, a research was conducted on how to reuse material from existing furniture of IIT Gandhinagar campus and improvise the new design with an addition of sustainable material alternatives in place of costly and not environment-friendly materials and processes.

### 3.IMPLEMENTATION PROCESS

#### 3.1.Ideation

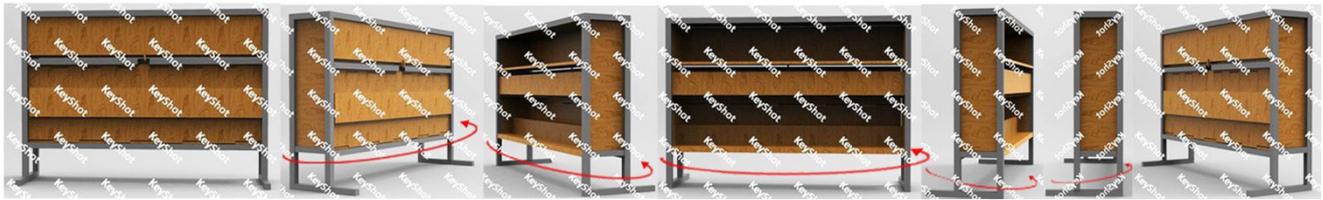
Technologies used in the newly developed products were explored to research on the consumer psychology, advanced sciences, hazardous effect of designs on the environment, to stimulate generation of new ideas, techniques, material and forms to be used in this process. Consumers preferred the goods that were easy to use and convenient to store. One such admirer of transformable furniture was a person living in a small room who liked doing yoga and exercise on the ground. He needed space that could be later used for some other purpose.

#### 3.2.Software modeling and designing

Computational implementation of the design is essential for having transparency in thoughts. It provides a better judgement on the dimensions and volume occupied by the model. This model of a hybrid bed was modeled using Rhinoceros software and rendered using Keyshot software. As a result of brainstorming with research outcome and conventional ideation process, the proposed design of a hybrid bed was conceptualized and presented to Institute authorities.

### 4. HYBRID BED

The hybrid bed is an innovative furniture design involving structural changes as per user convenience. It is a combination of the traditional architectural design of a bed, bench and table sealed in a small cuboidal area that expands when needed (as shown in figure 4). Its main approach was to solve the space constraint problem by reusing the materials of conventional designs. In 'closed position', it occupies a volume of 6'-11" X 1'-4" X 5'-6" (L x W x H) while in 'open position', 6'-11" X 4' X 5'-6" (L x W x H).



[Figure 4] A 360 degree view of hybrid bed in closed compact position

Other features of the hybrid bed are shown in Table 4.

General Features and Specifications: Hybrid Bed	
Particulars	Description
Size of entire structure	6'-11" X 1'-4" X 5'-6" (L x W x H)
Size of metal frame	Wall thickness 1.2mm CRC Square Tube Size: 1" X 1", extracted and fabricated as per desired the size from existing furniture
Wood/alternative to be used	Nutshell board section or wood composite sheet
Metal Coating	Powder Coated
Ply	18mm Thick, 3'X6'6" ISI Ply Oil Painted on both sides
Powder Coating	Black or as per selection
Wood Furniture Polishing	French Polishing
Minimum Thickness of powder coating	7 Micron
Platforms and shelves	Plastic wood

[Table 4] Features of Hybrid Bed

### 5.KEY ELEMENTS OF HYBRID BED:

#### 5.1.Bed and Mattress

The structure of the bed is held by a knob. To unfold the bed, the knob is first rotated by 90 degrees and then the stands are first pulled out from the structure after which the bed is gently tilted to stabilize in a horizontal position (as shown in figure 5.1). The mattress in 'closed position' lies vertically inside the hybrid bed structure and in 'open position' is titled along with the unlatched structure.



[Figure 5.1] A systematic approach to unlatch the bed in The Hybrid Bed

### 5.2. Bench/Chair

The stands of the bed are folded inside the structure to divide the bed into two halves, outermost acting as a stand for this bench position (as shown in figure 5.2). The mattress in this situation is kept vertical like in the 'closed position' of the bed to act as a back support.



[Figure 5.2] A systematic approach to transform the bed into a bench

### 5.3. Table

In this model, the table is suspended with the use of hydraulics on both sides, one attached to the top of the table and other attached to the inner side of the bed on each side in line with above hydraulic. The table drops down from the top, that was initially acting like the shelf cover (as shown in figure 5.3), to stabilized at a convenient height using hydraulics for better ergonomic stability. In the 'not in use' position, the table is supported by a knob that also holds the bed in its 'closed position'.



[Figure 5.3] A systematic method to unfold the table from a cover of the upper shelf

\*[Note: All the above images were extracted from a video that was previously rendered using unlicensed Keyshot software due to which while rendering the above Keyshot watermarks remained]\*

## 6.SUSTAINABLE ELEMENTS:

We plan to reuse the materials from the existing conventional designs of beds, tables, and benches to present more comfortable and economic solution. For example, the wood used in making the bed can be reused for making this structure. In order to further strengthen the sustainability element, it is suggested to use below-mentioned materials alternative to wood.

#### i. Nutshells

It is a recyclable material made out of crushed almonds, hazelnuts, and walnut shells. The innovative process of producing nutshell boards is unique and the most environment friendly approach to produce furniture without cutting down a single tree.

#### ii. Wood and waste paper composites

As the name suggests, composite materials combine wood with recycled plastics or other components. A study depicts that when the wood particle is blended with waste paper and made into a composite, the mechanical properties of the composite could meet the particle board for furniture [2].

#### iii. Plastic wood

A study by S. Mehmood, A. Khaliq and S.A. Ranjha clearly indicates that the wood wastes such as the primary and secondary wood wastes, municipal solid waste, paper waste, paper sludge and the agricultural crop waste can be processed into a usable form by mechanical milling and chemical treatments [3]. The waste materials can be formed into composite boards and used for making furniture and other applications.

#### iv. Bamboo

Bamboo is often considered wood, but this grass is really a wood alternative. It is a very trendy option as furniture, flooring or structures. It is proved that the bamboo is extremely renewable material compared to other hardwood species which are growing for at least 50 years. Bamboo grows quickly (6 months to 2 years) to its mature height and can be harvested after 3 to 5 years [1].

#### v. Hemp

According to the research conducted by DeeDee De Miranda, Colorado State University, it is suggested that hemp is a viable fibre used in furnishing applications. Among the facts concluded in the study, it is claimed that hemp is stronger and more absorbent than cotton. It also possesses UV protecting properties, superior to any other fibre [4].

## 7.ANALYSIS:

### i. *Stability Analysis*

An exhaustive study was conducted to estimate the approximate strain and moments of force acting on the bed when the bed is in use and at its closed position. Parameters such as Young's modulus of the wood, stress, an approximate distribution of force and center of mass distribution in each position were considered. Mechanical properties and basic physical formulae were used to calculate the result. Unpredictable disturbances in surrounding, like the lateral force acting on the top of the furniture, were taken into consideration to improve the yield of the result.

### ii. *Cost Analysis*

The qualitative and quantitative analysis of materials were conducted to ensure maximum productivity for the given price range. The outcome of the study stated that the material cost of the furniture was quite less.

## 8.ADVANTAGES OF THE PROPOSED DESIGN:

### i. *Greater Space efficiency:*

The fact that everything fits in a small cuboidal area helps in fruitful usage of space outside the cuboidal area. When not in use, the structure can be easily folded to consume minimal space of less than one-third of its total volume, thereby, ensuring a larger effective area of the room.

### ii. *Dust-free surrounding:*

A healthy mind strengthens in a cleaner environment. Our productivity increases when our surrounding is clean. But often, due to the large shape of beds, it becomes hard to dig out dust from the corners and the center of the space occupied by the bed. The foldable mechanism ensures easy reach to every bit of land without disturbing the major setting of bed. Thereby, proposing a more hygienic atmosphere.

### iii. *More Organized Room:*

The provision of many scattered multipurpose shelves ensures efficient utilization of space. Space provided can be creatively used as per user requirements like frequently used items such as bottles or pen stands can be kept on the shelf in line with the bed while the books can be kept on topmost shelf and shoes can be organized below the bed.

### iv. *Better Cost Efficiency:*

According to the statistics of cost analysis, the manufacturing cost of the structure is comparable to the cost of a well-polished bed as this structure focuses on the use of cost-efficient and reusable raw materials. So Hybrid bed will be sold at an affordable price with high degree of quality that will fit within the budget of the user without burning a hole in their pocket.

### v. *Aesthetically Appealing*

Transformable furnitures are usually very trendy and catchy due to their stylish nature. Hybrid bed also possesses all those qualities along with its simplicity in using the natural texture of the materials used as its aesthetic element.

## 9.CONCLUSION AND FUTURE WORK:

In this paper we have presented our perspective of the design process with its implementation and execution shown in the new design of space efficient and sustainable model of a hybrid bed. We are optimistic about the potential of this new design of Hybrid Bed and believe that the current space problems can be eliminated, providing a larger defoliated area for productive use. We plan to work more on the aesthetics of the design to reduce the use of raw materials and yet present a sustainable product. Also, the mattress can be resigned for more ergonomic convenience along with newly introduced sustainable materials.

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## **PERIOD. A CARD GAME ON SOCIAL TABOOS AROUND MENSTRUATION**

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### **ABSTRACT**

PERIOD. is a co-operative card game designed to address prejudices related to menstruation and menstruating women. The game, encourages dialogue around the otherwise tabooed issue of menstruation and acts as a conversation starter, recognizing a woman's power to express their choice and voice their opinion. It is played by both men and women alike, sensitizing them regarding this integral issue, and creating a sense of empathy. The game play is such that one enters the places that stereotypes menstruating women or is inaccessible to them; such as a place of worship, sports field, workplace or school. Collective and cooperative actions can help break these prejudices and winning is possible, in the game as well as the real world.

## INTRODUCTION

Sustainable Development Goals have been adopted by the United Nations in 2015, as indicators of development by addressing key issues for holistic social development. This includes addressing issues of poverty, hunger, gender equality, education, clean energy, consumption and developing global partnerships, urbanization, environment and social justice. Women have a critical position in SDGs in present context. Goals like gender equality, clean health and sanitation, quality education, decent work and economic growth, sustainable consumption and economic pattern have objectives that specifically deal with equality, health, education and empowerment of women. There are several other issues that are not directly addressed by specific SDGs but are critical to the success of the SDGs. The cyclic monthly process of menstruation is a natural physiological process of the female body.

## TABOOS IN INDIA

Even at the turn of 21st century myths and taboos prevail around menstruation in different cultures and traditions of the country. Considering women impure, considering menstruation un-holy, isolation of women, restraining from sexual intercourse are consistent across all cultures. (Guterman M 2007). (Manju Kaundal 2014) It is ironic as in the same country menarche is celebrated and festivals are celebrated when goddess are believed to be menstruating. Festival in *Kamakhya Devi* temple in Orissa or closing temples after *Navratri* (festival of Goddess) till full moon believing the goddess needs rest through her menses are few such examples (Chawla 1994). In south India Puberty functions are celebrated in pomp. Yet few temples restrict entry of women in their menstruating age considering them impure or cursed. After the unprecedented fight led by women and progressive groups, Supreme court has allowed entry of Women in the Sabrimala temple in Kerala, Shani Shingnapur and Haji Ali mosque in Maharashtra (BBC 2018).

## NORMALIZING MENSTRUATION

As menstruation is considered a curse and deemed as impure, Women are not allowed to visit worship places. 77% women observe this restriction. (van Eijk, et al. 2016). Even in their homes restrictions are made so severe that women isolate themselves from the rest of the members and parts of the house. 26 % women sleep separately and 24% women are reported to sit separately. 30 % women observe various food restrictions imposed on them by themselves or society. (van Eijk, et al. 2016). When menstruation cannot be managed with dignity it impacts human rights, including right to education, right to work, right to health, and gender equality. It is thus important that with others things, women, girls and anybody menstruating should have right to improved health facilities and health related education. Hence the potential impacts of the game include normalizing discussions regarding menstruation, creating awareness about importance of menstrual hygiene management. This is important objective of SDG #3 Good health and Wellbeing at all ages.

Taboos propagate due to false or poor understanding about menstruation. Such myths and taboos create a culture of silence around this topic. Only 23% of girls are aware of uterus as source of bleeding (van Eijk, et al. 2016). For over 50% of girls mothers are source of information (van Eijk, et al. 2016). As much as 70 % of mothers believe menstruation to be dirty and polluting (van Eijk, et al. 2016). It causes adverse social and educational impacts on the adolescent school going girls. About 24 % girls miss school during their menstruation (van Eijk, et al. 2016). It is important to provide scientific information regarding menstrual hygiene management and curb taboos at right age. The game through its co-operative gameplay promotes discussions on the usually hushed up topics. This will help to strengthen cooperative effort towards ensuring inclusive and equitable quality education which is important objective of SDG #4 Quality education.

'Period' being a game which is not restricted to only females will help to achieve gender equality and empower those who menstruate by providing a chance to create dialogue across different genders. This will help in developing inclusive, equal and productive platforms in society. This addresses SDG #5 Gender Equality.

## METHODOLOGY

The research is for the most part auto-ethnographic. Pulling out from our personal experiences as women, using self-reflective exercises such as collectively creating diagrams related to our Dreams, Choices and Obstacles, helped us map out the game. There were semi structured interviews carried out as well to gather qualitative data on the various obstacles adolescent girls/women face related to menstruation. The game play itself was an iterative process which was revised with every game test. There were three iterations made.

### Iteration 1:

In the first iteration we decided the game to be a cooperative card game where the players will help one another to win. There would be three sets of cards: Dream card, Obstacle card and Choice card. Content would be written on each of these cards.

- 1). The dream card contained a) I want to become a pilot, b) I want to pursue higher education, c) I want to stay single, my entire life. etc.

- 2). The Obstacle card contained a) You can't be out late at night, b) Wear decent clothes, why is your cleavage showing? c) Don't enter the kitchen or the temple, you're impure. Period.etc
- 3). The choice card contained a) I chose to not get married now. I want to focus on my career, b) I chose to enter the kitchen, and do my daily prayer. I am on my period, c) I chose to not have children. I am not ready.

Game Play: a) Each player will get 5 dream cards. b) The player has to pick up 1 card from the stack of shuffled obstacle and choice cards. If a player gets an obstacle card then he/she has to give away the dream card. c) If a player gets a choice card then he /she can collect one dream card from the stack. d) If a person is losing a dream card then another player can help that person by giving his/her choice card. For this, the content on the choice card and obstacle card should complement each other. f) If a player loses all his dream cards then the game ends.

Challenges we faced while playing: a) For some of the cards the content did not match, b) Winning situation could not be achieved.

### Iteration 2:

In the first iteration we had considered larger problems like gender inequality, domestic violence etc. In the second iteration we narrowed down our topic to 'Menstruation'.

In India there are many taboos about menstruation like women should not enter the kitchen while on period; women should not enter the temple while menstruating and so on. So the aim of the game was to collectively achieve any place card like temple, kitchen, work, etc. by overcoming all the taboos with the aid of 'Helping cards'. Here we came up with the idea of a board game which could be navigated using play cards. The layout of the game was a spiral path with blocks on it. Each block had some obstacles that would create a setback for the player. There were helping cards to aid the player move forward on the board. It will act as a dice. If everyone reaches the end point i.e. a certain place then you win the game. The obstacles are written on the board which will have certain tasks like 'skip a turn', 'take 3 steps forward', etc.

### Iteration 3:

After many iterations and play tests we decided the final format of the game to be a card game.

The aim of the game is similar to the previous iteration i.e. to collectively win a place card. Players will be dealing with Place Cards, Power Cards (Empowering Card), Prejudice cards (Obstacle Card) and Pioneer Cards (Master or Helping Card). There will be 6 cards each of power card and prejudice card. There will be total 6 Pioneer cards. When all the 6 power cards of a particular place are achieved cooperatively then the group is successful in entering that place. Prejudice cards are obstructing the player from collecting more power cards. While Pioneer cards are used to aid the player.

## PROTOTYPE

In the next stage we created a final prototype of the third iteration. The following is the set of rules defined for the game.

The game has four types of cards: Place, Power, Prejudice and Pioneer

1. Place Cards: These are the places which the players have to collectively enter. There are 5 such place cards viz Sports, Kitchen, Temple, School and Workplace. Each place is associated with a color. Example:

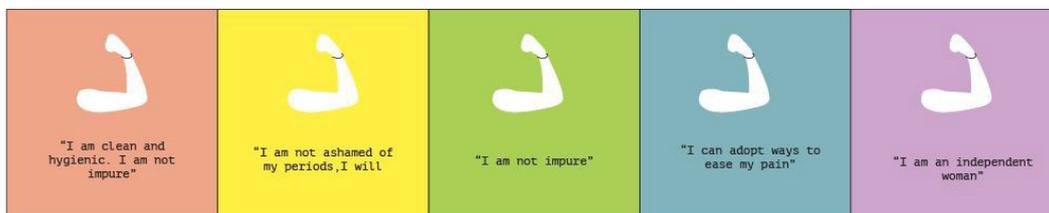


[Figure 1] Game Play and Instructions



[Figure 2] Place Cards

2. Power Cards: Each place card has six power cards associated with it. The players need to collect all six power cards to enter a certain place. Each power cards has some content written on it. Example:



[Figure 3] Power Cards

3. Prejudice cards: Each place has six prejudice cards associated with it. These cards are like setbacks in the game. When any player gets a prejudice card of a particular place then he/she cannot collect any more power cards of that place. Each prejudice cards has some content written on it. Example:



[Figure 4] Prejudice Cards

4. Pioneer cards: There are six pioneer cards. These cards are like master cards which aid the player. Each pioneer card has some text written on it. These cards help the players to get rid of the prejudice cards. Example:



[Figure 5] Pioneer Cards

## USABILITY TESTING

The game was tested among 4 groups.

Group No.	No. of Members	Age Group in Years	Gender	Insight from Testing
1.	5	28- 40	Male – 2 nos. Female – 3 nos.	Some members were uncomfortable while reading the content. Also they were unaware about certain taboos existing in India.
2.	4	16-24	Female - 4 nos.	While reading the content members were able to relate it to their own personal experience. The members were discussing about the taboos.

3.	4	20-30	Male - 2 nos. Female - 2 nos.	In the beginning the players were confused about the game play but later understood it. The men found few taboos to be funny since they were learning about it for the first time.
4.	4	30-40	Male – 1 nos. Female – 3 nos.	The players were discussing about their personal experiences. They enjoyed the game till 7-8 rounds but later felt it to be less interactive.

*Table 1: User Testing and Insights*



*[Figure 6] User Testing*

We also got an opportunity to present our game at ‘We the Women 2018’ conference in Bangalore which was conducted by Barkha Dutt. The game idea received tremendous response and also we got a chance to conduct user testing with different people from different backgrounds.



*[Figure 7] User Testing at ‘We the Women, 2018’ Conference*

People found the game to be very innovative and interactive. The content written on the cards is effective and it makes the player realize the intensity of the issue. The game can be a conversation starter while in a group. It can be used as a learning toolkit for school children to educate them about menstruation and the prevailing taboos in India. The content written on the cards can vary according to place, language and audience.

## CONCLUSION

The game can be used as Interactive, educative tool to create inclusive work and social spaces through change at various levels (institutional, individual and societal levels). It has potential to promote positive sustainable development through change in behaviors, policies and practices by achieving the above mentioned objectives related to SDGs.

The ‘Period’ game is designed with the same motive of bringing about the sustainable development in society by creating positive social norms around menstruation by breaking down taboos and myths through collective action. In a context in which puberty, sexuality, and sexual and reproductive health are not discussed fully and openly in families, communities, or schools, a tool like this needs to be initiated to minimize stigma around menstruation and encourage a healthy menstrual attitude. What the game does in its play is that it compels the players to read out aloud and address taboos related to menstruation, which otherwise is a topic spoken about only in whispers, or

strictly female groups. Identifying and then accepting a problem is the first step to solving it, and by encouraging dialogue during play, the period game aims to do that. It acts as a conversation starter, not only among women but also between diverse groups of both men and women. It is essential that this topic does not remain confined to being a female problem only, but is addressed as a societal issue, which strongly impacts the mental and physical well-being of women.

As a result of various gameplays we have concluded that the game enables both, men and women to empathize with the latter facing and overcoming obstacles related to menstruation. Among adolescent girls (12-15 yrs.), on the onset of puberty, it brings a certain level of awareness about this issue.

## FUTURE PLANS AND DEVELOPMENT

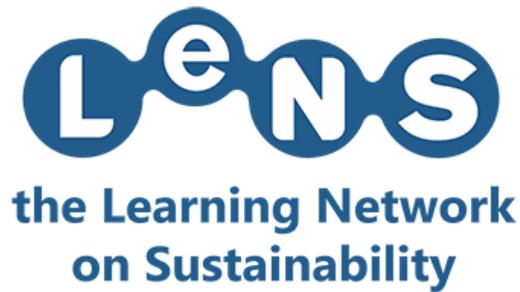
The “Period” game has undergone the first phase of developing into a finished product. The game is currently in English only. However, with India being a multilingual country, and in order to have a far reaching base, it is essential to translate the game into regional languages. It is only with this translation that percolation of the message will be possible to all layers of society. The other step to take would be to adequately present the game as the learning and awareness tool it primarily is and to be able to use it in educative and health purposes.

## ACKNOWLEDGEMENTS

We would like to acknowledge the contribution of Dr.Padmini Ray Murray, our facilitator for the unit Digital Humanities at Srishti Institute of Art, Design and Technology, Bangalore; during which the project was conceived. We would also like to acknowledge the contribution of Cristina Muto, exchange student from Politecnico di Milano as co-founder of the project.

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## **ESTABLISHING A QUANTITATIVE EVALUATION MODEL FOR CULTURE-BASED PRODUCT DESIGN**

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### **ABSTRACT**

Recent years have seen a rapid growth in the cultural and creative industries worldwide. The design quality of culture-based products, however, is relatively low for a lack of reliable methods of designing and evaluating them. This paper is aimed to establish a quantitative evaluation model for cultural-based product design. Firstly, keywords of the comments on selected culture-based products were obtained through web crawler, text abstraction, and literature review. Secondly, evaluation indicators on extracted were acquired through card sorting by experts, and weight score was obtained through questionnaires. Finally, the quantitative evaluation model was obtained through logistic regression analysis. The model proposed in this paper is helpful for designers to understand the development trend of cultural creative design and the important factors influencing cultural creative design.

Keywords: Cultural-based product, Quantitative evaluation model, Web crawler, Logistic regression

## INTRODUCTION

The cultural and creative industries have been expanding rapidly worldwide, yet the design quality of culture-based products remains at a relatively low level. The creative design of culture-based products is featured with subjectivity, uncertainty, and complexity (Chandrasegarans K, Ramani K, Sriramr D, et al. 2012). Designers, consumers, and producers have a different understanding of the design outputs, and the decision-making and communication of related stakeholders are separated (Kelly K, 1994), therefore it is urgent to have relevant evaluation model in the cultural and creative industry. The design evaluation model can be helpful for establishing unified evaluation criteria in the design process. Its strategic guidance and systematic plan of design evaluation model can effectively lead to a distinctive design image for culture-based products. Currently, relative researches in the evaluation model are insufficient in China. This research aims at establishing a quantitative evaluation model for culture-based products and providing effective guidance for cultural creative designers. This research adopts data from web crawler, then obtain 5 evaluative indicators by card sorting, finally put forward the evaluation model of culture-based products with logistic regression analysis.

## LITERATURE REVIEW

Culture-based products reflect cultural extension and materialization. For cultural protection, more and more designers participate in cultural and creative design. Donald Arthur Norman (Norman D A, 2015) believed that the design includes three layers: external layer (product color, texture, and design), middle behavior layer (operability, security, and functionality) and internal layer (special meaning of product, storytelling, and sentient involved).

Based on his research, the three layers can be made as the design connotation of culture-based products. The expression of design connotation should use reasonable way, which should not only realize cultural inheritance but also adapt to modern people's sentiment in life. On the whole, the characteristics of culture-based products can be summarized as uniqueness, territoriality, innovation, and added-value.

Jones pointed out that the design was composed of analysis, integration, and evaluation (Jones, 1992). Rosenman thought that design evaluation needed to compare the product with the expected result, in order to understand how to improve the design outcome (Rosenman M A, 1990). The above two scholars verified the necessity of design evaluation, and they believe the design evaluation can advance the iteration cycle of culture-based products and the sustainable development of the relative industries. Currently, there are few pieces of researches on the design evaluation model. For instance, Xu Zhixian et al. (Xu Qi-xian, Lin Rong-tai,2011) selected the representative samples of Taiwan's culture-based products and adopt quantitative to understand consumers' preferences, and the result showed that consumers paid more attention to product performance, texture, fashion, creativity, sustainability, storytelling, and regionalism. Rung-Tai Lin refined the design process of culture-based products by studying cross-cultural product cases, so as to explore how to establish design evaluation models (Lin Rong-tai, Liu Bang-chu, LI Ying-jie, 2010).

The scholars established the evaluation models of culture-based products from different analytical perspectives. In summary, their researches focused on extracting keywords from the design process of culture-based products and the product samples. But there are a few shortcomings in the research, such as single sample category, insufficient samples, and limited geographical selection. In view of the above analysis, the research of this paper is to discuss culture-based products at home and abroad and propose the evaluation model based on sufficient data.

## METHODOLOGY

Firstly, this paper used web crawler for data collection. Secondly, some experts with 5-10 years' experience extracted the keywords from the thesaurus with card sorting and then concluded the evaluation indicators. Then, experts were requested to grade the samples of culture-based products in the form of questionnaires according to different indicators, so as to study the relationship between variables and culture-based products. Finally, the binary logistic analysis was utilized to analyze the data results, and rank the weight hierarchy (Roozenburg N F M,1995) of evaluation indicators, and establish the framework of the evaluation model.

## DATA COLLECTION

By analyzing the classification of creative products by UNESCO and UNCTAD (UNCTAD,2018), this paper divided them into 4 categories: culture-based gift, office supplies, home accessories, and native products (wine, tea, and medical materials).

The research selected culture-based products above 4 categories as the research objects, which were published by the Palace Museum, the Taipei Palace Museum and the British Museum, and popularly and influentially in the field of cultural creativity at home and abroad. By crawling user comment keywords with Python toolkit(Liu X, Hu W,2018), this research provides real data support for the establishment of an evaluation model.

A total of 32,897 comments were crawled from the user's comments over the past year. Subsequently, the keyword extraction was carried out through the CRF algorithm(Nikolaos Korfiatis a, Marios Poulos b ,2013). Keywords with high frequency and strong characterization were selected, and the meaningless words (such as modal words, auxiliary words, prepositions) were filtered. Finally, 78 comment keywords were available from the 5000 words crawled.

**DATA ANALYSIS AND RESULTS**

**1. Abstraction of core keywords**

Due to the different meaning of the comment keywords, the method of card sorting was adopted for clustering analysis.

First of all, 20 graduate students majored in industrial design and 10 designers experienced in cultural and creative design for over 5 years were selected. 78 Cards labeled with the keywords were randomly distributed to 30 design experts, and the experts classified the keywords according to the semantic category. Then the classification result was discussed repeatedly until no objection exists. The statistical diagram of the thesaurus was shown in Figure 1.

Through the comparative analysis of the core keyword, 5 evaluation indicators were finally defined. The indicator differs from each other largely, which reflects the cultural, innovative, experience and design of the culture-based products.

To sum up, 5 semantic words were selected as the evaluation indicators, including storytelling, humor, elegance, craftsmanship and novel appearance.

**2. Weight analysis of evaluation indicators**

This article firstly selected 90 kinds of culture-based products randomly from the well-known creative stores and forum sites for making the questionnaire survey. According to the picture of each product which was labeled with their processes, material and design source in the questionnaire, 15 products which were considered to be innovatively needed to be selected. Evaluation questionnaires were distributed to 50 design experts and 100 consumers, and 144 valid questionnaires were collected. Depending on the evaluations of the experts and consumers, the top 15 and the bottom 15 were used for the evaluation indicator weight score questionnaire.

Distributed the questionnaire of “product evaluation indicator weight score” to 30 design experts, who were required to give scores to five evaluation indicators with the five-point Likert scale. Finally, 28 valid questionnaires with 742 sets of data were collected in total, and these data were integrated for binary logistic regression analysis.

Storytelling	Humor	Elegance	Craftsmanship	Novel Appearance
Archaic Chinese Rhyme	Special	Quietly Elegant	Refined	Novel
Primitive Simplicity	Amusing	Gracious	Textured	Unconventional
Retro	Fascinating	Restrained	Excellent	Chic
Classical	Divertingness	Delicate	Lean	Fresh
Lasting Appeal	Interesting	Pretty	High-quality	Original
Historical Feeling	Distinctive	Polish	Legible	Creative
Literature	Unique	Historical	Durable	Stereoscopic
Artistic Style	Humorous	Pure	Mastery	Etherealize
Culture	Witty	Magnificent	Exquisite	Flexible
Cultural Deposits	Antic	Elegish	Practical	Innovative
Moral	Fantastic	Tasteful	Pragmatic	Extraordinary
Feelings	Weird	Gentle	Comfortable	Unusual
Propitious	Absurd	Artistic	Ingenious	
Connotations	Vivid	Beautiful	Massy	
Inheritance	Lively	Gorgeous		
Cultural Heritage		Pure		
Cultural Continuity		Attractive		
Auspicious		Demure		
		Gracious		

[Figure 1] Thesaurus clustering under expert evaluation

The selection and scoring situations of the culture-based products were detailed in Table 1.

High Rank							Low Rank						
Products	Storytelling	Humor	Elegance	Craftsmanship	Novel Appearance	Average score	Products	Storytelling	Humor	Elegance	Craftsmanship	Novel Appearance	Average score
	4.1	4.3	2.7	4.1	2.9	3.62		1.6	1.4	1.5	1.5	1.5	1.50
	3.7	3.9	3.1	4.3	3.2	3.64		2.1	1.6	2.0	2.1	1.7	1.87
	3.6	3.3	3.3	3.8	2.8	3.36		1.9	1.7	2.2	2.0	1.9	1.93
	4.2	3.4	3.2	4.4	3.1	3.66		2.1	1.6	1.5	1.7	1.8	1.72
	4.3	3.9	3.9	3.2	2.9	3.64		2.7	1.7	1.6	2.0	1.6	1.90
	3.8	4.1	3.2	4.5	3.2	3.76		1.7	1.5	2.1	1.6	1.7	1.72
	3.9	4.0	3.5	3.8	3.2	3.68		2.5	1.5	2.1	2.3	1.8	2.03
	3.9	3.0	3.2	2.7	3.0	3.16		2.3	1.5	1.7	2.0	1.5	1.70
	4.1	3.3	3.5	3.3	2.9	3.40		2.3	1.5	1.7	1.8	1.8	1.81
	4.1	4.1	3.8	3.1	3.5	3.72		2.1	1.9	2.3	2.0	2.5	2.16
	4.2	4.2	3.1	4.2	3.6	3.86		2.0	2.0	1.7	2.0	1.6	1.83
	4.0	3.0	3.2	4.1	2.9	3.44		1.8	1.5	1.7	1.8	1.5	1.58
	4.1	3.3	3.7	3.4	3.4	3.58		2.0	1.5	1.8	2.1	1.5	1.75
	4.0	2.7	3.1	4.2	3.0	3.40		2.3	2.0	2.3	2.4	2.3	2.24
	4.2	3.5	3.2	3.3	3.6	3.56		2.1	1.5	2.2	2.2	1.7	1.95

[Table 1] Sample data of cultural and creative products

### 3. Results analysis

Take innovation as the dependent variable, storytelling, elegance, novel appearance, humor, and craftsmanship as the independent variables to establish a binary logistic regression model. The regression analysis results in Table 2. It can be seen that the P value of novel appearance is more than 0.05, which shows that novel appearance has an undistinguished influence on innovation, the P values of storytelling, elegance, novel appearance, humor as well as craftsmanship are less than or equal to 0.001 respectively, which indicates that these 4 evaluation indicators have a significant influence on innovation. Based on specific values of each evaluation indicator, the influence degree of evaluation indicator on innovation is ranked from large to small as follows, storytelling — humor — elegance — craftsmanship — novel appearance. Take into account this, the regression equation can be obtained,  $y = -10.276 + 1.438 * \text{storytelling} + 0.164 * \text{novel appearance} + 0.956 * \text{elegance} + 1.089 * \text{humor} + 0.535 * \text{craftsmanship}$ .

In order to determine the credibility of the above 5 important factors affecting innovation, structured interviewees are conducted from the 30 scorers. All of them have been involved in the cultural and creative industry for 5–10 years. Three evaluation indicators are identified as having a great impact on the innovation of culture-based products by interviewees: storytelling, humor, and elegance. As they said:

	B	S.E	Wals	df	P	Exp(B)	95% C.I. for EXP(B)	
							Lower	Upper
Storytelling	1.438	0.187	7.689	1	0.000	4.214	2.920	6.080
Novel- Appearance	0.164	0.179	0.917	1	0.359	1.179	0.829	1.675
Elegance	0.956	0.186	5.129	1	0.000	2.602	1.805	3.749
Humor	1.089	0.161	6.782	1	0.000	2.972	2.170	4.072
Craftsmanship	0.535	0.161	3.332	1	0.001	1.707	1.246	2.338
Constant	-10.276	0.832	-12.354	1	0.000	0.000	0.000	0.000

[Table2] Dual logistic regression analysis of innovation

- 1). I like the product that embodies the cultural story so that people can feel what it express, as if to tell you a certain place, a certain time, what happened here. And they must be beautiful and interesting.
- 2). Designers pay more attention to the products' appearance, which is not only generous, elegant, beautiful but also cultural. Now the traditional handmade products are very few. After all, manual fees are very high, and handcraft is the best choice when the budget supports.
- 3). The prospect of culture-based products is getting better and better, and our own traditional skills used to promote innovation. Tourists often buy products with traditional patterns. They feel that the most primitive product present the most authentic taste of our place, and we should try our best to protect the cultural heritage.

### 4. Application verification

This paper selects another 3 culture-based products, and a questionnaire survey is carried out to verify the model with its scoring input regression equation. Based on market researches, the article gets the conclusion that 3 product score rankings are basically in line with their market response. Therefore, the model is reliable and practical accordingly. The calculation process of regression equations for 3 innovative products is as following Table 3.

Product Picture	Storytelling	Humor	Elegance	Craftsmanship	Novel Appearance	Model Score	Sales Ranking	Praise Ranking
	4.1	3.0	4.4	4.1	4.3	5.992	1	1
	4.2	3.0	4.2	4.2	3.6	5.883	2	2
	4.1	3.5	3.8	4.1	3.1	5.766	3	3

[Table3] Analysis results of model application for three products

## DISCUSSION

This paper selected the representative products of Taiwan, Britain, and China as the research objects, and considered how to establish the evaluation model reasonably and effectively under the cross-cultural differences. The research method in this paper carried on quantitative investigation and interviews to support the research result. The result shows that storytelling, humor, elegance, and craftsmanship are important influence factors affecting the cultural creative design. Storytelling is an important design reference to product connotation, which sublimates the value of culture-based product. Elegance stresses the innovation output is elegant and unique, which give guidance to external form, texture, color, and strengthen aesthetic value. Humor gives more surprise to people, and the unique culture-based product can present the brand value intangible. Craftsmanship temperature is the important presentation

of the technical value of culture-based product, the institutional cultural symbol can arouse rich cultural memories and emotional resonance. Cultural creative design should pay attention to the rational expression of culture, not to the shape to attract attention, so the impact of novel appearance on the innovation of culture-based products is not high. However, novel appearance is also an indispensable factor in cultural creative design. The above-mentioned indicators can provide suggestions and guidance of design aspects for the designers.

But this research still exists with limitations: firstly, this paper only takes physical products as the main research objects. Due to the limitations of the questionnaire, APP, VR, and other new media products did not be contained in research. Secondly, the research conducts a questionnaire survey for design experts and consumers, however, craftsmen, producers should be included in the survey in order to improve the robustness of the research results. Finally, the sample size is less.

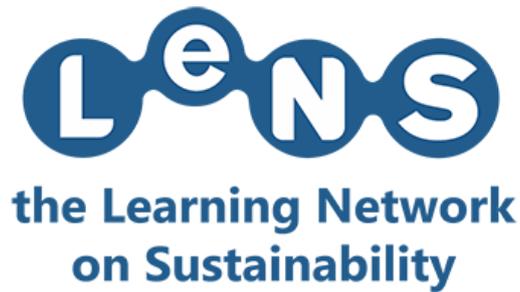
## CONCLUSION

This paper adopts web crawler for data collection to analyze the culture-based product samples in the current market. Then, experts conducted card sorting and questionnaire to get indicator weight score data. Binary logistic regression analysis is used for data analysis to get the weight hierarchy: storytelling — humor — elegance — craftsmanship — novel appearance. Furthermore, the regression equation of evaluation mode can be obtained:  $y = -10.276 + 1.438 * \text{storytelling} + 0.164 * \text{novel appearance} + 0.956 * \text{elegance} + 1.089 * \text{humor} + 0.535 * \text{craftsmanship}$ .

This paper systematically discusses the method and process of establishing the evaluation model, which provides a systematic reference to the relative studies. This paper proves that big data is an effective research method, which is useful for cultural creative design created in a cross-cultural context.

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## **SUSTAINING CULTURAL HERITAGE : DERIVING THE CONTEMPORARY FROM THE IDIOM OF TRADITIONAL CRAFTS**

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### **ABSTRACT**

This paper explores ways to contemporize traditional crafts by adapting them for the modern context by proposing symbiotic craft-design relationships that can be helpful for development and sustainability of cultural crafts.

To research such synergies between craftsmen and designers, the authors worked with craftsmen to develop interior products. As part of a classroom project, design students collaborated with craftsmen to create new product concepts.

The study proposes that Craft–Design collaborations can result in products that combine the existing traditional aesthetic and hand-skills with innovative thinking. This alliance between craft and design can lead to a win-win situation for both sides.

Giving a new life to traditional practices/crafts will promote and sustain this cultural heritage and provide craftsmen with increased earnings, while ensuring that both Tangible and Intangible traditional skills are preserved for posterity, and the rich legacy of India's crafts can continue to be enjoyed and admired.

Key Words: Contemporary, Cultural Heritage, Design Intervention, Sustainability

## INTRODUCTION

With a background of the rich crafts heritage of India, this paper aims to explore ways and methods to contemporize traditional cultural crafts to adapt them to the context of modernity with application in interiors. The study proposes symbiotic craft-design relationships that can be useful for development and sustainability of cultural crafts.

Since a significant part of the Indian population is dependent on crafts for their livelihood, it becomes imperative to preserve and nurture these traditional crafts. Indigenous communities have traditionally created products primarily for their own consumption, and some may be set aside for trade and bartering, but barring a few, most traditional crafts today are stagnating and on the verge of dying out due to use of outdated designs that do not conform to modern day consumer demand as well as availability of cheaper products that are produced industrially.

As per the current trend predictions, Hand-made is becoming the Luxury brand of the future, especially in the realm of Interior design. Products that have a cultural value and uniqueness as compared to mass-produced goods are finding a growing niche market today, especially with all the current awareness of sustainability issues and interest in all things cultural.

The paper looks at ways to contemporize traditional crafts, and provide them a place in modern interiors, not merely as a decorative piece but also something that can be functional and still possess that link between the old and the new with an aim towards sustenance of our cultural traditions.

Due to the changing consumer preferences, dictated by cheaper mass-produced items, a large section of India's craftsmen population is losing their craft heritage, and many hand-skills have already vanished, and several more are on the verge of becoming extinct. This begs the question about the position of crafts today, the craftsmen and their traditional skills in the modern world. Therefore, it becomes imperative to create newer avenues for traditional crafts to spread and grow, to ensure their survival.

## RESEARCH METHODOLOGY

As part of the Primary research the authors have observed and understood how the designer and craftsmen collaboration works by looking at the traditional work of the craftsmen and the changes incorporated in their products after Design Intervention by Designers. The authors studied the work of a few Indian designers working in the field of contemporary application of traditional crafts. The authors also conducted research with organic wool derived from Gaddi sheep from the Chamba region of Himachal Pradesh, and have developed an innovative textile using this indigenous organic fiber and incorporating design interventions by exploring natural dyes and weaving techniques. The products and fabric developed through this intervention has been used by the authors for various purposes in Interiors. In addition to this, an explorative design exercise was given to students of an Interior Design programme, where the students first researched and then designed and finally produced Interior products by contemporizing a chosen craft, while working with traditional craftsmen. Secondary research included literature reviews to understand the current scenario of traditional crafts in India, and the benefits of design intervention for craftsmen and the crafts.

## CRAFTS & THEIR STATUS TODAY

India is a land with a rich heritage of craft traditions and it is these traditions and associated knowledge and skills that form the cultural identity of her people. A sizeable chunk of India's rural populations subsists on crafts as a source of earning, with the crafts sector as the second largest unorganized sector in India. Based on literature reviews, the data suggests that there are around 7 million artisans in India (unofficial figures estimate 200 million), and these artisans form the non-farm rural economy (*Jena, P.K., 2010*).

Traditional crafts and hand-skills are a historical connection to the heritage and culture of a people. In the modern era, crafts have been seen as a product that is decorative and is objectified into something that is a reminder of ancient memories but craft is not just a product, it is a construct, a conglomerate of the tangible and intangible heritage of a people and their culture. According to Darlie O Koshy, Crafts are an important source and form the foundation for bringing innovations in modern design. Koshy likens Craft to a river that flows into design and carrying with it, culture and emotions (*Koshy, 2017*).

## NEED FOR DESIGN INNOVATION AND POSSIBLE OUTCOMES

The global market for handicrafts is \$400 billion with India's share below 2%, representing a tremendous growth opportunity (*Kapoor, R, 2016*).

In such a situation, keeping our traditional cultures and crafts alive is very important as this is what constitutes our unique identity. The authors believe that for indigenous crafts to survive, changes in terms of design have to be introduced to suit the modern market and that there is a need to sustain these crafts, and their study focuses on how designers can collaborate with local craftsmen to come up with design ideas and products that help increase the economic value of traditional crafts. The symbiotic craft-design relationships can thus be useful for development and sustainability of cultural crafts.

To this end, organizations like the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Crafts Council (WCC), and Aid to Artisans (ATA) have been working to bring traditional crafts to the mainstream by involving designers to work with craftsmen to develop new products

Syeda Hameed, member of India's Planning Commission, has this to say for crafts: "If we are able to fuse contemporary styles with traditional crafts, if we are able to diversify our products and most importantly, if we are able to tap the tourist flow and urban markets, then the handicrafts sector could surge ahead. At the same time we have to ensure that we do not neglect our domestic market and above all the importance of our artisans." (Hameed, S, 2017).

## NEED FOR DESIGN INTERVENTION

Design Intervention is a process that involves creating new products by re-designing existing ones by:

- Introducing modifications in functionality (whether utilitarian or decorative), colour, shape and size;
- Incorporating newer materials, techniques and processes (differing from those used traditionally);
- Adapting traditional crafts for modern consumer tastes, by marrying the traditional with the modern.

Design innovation stems from reuse of existing knowledge or reinterpreting existing knowledge in newer ways. (Pannozzo, 2007, p. 19) While the traditional craftsman has gained their traditional knowledge through hands-on experience with materials and techniques, as well as being born into that culture, and also handed down this knowledge from their forebears, the designer has been trained in modern approaches and process/techniques. The designer can learn from the traditional craftsmen and collaborate on design projects that bear the stamp of both the designer as well as the craftsman. This interaction will imbue the end product with more intrinsic value, and will set it apart as a unique creation, worthy of value.

By blurring the boundaries between Craft and Design, the designer and the craftsmen can thus work together by exchanging ideas, explore design problems and issues, and together identify areas for opportunities. With an ear to the ground so to speak, the designer can act as a mediator between craftsman and the market, and has a better understanding of the aesthetical and cultural needs of the customer. As per Laila Tyabji, the reason for declining crafts is a saturation of new ideas, and not any waning demand in the market. Any efforts for design and product development must stem from a partnership between craftsmen and designers (Tyabji, L, 2017).

The authors believe that sensitizing design students about the rich culture and heritage is important as they will be the future custodians of our culture. Bringing the culture of crafts in to design education curriculum will help the new generation to get connected with our rich cultural past, will help the students to think in new directions and will become a source for sustenance of our craft and culture before it becomes a thing of the past.

## CASE STUDY ANALYSIS

The designers found that in both the cases – The Brands 'Beehive' by Pankaj Narain and 'Organic Connect' by Tanveen Ratti, the design intervention helped to improve the status of the both the crafts. Pankaj Narain adapted the comb crafts or Kangsi to develop innovative interior accessories and products.



[Fig 3.1] Traditional Craft Kangsi (Wooden Comb) and Interior Products Developed by Designer Pankaj Narain from Beehive using the Craft Technique and skill of making wooden carved combs

Similarly, the traditional craft of block making as practiced by Arshad Kafeel (A National Award winner craftsman) was studied. Arshad and his fellow skilled craftsmen from Pilakhuwa in Uttar Pradesh were not earning enough to sustain themselves as they were not making enough blocks due to introduction of screen printing technique in the industry. So the collaboration by Tanveen Ratti & Arshad Kafeel helped the designer and craftsmen to revive the craft and adapt the craft for development of products for contemporary usage. Now Arshad is also supplying his products to stores like Fab India and Kamala .

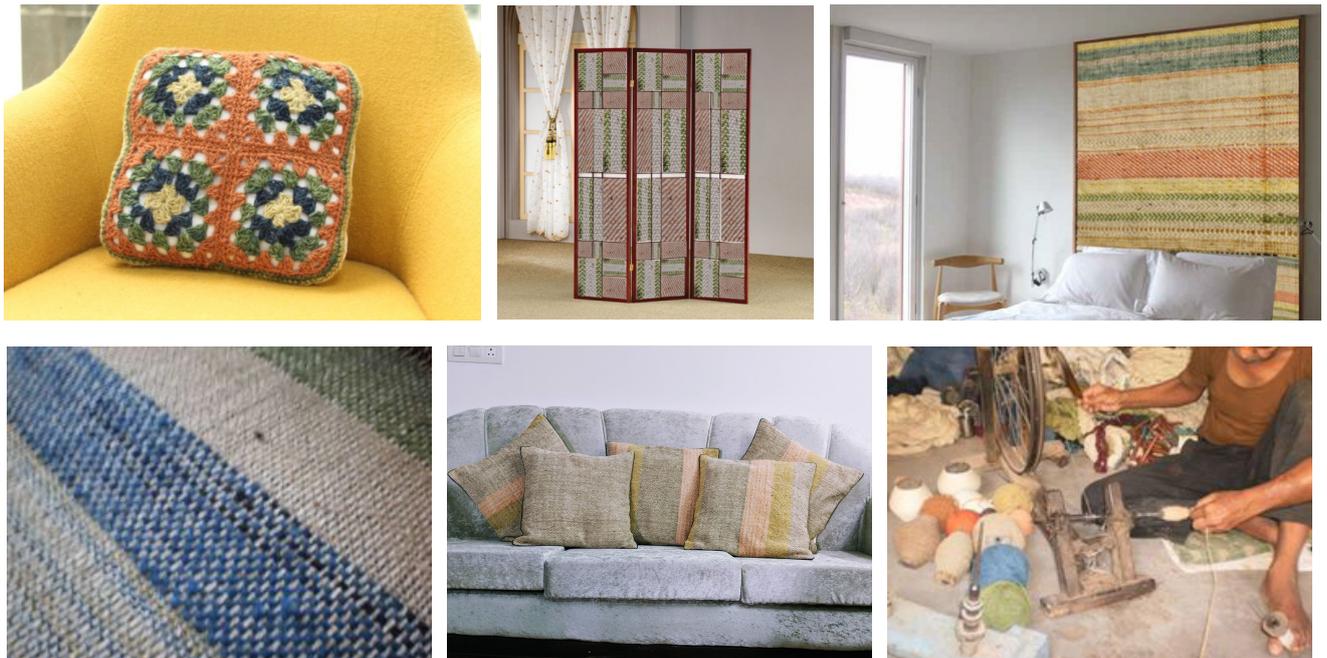


[Fig 3.2] Traditional Wood Carving Craft by Block Maker and Master Craftsmen Arshad Kafeel and Innovative Interior Products developed with Designer Tanveen Ratti from Organic Connect

### DESIGN INTERVENTION BY AUTHORS

The authors have collaborated with Ms. Seema Singh, a textile designer colleague from the Fashion Design department at Pearl Academy. After researching about possibilities of using Gaddi wool from the Gaddi sheep, the authors have created interior products and textiles by experimenting with natural dyes and weaving techniques. Such experimentations were done in Chamba district, and newer weaves were incorporated in the traditional textile. Furthermore, Gaddi yarn was also taken to Bikaner where the local weavers wove textiles based on the authors' ideas. The Gaddi yarn was also combined with Kala cotton from Gujarat, and products were developed, and are also being marketed under the design label AR-MOUR based on a sustainable model for circular economy.

[Fig 3.3] Traditional Craft of Gaddi Wool Weaving and Interior Products Developed



by Authors as part of Design Intervention at Chamba and Bikaner

### ACADEMIC EXERCISE

As part of one of the subjects (craft for interiors) for the pg interior design & styling programme at pearl academy, a project was given to the students with the aim of engendering interaction between design students and craftsmen for design and product development for the contemporary interiors market.

The objectives of this project were: To encourage craftsmen to engage with Design in order to equip them with the skill and understanding that they would use and build on progressively; To create areas of shared opportunities for the designers and the craftsmen, within a collaborative process; To foster a two-way learning process along with the spirit of cooperation; To develop a sense of empathy in the students towards the act of creating/ making and the maker.

**OUTCOME OF DESIGN INTERVENTION**

Each student worked with a craftsman, studied the background of the craft chosen, the symbolism, stories, patterns, motifs and techniques, and then developed interior products that incorporated the traditional aspects of the craft with modern and contemporary function and aesthetics. This not only helped the students in terms of understanding how design intervention works, but the craftsmen also benefitted by getting new ideas for products. As part of an informal survey conducted by the students with their chosen craftsman, it was found that the new products thus developed, did have acceptance and value in the market. This collaboration developed more confidence in both the students and the craftsmen.



[Figure 3,4] Different Interior Products Developed as part of Design Project (Designer + Craftsmen) by Students of Pearl Academy

**CONCLUSIONS AND DISCUSSIONS**

The authors propose that integrating traditional crafts into contemporary society by providing them a wider audience in the main stream will help sustain the traditional crafts. The authors suggest that reinterpreting traditional crafts into contemporary forms can be helpful in preserving the unique cultural heritage of our country. Such measures will also provide better earning potential for the craftsmen and artisans practicing these languishing crafts.

By using the traditional craft skills in a contemporary context, the study proposes how the link of continuity between the past and the present can be maintained. The design intervention and collaborative efforts between the traditional craftsmen and the designer will generate new product ideas and add value to these crafts and skills by adapting and applying them to contemporary products for the present urban market. The study also reveals that such synergies can result in craft products that are a unique marriage of tradition and modernity, by combining the existing traditional aesthetic and hand-skills with innovative thinking, craft –design collaboration, thus contributing towards a sustainable future for traditional crafts and their practitioners. This will give a new lease of life to traditional crafts that are currently in the verge of being lost. Giving a new life to traditional practices and crafts will not only promote and sustain this cultural heritage but will also provide artisans with more earning potential, stable employment and sense of pride and will also prevent loss of skill. Hands-on experience of working in collaboration with traditional craftsmen can help design students gain more awareness about cultural heritage and the challenges faced by traditional craft skills, and help prepare them towards an increasingly modernizing world. Furthermore, the younger generation of designers will thus be better equipped to deal with the issues of sustainability and shall be able to forge sustainable futures for traditional crafts and craftsmen, while keeping alive the nation’s cultural heritage.

Such measures can ensure that the traditional skills, both tangible and intangible are preserved for posterity, and the rich legacy of India’s crafts can continue to be enjoyed and admired.

For any developing nation, innovations in indigenous crafts/products using traditional materials and indigenous processes are very crucial in order to achieve cumulative growth, both economically and socially. As contemporary societies are rapidly advancing towards the future, care should be taken to create ways to sustain the time-hallowed knowledge and skills that form the very foundation of a culture and give them their due respect. To translate a skill from one medium to another the original must remain, otherwise the translation will have no rhythm. Care should be taken that experimentation and exploration during the collaborative process between the craftsman and the designer must maintain the integrity of the traditional craft, and retain its identity, diluting its essence.

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## **EMPATHY SQUARE: AN AID FOR SERVICE DESIGN FOR BEHAVIOUR CHANGE TO SUPPORT SUSTAINABILITY**

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### **ABSTRACT**

Service Design for sustainability requires an integrative intertwined approach for interventions addressing economic, environmental, and social concerns. These design interventions are socio-technical in nature where human beings play a crucial role. To contribute to the larger cause of sustainability, people may have to change their behaviour according to a complex pattern: behaving in a desirable manner once, for a short duration and eventually sustaining the behaviour for a long time. Inducing behaviour change in people often poses an ethical dilemma. Assuming that services trigger new behaviours, designers need to achieve a delicate balance between the concerns of the service-user, human-touchpoints (service staff), service organization and the society or environment as a whole in order to foster more sustainable habits. When designers attempt to address the concerns of all these four stakeholders represented as the Empathy Square, it enables them to facilitate a balanced and ethically appropriate service design solution.

Key Words: Sustainability, Service Design, Behaviour change, Empathy Square

## 1. INTRODUCTION

Service Design for sustainability requires a human-centric, holistic and integrative approach that balances the individual's perspective and the larger economic, environmental, and social concerns. The design interventions are socio-technical in nature in which human beings play a crucial role. To contribute to the cause of sustainability, people often need to change and align their behaviours to sustainability goals. They may have to adopt a new behaviour, increase desirable behaviour, decrease and eventually cease current undesirable behaviour, or sometimes balance between the two equally desirable behaviours. These behaviour changes would typically progress as one time, initial behaviour change, a continuation of the changed behaviour for a short duration of time and eventually sustaining the behaviour for a long period of time (Fogg, 2009). Considering the noble cause of sustainability, people would progress from being unaware of the needs and suitable behaviours to become the advocates of the intended, desirable behaviour change.

Induced behavioural change often poses an ethical dilemma for designers because there is no universal truth about what is ethical and what is not. Instead, an ethical approach is considered as the act of making conscious and deliberate decisions addressing concerns of all stakeholders in a particular context (Acaroglu, 2019). It becomes challenging for service designers to select the consequential ethics approach i.e. maximise the best outcome for the most people or deontological ethics approach i.e. do the right thing using whatever is current 'rightness' (Acaroglu, 2019). Considering the subjectivity associated with the ethical dimensions of human behaviour, it becomes challenging for service designers to coincide both ethical approaches to initiate and facilitate design interventions. This paper explains how to navigate through this ethical dilemma by balancing the concerns of multiple major stakeholders while designing services for sustainability.

### 1.1. Sustainability from a social, economic and environmental perspective

Several researchers define sustainability as an interconnection between three pillars – environmental sustainability, economic sustainability and social sustainability (Elkington, 1997). Environmental sustainability is the process of maintaining a balanced environment by considering factors like conservation of natural resources and environmental protection among others on a long-term basis. Social sustainability aims at creating healthy and liveable communities both for current and future generations. Economic sustainability aims at having long lasting and fair activities. Overall, sustainability is a broad area of research aiming at design, development, and use of resources in the environment to ensure a balance between meeting the current and futures needs, while achieving social justice. Achieving sustainability requires intricate attention and conscious efforts towards the design and development of products and services. It involves a holistic approach considering technologies, change in human behaviour, man-made architectures, consumption of natural resources, and so on.

Environmental and social sustainability related problems are rooted in human behaviour. For example, the way we consume natural resources might lead to scarcity of that resource in future or the way we use products (e.g. vehicles) for our convenience might lead to unsafe (polluted) environments for our future generations. To achieve and to maintain environmental and social sustainability, individuals can contribute significantly by promoting sustained behaviour that can contribute to a greater cause (Abusafieh & Razem, 2017). Therefore, there is a need to examine the role of human behaviour while designing sustainability-driven solutions. It is well established that design interventions influence user behaviour and hence, designers have the potential to consciously design products, services, and systems with an intent to change people's behaviour. While cultivating human values and socially desirable behaviours, designers need to understand the human-environment dynamics in promoting pro-environmental behaviour for users.

### 1.2. Holistic and Integrative Service Design

Designing services that evolve over time through a sequence of events, is a user-centric activity of orchestrating people, infrastructure and communication as an integrative socio-technical system (Bitner, Ostrom, & Morgan, 2008) (Fensel, Facca, Simperl, & Toma, 2011). Service Design provides a holistic approach while solving problems, by leveraging trans-disciplinary collaborations. It encompasses the design of all human-human and human-machine interactions involved in the service. It also focuses on the service environment and the service experiences, by dealing with the emotions and values of humans along with the functionality of the service in a given context. Design in general and Service Design in particular can definitely shape user's behaviour and facilitate to maintain it for a long period. When a service user is using the service for a certain duration, the behaviour of an individual or within a group is influenced by the designed product-service systems. Changing or shaping an individual's behaviour, eventually after a certain time, is a starting point towards the change at a wider level e.g. societal level.

Users of today have an abundance of choices of products and services. Service providers find challenges in being a differentiator in the market and sustaining their users. Value creation through impactful service experiences is the locus of service-providing organizations today. Traditionally, it was a common assumption that organizations can solely design, develop, and sell products and services with little or no interference from their users. This assumption is slowly fading away and the need for value co-creation is becoming more prominent, wherein the users are actively engaged, rather than merely being passive recipients of the service. (Prahalad & Ramaswamy, 2004) (Prahalad & Ramaswamy, 2004). Value co-creation can be defined as a 'benefit realized

from the integration of resources through activities and interactions with collaborators in the customer’s service network.” (McColl-Kennedy, Vargo, Dagger, Sweeney, & Kasteren, 2012). Co-creation of value is heavily based on the interactions between the user and the provider, of which the basic components have been identified as dialog, access, transparency, relationship, and some others. (Prahalad & Ramaswamy, 2004) (Hansemark & Albinsson, 2004), Along with the service users, human touchpoints i.e. service staff involved in service, play a crucial role in enabling the value co-creation for a user.

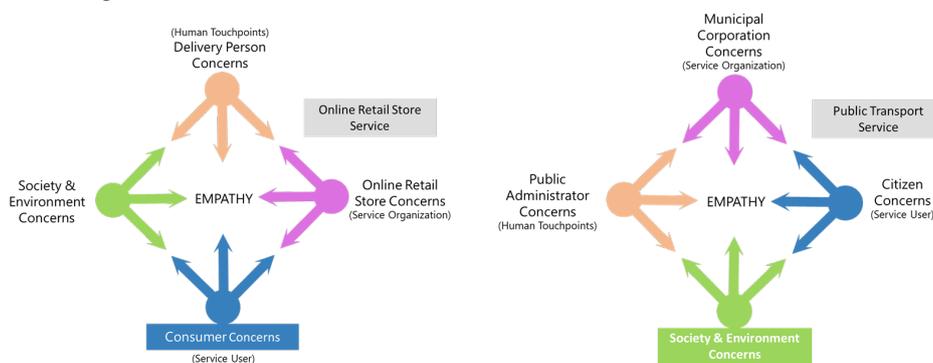
## 2. ROLE OF BUSINESSES AND CORPORATIONS IN SUSTAINABILITY

Every human being is responsible for shaping a sustainable ecosystem. Individuals, group of individuals, businesses, and government organizations share an active responsibility in crafting and enabling activities that create a symbiotic and sustainable tomorrow. With the increasing rate of climate change affecting the global landscape, it’s imperative to include sustainable design as an integral part of business models and state policies. The transformational era of higher automation and interconnectedness in industries compel the later to initiate sustainable design not as a separate corporate social responsibility but as a core to every industrial activity by leveraging on smart solutions that facilitates long term relationship rather than one term consumerism. The movement towards being empathetic towards society and environment as part of the business planning and not as a separate corporate social responsibility i.e. CSR initiative is now evident in organizational practices. It is a right time to adopt social and environmental responsibility through each and every corporate action.

## 3. EMPATHY SQUARE

Design for sustainability is not just a human-centered design approach but an ecosystem-based holistic design attitude which enables rich symbiosis between the stakeholders constituting the ecosystem. The stakeholders can be majorly categorized as users, design enablers such as industry, service providers, business organizations, society, and environment (includes various flora and fauna). It is imperative that an integrative design approach for sustainability will include the perspectives, concerns, desires, and mutual-benefit of all the stakeholders. Let us take an example; Electric cars are positioned as an eco-friendly vehicle because they run on battery-stored electricity producing no poisonous smoke, minimizing air pollution for a safer environment. However, if one observes with a holistic lens, one can evidently see the amount of pollution that emerges during the manufacturing process of electric batteries that are used in the Tesla cars. Furthermore, it’s worth wondering about the lifecycle of all the other materials that are used in the Tesla cars, and their possible impact on the holistic sustainability of our living ecosystem. (Tesla’s Electric Cars Aren’t as Green as You Might Think, 2016)

The design philosophy of Design for Circular Economy (Ellen MacArthur Foundation, 2015) enables designers to look at the complete lifecycle of products and materials and directs the design ideation from building ‘*consumership*’ of products towards ‘*usership*’ of the same. Circular Economy enables this paradigm shift in design ideation towards Design for Sustainability by engaging into six principles (Macarthur, 2006) namely: designing out waste, building resilience in diversity, thinking in cascades, thinking in systems, shifting to renewables, and by focusing on restoration and regeneration. There are similar examples, which emphasises on the role of service design for solving sustainability problems by unlocking value for each stakeholder in a value chain. Among the various stakeholders, service staff i.e. human touchpoints are generally getting less or no attention, which may be detrimental for sustainability. On one side, service staff plays a key role in helping service users to encourage, engage, perform and maintain the behaviours towards sustainability. On the other side, it needs are very often neglected, as the staff was not part of a wellbeing equation that is not only crucial for social sustainability, but for the overall quality of the service too (Meroni & Sangiorgi, 2011). It’s the prima facie responsibility of the service organizations to take care of the social and financial wellbeing of its service staff.



[Figure 1] CraftChange – Empathy Square (Mahamuni, Khambete, & Mokashi-Punekar, 2019)

Through multiple service design for sustainability projects (Prendeville & Bocken, 2017) (Matthing, 2017) it is evident that the service design solution needs to be empathetic to the concerns of a service user, service organization, human touch points and most importantly society and environment. To achieve this and arrive at a balanced

and ethically appropriate service design solution for any kind of problems, Empathy square (Mahamuni, Khambete, & Mokashi-Punekar, 2019) as shown in figure 1 seems useful. It can enable designers, all along the design process, to focus on the ecosystemic approach, so to maintain the delicate balance between the concerns of the service-user, human-touchpoints (service staff), service organization and the society or environment. During 1970s Victor Papanek, first asserted that “*Design, if it is to be ecologically responsible and socially responsive, must be revolutionary and radical*” (Papanek, 1970).

The Empathy Square requires the design team to explicitly articulate and match, not only the concerns of the service provider and service user, but also those of the human touchpoints (the staff) and of the society and environments, as entities that have the rights to be “served” and fulfilled in order to achieve sustainability.

In case of online retail shops, to address the concerns of the service user i.e. purchasing required goods effortlessly, anywhere at an affordable cost, service organizations are providing access to the various goods at affordable rates through their websites and mobile apps to the service users leading to the increase in gross revenue. To make it affordable, the service organizations need to address the concerns of the human touchpoints that is in this case, a delivery person from a social and economic wellbeing perspective. While making it affordable to the service users, organizations should not give inadequate wages to the delivery person leading to negligence towards their social and economic wellbeing. The environmental concerns need to be taken care of, by reducing plastic usage as part of packaging and use of non-polluting vehicles to deliver the goods. For example, the iPhone ships with a biodegradable potato-starch-based shipping material rather than plastics (Sheesley, 2008). Thus addressing the concerns of all the four major stakeholders, the overall solution can be sustainable.

There is no sequence to start from a specific node of empathy square. Designers may start with a node that requires immediate attention and can act as an anchor for other three nodes as shown in figure 1. If it's a sustainability initiative, then designers may start from society and environment node and sequentially move to the other nodes. For an employee wellbeing initiative, designer can start with human touchpoint node and then balance the concerns within other nodes. It's important to be empathetic to the concerns of all four nodes while designing the services to sustain it for a longer period of time. We have used Empathy Square in multiple projects in social and business sector; and found it to be promising. It gets operationalized by addressing the concerns with an anchor node and then taking care of concerns of the other three nodes. It is a part of the larger CraftChange framework (Mahamuni, Khambete, & Mokashi-Punekar, 2019) which is achieved through multiple canvases and design enabler cards. CraftChange is Design for Behaviour change framework which has other elements such as add-on process, Current Intervention Cards for user research phase, Ignite Cards for ideation phase, Challenge Cards for validating and prioritizing ideas and Enrichment Cards for checking completeness of ideas. All these elements, along with multiple canvases, have undergone initial testing and seems promising. The work is in progress and would be reported shortly.

#### 4. CONCLUSION

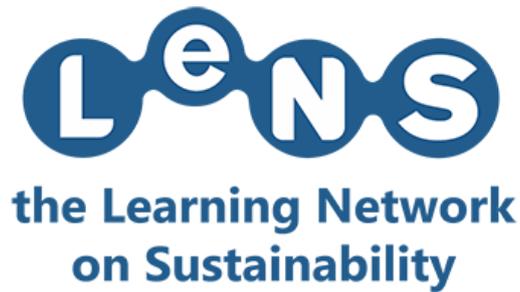
Service design, due to its holistic and long temporal nature, is a desired approach where sustainability concerns are to be addressed in a sustainable manner. It is evident that people's sustained behaviour plays a crucial role in sustainability endeavours. If service design takes care of sustainability concerns by designing for sustained behaviour change, it will contribute to a long lasting impact. Thus, business organizations can change the focus from CSR initiatives to make sustainable service design as a part of their core business strategy. Empathy Square enables the service designers to balance the concerns of multiple major stakeholders, interlinking service design, sustainability and sustained behaviour change.

With a drastic increase in awareness about sustainable actions among people, society and organizations, it is inevitable to address the concerns of all the four stakeholders consistently through actions, as part of their business. This shift from sustainability as CSR activity to becoming a crucial element of core business strategy has started, and this congruence can expedite the process. We believe that this knowledge will be helpful while designing impactful design interventions, addressing sustainability concerns.

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## **ECOMUSEUM AS A DESIGN TOOL FOR SUSTAINABLE SOCIAL INNOVATION**

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### **ABSTRACT**

This study aims to identify points of convergence between the concepts of Ecomuseum and Social Innovation, from the point of view of Design. The concept of Ecomuseum, highlighting information such as the emergence of the concept, its objectives and characteristics will be developed. This article will also present the concept of design for social innovation and sustainability. The aim is to identify a framework that will allow classification of the concept of Ecomuseum as a sustainable social innovation initiative. It will start with an exploratory bibliographical research and in addition, it will be used documentary research. Design role will be highlighted, with its interdisciplinary and transversal vision capable of identifying solutions to the obstacles to a new model of life: sustainable, creative and that privileges the collective benefit over the individual.

Key Words: Ecomuseum, Social Innovation, Sustainability, Design.

## 1. RESEARCH PROBLEM/GOALS

The maintenance of human life on planet Earth is the greatest challenge of today's society. Even though this question directly involves the natural resources with which we satisfy our physiological needs, it is equally important that this survival be permeated with well-being. Beyond surviving, human beings strive to adopt a new model of life: sustainable, creative and that privileges the collective benefit over the individual. It is in this effort that design role is highlighted, with its interdisciplinary and transversal vision capable of identifying solutions to the obstacles that interfere in this new model of life – and opening the way for the implementation of socially innovative actions.

Innovation, therefore, is one of the designer's attributes whose challenge is to narrow the relationship between social welfare and respect for available natural resources. Cipolla (2012) considers that social innovation is related to the capacity of society in solving its own problems. Manzini (2008) states that a particular role in transition towards sustainability will be fulfilled by series of local actions that will increasingly be able to break through the established patterns, guiding us toward new behaviors and ways of thinking.

One of the local initiatives highlighted for breaking down the paradigms of the subject's relationship with the territory where he lives is the Ecomuseum – a proposal for the appreciation of the cultural identity of communities that, according to Brulon (2015), evolves through collective local memory rather than through material collections.

This paper aims to analyze the concept of Ecomuseum as a tool for sustainable social innovation, identifying points of convergence between the concepts of Ecomuseum and Social Innovation, from the point of view of Design.

## 2. THORETICAL BACKGROUND

### 2 .1. Ecomuseum

Ecomuseum is a contemporary model of museum<sup>1</sup> where the basic principle is always the solidarity between forces of the territory that are concerned with the heritage and its social utility (Filipe & Varine, 2015).

The concept of Ecomuseum emerges, according to Brulon (2015), from the discussions concerning the entitled "new museology" in 1960's in France, and becomes official in 1984, at the First International Ecomuseums Workshop / New Museology, held in Quebec (Canada). This movement reflects the growing debate on the role of museums in society, proposing improvements on methodologies and techniques previously developed in museological spaces (Leite, 2015; Santos, 2017). It also intends to transfer power to safeguard held by the museological institution - traditionally represented by its buildings and stored collections - to the community whom in a particular territory, produces culture and interacts with natural resources. Varine (n.d.) considers that the heritage is a cultural, social and economic capital of the territory and therefore, a collective responsibility.

While traditional museology focuses on museum building, collections and visitors; the new museology privileges the scenarios whose interaction between community and territory results in objects and memories (Milk, 2015).

According to Rivière (1983), the Ecomuseum is an instrument where government and population conceive, manufacture and explore together. Government with the experts, the facilities and the resources that it provides. Population, according to their aspirations, their knowledge, their capacity for analysis. This context of production of knowledge and citizenship, hence, privileges the experimentation of social innovation (Leite, 2015).

Santos (2017) produced a dissertation for Museology Master's at University of São Paulo (USP), composed by an exploratory study that examined and contrasted terms and concepts related to Ecomuseums, referencing French museologists Georges Henri Rivière, Hugues de Varine, René Rivard, André Desvallées and Mathilde Bellaigue; Brazilian museologists Heloisa Barbuy and Bruno Brulon; and Spanish museologist Ignacio Díaz Balerdi .The result was presented in the form of conceptual maps, and will support the analysis proposed in this paper.

### 2 .2. Design for social innovation and sustainability

When society realizes that the patterns of production and consumption in consolidation since the Industrial Revolution will no longer be feasible, arise concern about the availability of natural resources needed for the maintenance of human life on planet Earth. Emerged from this fear, the concept of "sustainable development", which was described in the 1980's in the Brundtland Report<sup>2</sup>, as development that meets current needs without compromising the ability of future generations to meet their own needs (Lana, 2016). Manzini (2008) states that to be sustainable, a system of production, use and consumption must meet the demands of society for products and services without disrupting natural cycles and without depleting natural capital.

For Vezzoli and Manzini (2016), design for sustainable system innovation begins with the local but at the same time develops the transcultural creativity-attitude, only to be endowed with an effective social creativity, able to become part of wider sustainability. Achieving full sustainability requires working in partnership and intellectual investment, and highlights the strategic role of design as an activator of interactions and innovations in society.

For a long time, it was considered innovation as a concept strictly connected to the field of materials and technology (Tamborrini, 2012). Currently this process also takes into account the attendance to contemporary and fu-

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1 According to the Statutes of The International Council of Museums (ICOM), "A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment." Retrieved from <https://icom.museum/en/activities/standards-guidelines/museum-definition/>

2 Comissão Mundial sobre Meio Ambiente e Desenvolvimento. Relatório de Brundtland – Nosso Futuro Comum. Oxford: Oxford University Press, 1987.

ture social needs. Cipolla (2012) warns that it is also necessary to observe that the “innovative” character of each case is strongly based on its local context, since what is innovation in a given territory may not be to other localities. Another pivotal point related to innovation is the involvement of the population, which best identifies and interprets the problem and, in a collaborative way, recognizes and implements possible solutions. Collaborative networking is also a way of sharing innovations.

Social innovations also play a key role in developing new models and services to meet social needs, connecting people, ideas and resources. (Murray, Caulier-Grice, Mulgan, 2010).

The Young Foundation<sup>3</sup> (2012) states a working definition of social innovation as new solutions (products, services, models, markets, processes etc.) that simultaneously meet a social need (more effectively than existing solutions) and lead to new or improved capabilities and relationships and better use of assets and resources. In other words, social innovations are both good for society and enhance society’s capacity to act. This work also provided a set of core elements, therefore providing the intended framework for analysis in this paper.

The set of core elements for social innovation is displayed in the Table 1:

Core Elements	Description
1) Novelty	Social innovations are new to the field, sector, region, market or user, or to be applied in a new way
2) From ideas to implementation	There is a distinction between invention (developing ideas) and innovation (implementing and applying ideas)
3) Meets a social need	Social innovations are explicitly designed to meet a recognized social need
4) Effectiveness	Social innovations are more effective than existing solutions – create a measurable improvement in terms of outcomes
5) Enhance society’s capacity to act	Empowers beneficiaries by creating new roles and relationships, developing assets and capabilities and/or better use of assets and resources.

[Table 1] Core Elements for Social Innovation (The Young Foundation, 2012)

### 3. RESEARCH METHOD

The present study was carried out by Exploratory Research to obtain the necessary data about the concepts of Ecomuseum and Design for Social Innovation and Sustainability. According to Gil (1991 p.45), “this type of research provides greater familiarity with the problem intending to make it more explicit,” with the main objective being the improvement of ideas or the discovery of intuitions. The exploratory then turned into Bibliographical Research - that is developed from already prepared material, and is constituted mainly of books and journal articles (Gil, 1991). Publications were analyzed concerning Ecomuseum, Design, Sustainability and Innovation. This theoretical basis, made possible by bibliographical research, guided the identification of points of convergence between the concepts mentioned above.

### 4. RESULTS AND ANALYSIS

The analysis of ecomuseum concepts combined with the core elements for social innovation made possible to identify all the key innovation proposed, as described in Table 2:

Core Elements for Social Innovation (The Young Foundation, 2012)	Concept of Ecomuseum (apud Santos, 2017)	Author
1) Novelty	“A new genre of museum”	Rivière (1973)
	“A new structure, tried and realized (...)”	Rivière (1976)
	“An instrument for a new pedagogy of the environment”	Varine (1973)
	“A modernization / improvement of the open-air museum”	Varine (1973)
	“An experimental creation of a new museology of origin and community essence”	Varine (1973)
	“A revolutionary innovation in the field of museology”	Barbuy (1989)
	“Museums that oppose (in their origin) to the patrimonialist tendencies by the sense that they confer to heritage”	Barbuy (1995)
	“A neologism that sanctions a process that precedes the invention of its name”	Balerdi (2002)
	“Was an ‘experimental model’, ‘imprecise new type of museum’ and ‘avant-garde museum’”	Brulon (2014)
	“Was aligned to the new discourse on the anthropological idea of culture”	Brulon (2014)
	Involved the “belief in a paradigm shift in world museology and which remains” the basis of the idea of a community museum	Brulon (2014)

<sup>3</sup> See <https://youngfoundation.org/>

2) From ideas to implementation	“Has a practical practice “	Desvallées (1985)
	“Are managed by the population”	Desvallées (1985)
	“Museums that have reached a certain degree of development, become institutionalized and integrated into official systems”	Barbuy (1989)
3) Meets a social need	“A school that associates the population with its actions of study and protection; and stimulates a better perception of the problems of its own future through critical information and analysis “	Rivière (1980)
	“Should contribute to the resolution of ethnic conflicts and cultural intolerance”	Devallées (1985)
	“Is a museum that spreads over the territory, in multiple fragments that can be people’s houses, buildings bearing history and memory, landscapes that allow understanding of an ecosystem and the development of the region, becoming spaces of non-formal education and instrument of instruction and understanding “	Bellaigue (1993)
	“Revalues the abandoned urban spaces and whose axis of action will be the territory in which a community lives (local dimension), with simultaneous activities for the recovery of community identity, and the daily patrimony that must be preserved <i>in situ</i> ”	Balerdi (2002)
	“Was created at a time of dissemination of a counterculture and emancipation of popular culture”	Brulon (2014)
4) Effectiveness	“An instrument that is shared, created and exploited jointly and by the population, with its aspirations, its culture and its power of approach”	Rivière (1980)
	“Museums that represent the reactivation of various regions of the world, of cultural awareness and reflection and elaboration of projects”	Barbuy (1989)
	“Museums that proposed ways of social interaction with communities”	Barbuy (1995)
5) Enhance society’s capacity to act	“Is developed by the community with the support of organized collectivities and associations that operate within it”	Varine (1973)
	“Place themselves (in many cases) as centers of cultural resistance”	Barbuy (1995)
	“Is a museum constituted ‘for’ and ‘with’ the population and makes it actively, working collaboratively with the trustee and the museologist”	Bellaigue (1993)
	“Associate local authorities and state agencies”	Brulon (2014)
	“” Place their own social relations at the center of the institution, “which are largely located in peripheral areas, that is, “on the margin of the hegemonic cultural system “	Brulon (2014)

[ Table 2 ] Core Elements for Social Innovation in the Concepts of Ecomuseum (translated by the authors)

The recognition of central elements of social innovation in the concept of Ecomuseu reinforces the pioneering spirit of this initiative, and especially its vocation for meeting social needs. The perception of all the authors mentioned above emphasized the mission of strengthening environmental and social links through which the Ecomuseum justifies its existence, placing itself in the position of establish connections between different stakeholders.

In this sense, the great challenge of Ecomuseums lies in the dynamics of relationship with the community. In addition, Filipe & Varine-Bohan (2015) emphasize the need to evaluate the social utility of the ecomuseum; choose its goals and priorities; choose strategies and become a mixed or hybrid company. Furthermore, it is necessary to adapt the concept - and, more importantly, to adapt the methodology and implementation of the Ecomuseums.

And at this overhauling time, design is the ideal setting for strategically develop a way of thinking able to fulfill needs and solve real problems, reinforcing the benefits of socioenvironmental interaction proposed by Ecomuseums.

This paper is a synthesis of the research that will result in a proposal of design performance in Ecomuseums, fostering its implementation and reinforcing its character social innovation and sustainability initiative, theme of the dissertation for the Masters in Design of the State University of Minas Gerais (UEMG).

## 5. IMPACTS ON SUSTAINABILITY

Balerdi (2002) states that the Ecomuseus became strategies for sustainable development. The practice of Ecomuseu, in order to bring social solutions of high quality and low environmental impact, there must be active, bottom-up and social participative (Vezzoli & Manzini, 2016). The quest for sustainability involves all sectors of society and, more sensitively, designer’s performance. It is necessary to re-formulate all stages of products and services, adapting obsolete practices to the current situation when natural resources are scarce and society is in crisis. Encouraging effective action by Ecomuseums is therefore a way of ensuring that the cultural and environmental heritage of these regions is maintained in this territory, continuing part of the life of the community and imbuing it each day more with meaning.

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## **MISLEADING IDENTITIES: DO PERCEPTUAL ATTRIBUTES OF MATERIALS DRIVE THE DISPOSAL OF SINGLE-USE PACKAGING IN THE CORRECT WASTE STREAM?**

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### **ABSTRACT**

In recent years, bioplastics have been massively introduced in the food-packaging field. However, users erroneously dispose them, causing the contamination of recycling chains. From this, emerged the need for a user centred research investigating: the gestures and senses involved in packaging exploration before disposal, the perceptual attributes of different packaging materials, the possible correlation between such attributes and waste streams. This research aims at expanding current knowledge of compostable materials perceptual attributes and suggest design hints to encourage sustainable behaviour practices. The understandings led to a design that induces a sustainable allocation of waste of Single-Use Products (SUPs). Avoiding waste stream errors by recognisability of the packaging material and make the compostable packaging distinguishable for users through the perception of them can contribute to reduce the overall impact of single-use products.

Key Words: Single-Use Products (SUPs), compostable packaging, materials perception, users' behaviour

## 1. INTRODUCTION

In the last XX years, a great concern arose around the topic of plastic materials derived from fossils (Lithner, Larsen, & Dave, 2011; Thompson, Swan, Moore, & Vom Saal, 2009). One of the major macro phenomena studied by the scientific community is the one of marine litter (Bergmann, 2015; Depledge et al., 2013; Derraik, 2002; Wright, Thompson, & Galloway, 2013). In May 2018, the European Commission put forward a legislative proposal seeking to address the issue of plastic marine litter (ICF & Eunomia Research & Consulting, 2018). Single Use Plastics (SUPs) products are a broad category, encompassing a wide variety of packaging and non-packaging items used in a significant way in everyday life. The EU Plastics Strategy (ICF & Eunomia Research & Consulting, 2018) aims to find alternative materials in substitution to fossil-based towards an effective Circular Economy approach/practice. SUPs, for example food packaging, are progressively being replaced on the market with products in bioplastic materials. According to European Bioplastics<sup>1</sup> definition, a plastic material is defined as a bioplastic if it is either bio-based, biodegradable, or features both properties. Bioplastics are driving the evolution of plastics, entering with their properties and peculiarities for their replacement. There are two main advantages of bioplastic products compared to their conventional versions: the use of biomass instead of fossil resources and the possible biodegradability, which is an additional property of some types of bioplastics (European bioplastics, 2017). Compostability is a further level, in fact, it exploits the biodegradability of starting materials to turn them into a final product that takes the name of compost. Not all biodegradable biopolymers are also compostable and they must pass the tests that are performed according to the UNI EN 13432 to be certified.

The introduction of a new material into consumer products represents a critical issue for both producers and consumers. The manufacturer aims at establishing a market and refine the technical feasibility, while the material is faced with the public assessment for the first time (Bahrudin & Aurisicchio, 2018).

Consumers can perceive new materials in different ways: appreciate them or feel them unattractive also through their previous perceptual knowledge. In recent years, several studies investigated how consumers perceive products by exploring the expressive-sensorial characteristics of the material they are made of (Labbe, Pineau, & Martin, 2013; Magnier, Schoormans, & Mugge, 2016; Schifferstein, 2009; Spence & Wan, 2015; Steenis, van Herpen, van der Lans, Ligthart, & van Trijp, 2017; Thackston, 2013). The expressive-sensorial characteristics, for instance, can drive consumers to sustainable or unsustainable behaviours in the last phase of products use. In particular, bioplastics expressiveness has been recently studied from different perspectives (meaning creation, sustainability and ethical consumption association (Bahrudin & Aurisicchio, 2018; Bahrudin, Aurisicchio, & Baxter, 2017; Herbes, Beuthner, & Ramme, 2018; Kale et al., 2007; Karana, 2012; Klaiman, Ortega, & Garnache, 2016). Furthermore, recognizing bioplastics as different from fossil-based materials represent a key factor in the food-packaging field. Bioplastics, indeed, are generally used in packaging if compostable and because of this disposed in the “organic fraction” of waste collection. However, new compostable SUPs are often indistinguishable from traditional ones. A critical issue in this context is that compostable SUPs (in particular food packaging) are not recognized and are therefore erroneously conferred causing the contamination of traditional recycling chains and not increasing organic recovery.

In the case of this work, the reference context is Italy's collection and differentiation system, in which compostable products have to be given to the “organic fraction collection”. CONAI<sup>2</sup>, the National Packaging Consortium shows us that the maximum quota of compostable bioplastics sustainable by the Italian plastic system is estimated at 10% of the total volume of treated plastic packaging. At the end of 2018, new supply chain consortium born in Italy: Biorepack (ongoing project) for the end-of-life management of biodegradable and compostable packaging collected with the organic waste fraction and transformed, with specific industrial treatment, into compost or biogas. Therefore, it becomes more and more important to understand if bioplastic packaging is recognized by users in order to achieve sustainability of their life cycle.

## 2. THEORETICAL BACKGROUND

To design increasingly sustainable products, it is essential to study and understand the dynamics of user interaction with products. In designing sustainable products, the designer has the fundamental role of combining the shape, the material and the communication of the product in order to “design” even the user's behaviour. Related to this, a discipline of product design has recently been born: Design for Sustainable Behaviour (DfSB). DfSB aims specifically on reducing the environmental impact caused by the way people interact with products (Boks, Lilley, & Pettersen, 2017; Lockton, Harrison, & Stanton, 2010). Strategies have been developed on how to induce purchasing choices of sustainable products, reduce food waste, life-time extension, reduction of energy use, and littering behaviour (Baxter, Aurisicchio, & Childs, 2016; R. Wever & \* L. van Onselen, 2017; Williams, Venkatesh, & Wikstr, 2016; Zafarmand et al., 2016). In the field of sustainable packaging, much has already been explored, because packaging is a “fast” product, which has the particularity of making its content preferable over an analysis that is first sensorial and qualitative. With the same speed with it is preferred, it is thrown and these two parts of its life cycle are crucial for sustainability. Different studies, based on a quantitative research approach (Magnier et al., 2016; Simmonds &

<sup>1</sup> <https://www.european-bioplastics.org/>

<sup>2</sup> <http://www.conai.org/>

Spence, 2017; Steenis et al., 2017) established how structural (material type, shape, size, weight and texture), graphical (colours, imagery, graphics and typewriting) and verbal (explicit textual information available on the package) elements can be drivers for a sustainable implicit and explicit message to the user. Steenis et al. 2017 investigated the product features that drives consumers to purchase sustainable packaged products. The outcome of consumer associations on packaging sustainability were then compared to the analysis of Life Cycle Assessment (LCA). The results showed that consumers were not able to recognize the real range of product sustainability and their judgment was mainly driven by their perception about packaging material sustainability. Literature analysis permitted to highlight a research gap. This research aims at expanding current knowledge of compostable materials perceptual attributes and investigating the gestures and senses involved in packaging exploration before disposal. This research presents the outcomes from a qualitative user testing activity conducted to answer these questions:

RQ1: Do the materials (proven to be a relevant factor in packaging perception) used in the packaging already have sensorial-littering correlations in consumers?

RQ2: How does the user analyse the packaging dispose it? Which are the senses involved and what are the assumptions that he makes in the association with the waste stream?

RQ3: Do the new compostable packages have this connotation of recognisability for the user? Alternatively, are they associated with other waste streams?

### 3. RESEARCH METHOD

Klößner & Blöbaum in 2010 normative, situational, and habitual influences on environmentally friendly behaviour. The main assumptions of the theory of planned behaviour (TPB) presented a Comprehensive Action Determination Model (CADM) that systematizes the factors influencing an ecological behaviour. This tool has been studied in this research to select a user centred design appropriate method for conducting the activities. Comparing User centred tools and the objectives of the study, is intended to explore internal factors that is what people think and external ones to understand what people do. Therefore, is necessary to adopt two main research methods respectively: verbal protocol and user testing associated with a continuous observation. This combination of tools will make it possible to study the user in his / her own: beliefs, attitudes, intentions, subjective constraints, social norms, personal norms, values (Verbal protocols), objective constraints (user testing and observation) (Daae & Boks, 2015a).

#### 3.1. Test Setting

Fifteen commercial food related products, made of different materials, were selected among the SUPs typologies. These products have been categorized according to their destination at the end of their life, according to the provisions of the municipality of Milan. Packaging were provided in their pristine condition, clean and free of printed graphics elements (Figure 1). The 15 products (i.e. P1, P2 ...) in randomised order, could be put into four different bins: plastic (n=6), paper (n=2), compostable (n=6) and generic waste (n=1), their specific information about materials and disposal are provided in Table 1.



[Figure 1] Commercial Packaging SUPs selected for the user test  
[Table 1] Selected Packaging SUPs categorized by type, materials and Right disposal bin

Prod.n.	Type	Material	Right Disposal
P1	Food containers	Polypropylene	Plastic
P2		Multi layer (12-24) barrier films, Recycled PET	Generic
P3		Biopap: paper with bioplastic coating	Paper (if clean)
P4		Biopap: paper with bioplastic coating	Paper (if clean)
P5	Plates	Cellulose pulp obtained from sugar and vegetable fibers	Organic
P6		Double layer of cellulose pulp with internal coating in PLA	Organic
P7		Polystyrene	Plastic
P8	Glasses	Transparent PLA corn polylactide	Organic
P14		Polystyrene	Plastic
P10	Cups	Polystyrene	Plastic
P9		Transparent PLA corn polylactide	Organic
P15		Polystyrene	Plastic
P11	Cutlery	Polypropylene	Plastic
P12		Plant origin Plastarch material	Organic
P13		PLA + hydrous magnesium silicate/talc powder	Organic

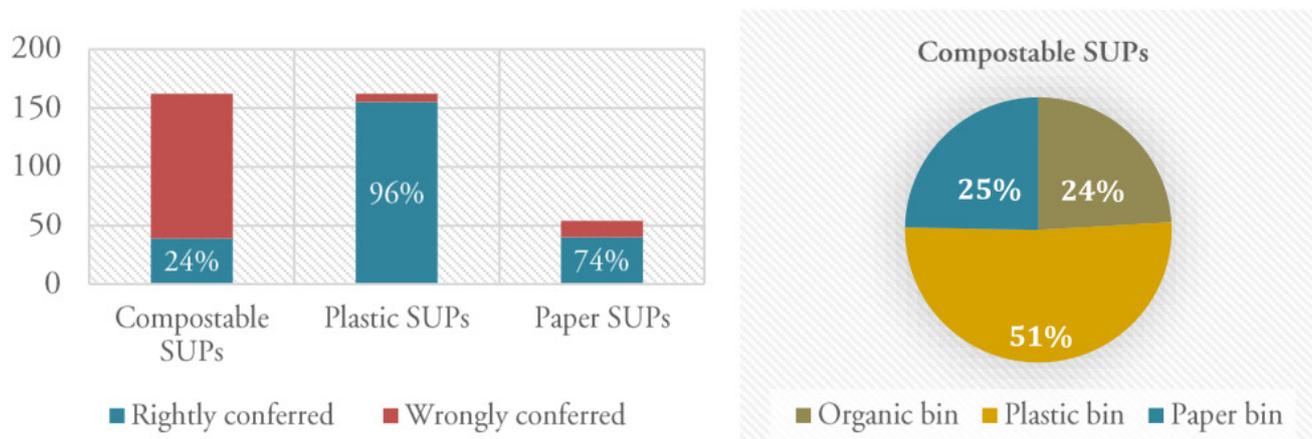
Twenty-eight non-trained assessors performed the test. A panel leader briefly explained the steps of the experiment. The test consists in two steps: in the first, one product (at a time) was presented to the assessor that, through a spontaneous sensorial analysis, was asked to place the product in a specific bin (Figure 2). A data collection app was developed that provides, after the profiling of each user, the registration of different parameters: the time of each analysis, the gestures that the user performed and the reflections that users provided. The user's gestures and their interactions with the product were collected, dividing the possible interactions into 5 macro exploration areas: Technical investigation (pulling, weighing, flexing), tactile (sliding the finger, scratching, compressing), olfactory investigation (sniffing), visual investigation (Looking against the light, searching for the recycle symbol, overturning), auditory investigation (tapping, shaking). After, in step 2 bins have been emptied and each user was asked to perform a survey to predict the correctness of their choices and the aesthetic attribute associations to products thrown in the same bin. At the end of this session, the real destination of the objects was revealed to each user and their reactions were collected.



[Figure 2] Set up of the test, the user is exploring the object and must decide where to throw it.

#### 4. RESULTS AND ANALYSIS

In analysing the results, the first outcome assessed has been how correctly assessors have allocated the products to their waste streams (RQ1). The products destined to the plastic supply chain were the most recognized by the users (96%) followed by those destined to recycling in paper (74%) and finally the single use products destined for compost (24%) as shown in Figure 3 (left side). This result differs from the one evaluated in phase 2 by asking users the percentage of presumed correctness of their choices. In fact, they considered they had conferred the products in the correct way for 67%. Data processing was then conducted to understand in which waste stream have been addressed the remaining 76% of compostable products. Results show that the 51% of the compostable products were disposed with plastic ones and the remaining 25% was disposed with paper-based products as shown in Figure 3 (right).



[Figure 3] On the left side, how correctly assessors have allocated the products to their waste streams. On the right side, how assessors do dispose compostable SUPs

Analysing the user's gestures has been found that the more recognized materials were the less sensorially explored (RQ2), while the less recognized ones were the more sensorially explored. This aspect has considerable relevance if we deduce that the user searches in product interactions to decide where to throw it, sometimes he/she finds it and sometimes he/she does not. The senses most involved in the analysis of compostable products (RQ3) were touch, sight and smell. Among these compostable products, four have involved the users in a greater way, they seem

ambiguous and hybrid: plates P5, P6 and forks P12, P13. The other two compostable products P8, P9 ie glass and cap made of transparent Polylactic acid (PLA) were not sensorially investigated in a relevant way and were destined together with plastic materials in 80% of cases. The verbal protocol allowed gathering more detailed opinions and observations. Many users were surprised that among the 4 bins, there was included the one for organic fraction, considering the different packaging analysed. Assessors' disposal choice was observed to be guided by the presence of the recycling symbols. Although, it was observed that in most of the cases, assessors were misled by symbols: in some compostable products, indeed, the symbol "PLA" was confused with the word "PLAstic".

#### 4. CONCLUSIONS: IMPACT ON SUSTAINABILITY

A compostable product that is disposed in the waste stream of fossil-based plastics or in other one contaminates that recycling chain. So, the circularity of compostable SUPs can be achieved only through a right behaviour of the user in the disposal phase. If the user-product interaction is not appropriate and the user does not take the right behaviour, the disposal phase can significantly influence the environmental impact. It is therefore relevant to note that users behaviour is an active and decisive factor when assessing the environmental impact of a product (Daae & Boks, 2015b) variations in the way the products are being used may have a significant impact on the results. The purpose of this paper is to investigate how a better understanding of the use phase, and possibly techniques and experience applied in Design for Sustainable Behaviour (DfSB. This study placed the user at the centre of the system to identify the causes and to highlight the impact that a wrong product design can cause. In this historical moment in which regulations and so the market is changing, the product designer is a key figure in the shift towards compostable SUPs. The new compostable bioplastic products should be designed in an active way, guiding their recognition. For example, transparency, much sought after in food packaging products (Cheng, Mugge, & de Bont, 2018), is actually a misleading factor for compostable products, as well as the current symbolism used in packaging products. Moreover, the compostable products that follow the formal archetype of the fossil-based ones do not lead the user to a sufficient sensorial exploration, since the user refers first to his previous visual knowledge. The colour (sight), texture (touch) and smell can be possible sensory channels to be explored in designing with bioplastics because they are the attributes that do not constitute, at this time, reasons for recognizing the objects of the other material classes. Plastics and paper have a strong connotation and detachment; compostable bioplastics single-use products have a misleading identity, not yet clear and diversified. DfSB therefore plays a fundamental role in the present research considering the human factor within eco-design strategies thanks to the multidisciplinary and user-centred approach.

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## **I TAKE CARE OF MY PLACES—PROJECT BY ALESSANDRO MANZONI HIGH SCHOOL, LECCO**

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## RESEARCH PROBLEM/GOALS

The experimental programme that we are presenting in the name of Liceo Classico and Linguistico Alessandro Manzoni high school, arises from a specific territorial context: the city of Lecco which, due to its natural position, is located in a spectacular naturalistic place. It overlooks the eastern branch of Lake Como and is thus characterised and surrounded by the Resegone Ridge, by the overhanging cliff of the San Martino mountain, and to the rear, by the summit of Grigna. Nevertheless in the past the city concentrated, for its own economic development, on its mineral resources that had already previously been used as an outpost for the iron and steel industry, rather than on its environmental and tourist potential.

The city in fact over the last few decades has created a vast industrial area which, for example used to also make use of the city's natural waterways such as the Caldone and Gerenzone rivers as its drains. Both rivers flow into the lake from the mountains behind making their way through the urban area. The same scenic patrimony seems modified and marked by the strong characterising presence of industrial buildings, however such aspects have been seen by the local population as the necessary offset for the economic development and wellbeing of the city.

The transformation processes of the iron and steel industry over the last few decades of the last century, brought about a profound transformation to some of areas of the territory. Some areas have been converted for residential use or new uses like construction of the Meridiana Shopping Mall, whose conception was partly by Renzo Piano and conveys the idea of the new architectural forms having a dialogue with the surrounding mountain skyline.

During these years of reconversion, an ever increasingly urgent worry to safeguard the environment due to the effects of climate change has been felt on a social-cultural level. Such effects have been plainly evident, also among the citizens of Lecco and its surrounding areas and awareness is spreading of the true wealth of the city and its territory, its scenery and its waterways.

The safeguarding of and regard for such wealth is therefore becoming a priority for a new launch of the city. The municipality, the school bodies and local cultural and environmental associations have acknowledged this urgency, going on to promoting concrete actions and awareness campaigns.

The new school reform, with the introduction of school educational plans for work-related projects, have in this way given Liceo Manzoni di Lecco high school the chance to plan programmes to analyse and give value to the territory, even in its environmental aspects. After having gained awareness, by means of other projects carried out during the two previous years, of the process of the economic and urban transformation of the city, it is time to promote or to adhere to projects that lead to visible concrete actions within everyone's reach. Such projects are aimed at reclaiming two of the city's waterways: the Caldone and Gerenzone rivers, and at increasing awareness among the high school's pupils of sustainable development.

In detail, the programmes undertaken by liceo Manzoni di Lecco High School and in the stage of implementation in this academic year that are to be illustrated in this document, aim:

- to integrate an educational school offer that in its curricular studies did not consider awareness of the details and requirements of the territory from an environmental point of view;
- to contribute to fulfilling the need to encourage the orientation of young students, in this case in the direction of university and/or professional courses regarding environmental and cultural development of the territory and to increasing the motivation to study;
- to adding value to personal vocations and to personalised learning styles also by means of creative and operative activities, adding aspects that concern design and the planning of specific objects, useful for promoting sustainability within state high schools.

## THEORETICAL BACKGROUND

The word 'sustainability' defines the reorientation of social behaviours towards products, services and behaviours that respond to the ever increasing social request for wellbeing using a quantity of environmental resources clearly inferior, to preserve them for future generations. This also implies a fairer type of social and economic-work relations. Its first official definition at the end of the eighties is that of the World Commission on Environment and Development, WCED "sustainable development is a development that guarantees the needs of present generations without compromising the chance that future generations can satisfy their needs".

Creating an economic development compatible with fairness links research and practical university projects, creative groups and research institutes in a variety of countries from Europe to Asia and South America, trying to find methodologies and project practices. Such interventions occur on different fronts that concern both the creation of cultural proposals that share values and visions of possible worlds, as well as the design of real actual products and services that can change the habits of people's daily lives, in a sustainable way and meeting a determined user need, right up to dealing with the communication relating to a new product.

The planning idea to create 'virtuous cycles', capable of generating alternative solutions to concrete problems of society in respecting ecosystems, has been developed on a theoretical level at large global conferences such as Rio de Janeiro (199), Joannesburg (2002) and Marrakech (2003), which have defined the principles (Rio Declaration, Joannesburg Declaration). It was introduced into national politics of states, into the practices of local administration management, like for example by means of the Agenda 21 process, it also became part of

company policies and found a space also in relevant school discipline programmes.

Liceo Manzoni high school, considers this a fundamental area of interest and wishes to examine it in depth, making particular use of new educational spaces offered by work-related projects. With the project that is presented in detail here following the high school intends to employ its pupils as proper sustainability designers, conducting all of the stages of research, from problem analysis right up to the designing of a product and its positioning to users. A new and different experience from normal school work that could strongly motivate participating pupils as a springboard to action. “It is important that the designer, who works in the field of sustainability, feels like an engine of social innovation and feels part of the community that is moving in this direction, taking part in the generation of virtuous cycles and of their evolution towards more efficient and accessible systems” (Vezzoli 2006)

Furthermore, another of our high school projects is Green Job, work-related project realized thanks to the support of the Cariplo Foundation, linked to orientation on the field of work, which aims to simulate situations of small enterprises that work with actions and products in a sustainable context.

## RESEARCH METHOD

Liceo Manzoni high school, in order to reinforce and integrate the work carried out by the teachers of the school, has considered it opportune and has implemented a course with external partnerships to enrich its specific educational offer regarding environmental aspects and relating to the promotion of sustainable lifestyles, working together with specific partners such as:

- Lega Ambiente, Lecco section;
- SILEA S.P.A. Lecco municipal refuse collection company;
- Consultancy with sustainable design expert from Politecnico di Milano;
- Contributions from experts from the *Altraeconomia* magazine.

Legambiente, through its head of its Lecco section and the availability of its associates, has offered training courses for the pupils of Liceo Manzoni high school concerning the theme of refuse collection, including food waste, with specific data referring to the Lecco area. Such training sessions are to be held with a second year Classics class, a class that is involved in a partnership with the French high school Teresa d’Avila in Lille for an international exchange that involves studying common areas of interest of themes like science, environment and culture, and also the proposal of concrete shared actions for the promotion of sustainable lifestyles. The chosen themes focus specifically on the wasting of food analysing the situation of some European countries. The pupils from both schools should afterwards, guided by their science and art teachers as well as a computer graphics expert for the visualisation part, design a board game as a tool to suggest good behaviour. This game, created in English, will be used and handed out to the pupils of both schools.

In addition, the creation of an annual work-related project has been designed in partnership with Legambiente and with SILEA S.P.A., the Lecco municipal refuse collector company, involving 27 pupils from the third year Linguistics class. The theme of water, very relevant to our territory, will be dealt with as well as presenting themes concerning the ways of consuming drinking water and facing problems relating to it.

This project, organised into successive stages, has integrated the work of external partners to the possible contributions of the class teachers. It began in October with the first educational meeting concerning the state of refuse collection in Lecco and about recent actions undertaken by Silea to promote the correct practices of separating waste.

Following this there was a symbolic day of cleaning the school yard, as an operational launch of the project, during which the pupils reflected on the behaviour or the bad practices common among students.

Educational sessions with Legambiente experts or with science teachers are also to be held to develop a survey concerning waste management in different contexts and making a comparison with other European states. The pupils in this case use and enhance their specific linguistic skills, reading articles of the field from the foreign press, in the language of origin. Afterwards, this will lead to the elaboration and the creation of a closed answer/multiple choice questionnaire with Google Modules to distribute online to a sample of students to learn in depth practices in reference to drinking water use, management of waste produced at school and at home, and also about aspects more generally related to lifestyles. The pupils will therefore have the means to utilise statistical elements and data elaboration.

Spring 2019 will be the time when the functional solutions are to be implemented elaborating effective communicative strategies for the spreading of good practices, through the application of team-working and problem solving. In this stage creative workshops will be held to experiment practices for plastic packaging recycling, with the art teacher and the history of art teacher. The educational session with the external design expert from the Politecnico di Milano as well as the hours from the following workshops will lead to the students designing a reusable drinking water bottle, creating advantageous promotion campaigns on social media managed by the pupils.

## RESULTS AND ANALYSIS

The internal tutor in agreement with the external tutor will deal with checking that the stages of the work-related project are regularly carried out, and that the students participate actively and productively and that the tasks as-

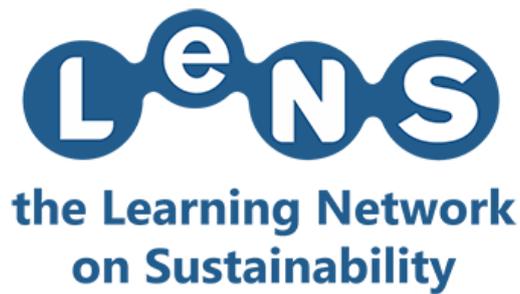
signed to them are completed in the agreed times. All of the work carried out by the pupils of the Liceo high school will be documented and made available to the public, on social media and the press with written presentations and photographic reports of the work conducted. A concluding meeting will be held for the participants where their work will be returned to them, enhancing the student's ability to speak in public.

The expected results of the undertaken courses by Liceo Manzoni high school concern:

- Extending awareness on the part of pupils for a detailed study of the characteristic of the territory from an environmental point of view, understanding the tourism potential of the city that can be increased also through a city that shows its tidy and decent side more
- Working with pupils, a positive influence also on families is hoped for and therefore indirectly on the citizenry and their practices pertinent to sustainable lifestyles.
- Lastly, the involvement of and increased motivation to study by the students is expected as well as an awareness to develop an individual learning course connected to the needs of the territory. Also the Green Job project, underway in the school, will lead to the discovery of new professional developments linked to sustainability and environmental safeguarding, also as potential orientation for future work for the students of the high school.

## **IMPACTS ON SUSTAINABILITY**

- The predicted impact on the practices of the students, concerning sustainability, aims to sizably reduce the consumption of bottled water purchased from the vending machines located in the school in favour of spring water. The creation of a water bottle with a graphic symbol designed by the students or with the school logo, could become a habit and an object considered trendy among the students, helpful in spreading such practices.
- Furthermore a change in behaviour concerning food waste and the handling of provisions is hypothesized in the families related to the students taking part in the project
- Lastly, correct information could lead students and the entire staff at Liceo Manzoni high school to separate waste correctly, without incurring fines that so far has held back the school administration from implementing such practices and up to now has been a deterrent.
- Aiming to increase awareness of users, who in turn give added value to the present day scenic beauty of the area, leading to a change in lifestyle to appreciate the naturalistic and environmental trails surrounding the immediate area of the city more (cycle path, lakeside walk and wood trails, climbing routes, etc.



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## THE ESPERANÇA COMMUNITY GARDEN AND THE CHALLENGES OF INTEGRAL SUSTAINABILITY

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### ABSTRACT

This paper presents the implementation of a community garden in a low-income community at Belo Horizonte, Minas Gerais, Brazil, as a research and extension project, practicing sustainability values. The garden was built in an area that has been made vacant by local authorities due to its geological risk. Three universities are working together in this initiative, mobilizing an interdisciplinary group of teachers and students. The guidelines of the interventions are the concepts of Systemic Design, Agroecology and Solidarity Economy, resulting in surveys, collective actions and discussions about the garden's principles and its management. Throughout this work, a spontaneous management group has emerged, establishing unprecedented interactions in the community, increasing their social cohesion. For that, the methodologies and references adopted include observant participation and field diaries, as well as participatory action-research. Some challenges have emerged during the process and the reflections are bringing new propositions concerning the increase of the local integral sustainability.

Keywords: integral sustainability, community gardens, Systemic Design, solidarity economy.

## 1. INTRODUCTION

This article presents an ongoing research-intervention started in 2017 in a low-income community with the goal of increasing the local social cohesion, collective identity and the protagonism of its inhabitants, using a community garden as the materialization of values and motivation for dialog, and having as indirect but important effect the improvement of their nutrition conditions and health through food sovereignty.

The project represents an interdisciplinary effort involving professionals and students from different areas such as economy, architecture, biology, sociology, psychology, promoting knowledge interconnection. The theoretical fundamentals are the principles of Systemic Network of Integral Endeavors, of Agroecology to Food Sovereignty and of the Social and Solidarity Economy. Those principles are reflecting the broadening of what we call integral sustainability.

The central methodology is the participatory research-action, complemented with focus groups, workshops and community works, supporting the community organization at the construction, planting, harvesting and distribution of their production, aiming to increase the local quality of life, as discussed next.

## 2. INTEGRAL SUSTAINABILITY

Sustainability has been recognized in the last decades as an essential value to the societies, as far as it comprises several features of the contemporary world and brings a humanist philosophy which has the potential to reconcile economy, society and the environment, diffusing the respect among the human beings and with the environment. The concept has been applied in many studies and researches and defends, through the conservation of the environment and the development of corresponding actions, the continuity and maintenance of life on the planet.

The concept of “development” is constantly being put together with the sustainability theme and acquires different meanings according to the social economical contexts of each period, that is, it is not neutral and it is also associated to the actors responsible for its conception.

However, many criticisms have been made, due to the overvaluation given to the economic development, letting apart fundamental necessities of a society, in disagreement with the purpose of a broader progress. As Naredo points out that (2006, p.17), “the failure of the “development theories” to eradicate the worlds’ poverty should open the eyes to the fact that this “development” did not intervene by increasing the conditions of life of the “peripheral” societies to capitalism, but provoking their crisis, without ensuring solvent alternatives to most of the population involved and sometimes giving rise to situations of greater suffering and detachment than those that were intended to be corrected *ab initio*”.

Therefore, this concept is being reevaluated, including other instances of power, incorporating at the contemporary world “the debate on the legitimate purposes of the appropriation of the material world” (ACSERALD and LEROY, 1999, p.24).

So, Naredo, Ribeiro (2003) and other authors consider that the development is based not only on the economic dimension, but must also embody social justice, equity, quality of life, including the openness of the citizen participation at the public life, that is, at the democratization of the decision processes. The concept “sustainable development” was proposed then, to connect the “development” with those new constitutive dimensions. Indeed, since 1990 the United Nations Development Programme promotes the paradigm of sustainable development based on three central points:

- the development of the people, to increase their opportunities, potentialities and rights of choice;
- the development to the people, aiming to guarantee the equitable appropriation of the results obtained by the population;
- the development for the people, to increase their power and the one of the communities, whilst they actively take part at the development process of which they are, at the same time, subjects and beneficiaries (UNICEF, 2001, p.58).

This Report describes two intertwined principles for human development: equity, in the construction and distribution of the benefits among human beings, and the integral sustainability, that is, sustainability in all its dimensions – economic, social, environmental, cultural and political.

Taking into account the current realities, new challenges are coming up and demand profound changes in several aspects of life including the increase of integral sustainability.

In this context, the *Esperança (Hope) Community Garden* project evolves, including the poorest populations who have little or no participation in public life and have no prominence around the decisions concerning their social realities regarding housing, food, education and health. The main guideline of this project is to observe and act on different aspects of their reality, trying to reach higher levels of integral sustainable development within their context of life. Along the process specific aspects stand out requiring special reflections, new behaviours, interventions and changes, conforming a mosaic with its particular challenges, as solutions must be developed collectively and equitably.

## 3. SYSTEMIC APPROACH

Integral sustainability understands that social, economic and environmental aspects must have equivalent weights. Cultural sustainability is also an element for this holistic approach, understanding that it is the individual's culture,

values, sense of belonging, ethics, that generate the energy and willingness for each one to take an initiative, get involved, participate in an activity or in a movement and make choices. Human beings, as a collectivity or an individual, are the actors and the addressee of every social action, even if not in immediate terms.

For long our society is failing at fixing problems that threats human quality of life such as health, security, education and housing. Efforts that focus in one aspect and don't try to balance the others are not being effective. In order to achieve integral sustainability all possible elements that interfere in the context that is being developed must be considered. Therefore, a systemic approach seems to be more promising to achieve broader results.

Systemic thinking is a way of reasoning that considers the complexity of the whole. It is a cognitive process that leads to the capacity of perceiving, modelling and evaluating the consequences of actions in an expanded way in terms of time and space (Andrade, 2014). Nevertheless, considering all possible variables makes the activity complex, and therefore methodologies must be developed to aid human reasoning and actions.

The "Product Service System" (PSS) is a methodology that values delivering to the customer what she/he needs instead of just a product with a specific function [...], making products work together seamlessly, combining products and services to create a high market value. It is about "a smart combination of", "function/ value creation for clients", "working modular" and "combining sustainable concepts with powerful presence in the marketplace" (Halen, C., Vezzoli, C., Wimmer, 2005). It is about aiming at sustainable efficiency for a specific case.

Other systemic approaches are not focused in a specific case or productive chain. Systemic Design, for instance is a methodology that, based on 5 principles (output/input; relations; auto-generation; act locally, human at the centre of the project): makes a qualitative and quantitative analysis of the current process with its outputs and inputs; identifies its problems having this guidelines as a reference; and proposes a systemic model that optimizes resources (matter and energy), improve equitable relations, foster networks, value local culture and give priority to human quality of life over product generation. In order to balance the system and try and reach zero waste, it puts in relation businesses from different areas.

This project aims at fostering the development of Integral Endeavours, bringing initiatives that gather efforts and make a network involving productive activities regardless of their sector, that follow Systemic Design's principles so that together, the result of their activities is integrally sustainable and changes for the society's quality of life.

#### **4. AGROECOLOGY, FOOD SOVEREIGNTY AND SOLIDARITY ECONOMY**

Agroecology is an agricultural practice adapted to the productive requirements of the land available, encompassing a multiplicity of farming forms, as far as adopting ecological solutions in tune with the territorial, cultural and social-economic conditions of each agrosystem. It is qualified by its principles, that maintain management forms faithful to the natural conditions available, contributing to preserve biodiversity, natural resources and ways of life, building a character of integral sustainability (EMBRAPA, 2006).

Therefore, agroecology offers a theoretical reference that respects the "place", decreasing the environmentally harmful agrochemicals and highlighting the importance of the diversity in farming, transforming its principles and practices into reality and valuing the ancestral knowledge as a product of the popular wisdom (EMBRAPA, 2006). For these reasons, agroecology manifests itself in a plurality of formats, encompassing historically gathered knowledge, reinforcing solidarity values and practices and preserving the identity of the local actors.

Agroecology principles corresponds to the Systemic Design ones, applied specifically to the area of agriculture.

The concept of food sovereignty, also used in this project, arised in the 1990s associated to the agroecology concept, through the social demands of the Via Campesina association, that gathers peasant organizations around the world. They were mobilized against the neoliberal rural politics recommended by the World Bank and by the World Trade Organization and that was adopted by many governments, affecting the way the land was occupied to produce and commercialize food (Campos e Campos, 2007). Food sovereignty defends the right of autonomy of the countries to deal with its politics and strategies of production, distribution and consumption of food, protecting the small and medium agriculture, coinciding with the basis of the agroecological principles (Burity et al., 2010).

The connection of Food Sovereignty and Nutritional Sovereignty demands the assurance of the food autonomy of a nation and the fair production and distribution of food (Burity et al., 2010).

In this sense, the extent of the interventions that intend to be materialized at the format of community gardens, within the principles of solidarity economy and agroecology has the potential to reach a complex list of solutions to face the deprivations suffered by [...] communities that are poorly included at the market economy, by promoting an unpredictable endogenous process [...] in which it is observed the promotion of latent resources and knowledge in favor not only of food sovereignty, but also of the local development (Mello et al, 2018, p.13).

In Brazil, since the end of the 1970s, poor communities began to practice the sharing and reciprocity to fulfill certain needs and improve their quality of life. This originated a new economy, with opposite patterns to the hegemonic capitalism, called social and solidarity economy (Singer, 2001). Within its scope came out associative forms to solve public local problems and the mutualism, product of a disposition to create a collaborative schema of generalized gain and self-management (Alves e Burszty, 2009; Ribeiro e Müylder, 2014; Borinelli et al, 2010, Flach, 2011).

Despite some variations of the models in this kind of organization, there are convergent principles in respect with the valorisation of the work produced, the use of technologies to fulfil the needs of all, the recognition of the

importance of the feminine concerning solidarity, the respect of the environment and the emphasis at the values of cooperation and solidarity (FBES, 2005, s/p). These principles constitute the basis of this project at the Esperança community garden, that is being built and maintained with real participation of the local residents, through the practice of agroecology aiming to reach their social cohesion and food sovereignty.

## 5. THE PROCESS

This project is the result of the confluence of needs, interests and resources. It all began by two projects that ran initially in parallel and are physically materialized by urban gardens – the LEIA, “Laboratório Ecosistêmico Interdisciplinar de Aprendizagem” - Ecosystemic Interdisciplinary Laboratory of Learning, that has an experimental garden at UNA University, where workshops on sustainable relations take place, and is closely related to the university’s Gastronomy course; and the Extension Courses on Urban Gardens from the Design School of the State University of Minas Gerais (ED-UEMG), used as a didactic resource and a means to communicate and practice the values of Systemic Design, as a methodological basis for design projects.

After a few inputs on the actions promoted by LEIA to create and maintain their garden, the ED-UEMG group and also members of the Architecture School of the Federal University of Minas Gerais have been invited to participate in some activities at the Santa Lúcia Community. The motivation was the request of a member of the community to one of the LEIA’s coordinator, also with the support of the urban planning institution from the local administration (URBEL). Its initial demand was to make interventions to deal with a piece of land within the community that represented geological risks, was a source of harmful synanthropic animals, putting in risk the health of the community and also used as a hidden place for illegal activities.

The project has evolved as a community garden developed to stimulate the protagonism of the local community. Its objective is to foster social cohesion, also acting in food security and compatibility of the use of this area.

Up to now, observant participation, meetings, focus groups, collective actions (“mutirões”) and workshops have been developed (Figure 1). These methods have been used to get to know each person involved, to try and understand their wishes and needs individually and as a community, to help understand and solve relationship issues, to effectively clean the land, making terrain level adjustments, enclosing the garden, planting and harvesting the productions. Welcome coffees are also being used as a moment to integrate and harmonize the group. The local participants are about a dozen members of the community, that live around the community garden, together with teachers, employees and children from the nursery school that is located in front of the garden, professionals and students from UEMG, UNA and UFMG from different areas, and employees of the urban planning institution from the local administration (URBEL).



[Figure 1] The chronological evolution of the Esperança Community Garden – First contacts at 2017 (left) and after interventions, at 2018 (right).  
(Font: Collection of authors)

The central methodology that is being used is the participatory action-research (Tripp, 2005), chosen for being coherent to the particular demands of the project, due to the possibility of creating a continuously reflexive and pedagogical process within the community, articulating the principles of Systemic Design, Agroecology and Solidarity Economy.

The actions are being made in cycles of four moments each: collective planning, implementation, monitoring, evaluation of the results and lessons learned, that are being registered through images, notes and reports. The action-research also contributes to the clarity of vision that the exchange between university, local authorities and community should evolve naturally, without any notion of superiority, as far as everyone participates effectively into the movement and learn from each other.

Systemic Design, on its turn, is being used when, for instance, the recognition of local resources is being stimulated. One example is the internal production of composting as a fertilizer instead of relying on donations of cattle

manure from local authorities. Using composts would be more beneficial since it acts in the questions of adequate urban waste disposal and grow independency from external resources. It also analyses the variables that are involved and their relations, stimulates the practice of inclusion, stimulates the conscious agent and promote then the reinforcement of local networks. The recognition of the importance of inclusive means of communication, of the quality of its graphics project and of the variety of means chosen for the involvement of the community is also a contribution of Systemic Design.

The production, so far, is being shared mainly to the direct participants and the inhabitants who live nearby the garden. The idea, though, is to increase the production for a broader distribution. The latest challenges are being to improve the management system of the garden and to include more participants in its daily activities, to make the process more effective, diverse and inclusive. The directly involved group is still small and personal differences are making a significant impact in the system as a whole. The problems are being analysed using systemic planning tools such as network representation and causal loop diagrams.

## 7. CONCLUSIONS

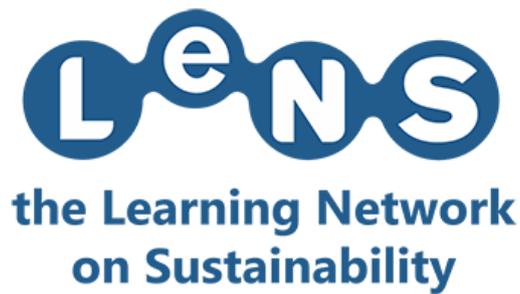
This project is being an important academic practice, bringing to the participants new knowledges and contributing to the society with effective methods, tools and actions. It is being an opportunity of practicing diversity, exchanging empiric and academic knowledge, making a network among academic groups and among a poor community and the public administration, putting together three pillars of the society: community, academy and public administration.

Theories are being verified in practice. The systemic approach is proving to be necessary for the broader goal of creating a context of change to try and solve chronic problems of our society by means of the protagonism of the community itself, which is also one of the basis of the solidarity economy.

After two years of exchange between the participants of this network, changes have been materialized by the transformation of an area of geological risk to a productive community garden. Nevertheless, there is yet work to be done to make the cyclic production a reality, to stablish more harmonious relationship among the group directly involved and also to broaden the participating group. It is an ongoing process making the community to understand the possibility and the significant value of being autonomous. It requires behaviour, social and emotional changes which, in its turn, requires time, strong connections and the development of the local cohesion. On the broader picture, it is perceived that as the project move forward new local tools are being created for the participants to deal with their realities, and the dimensions of integral sustainability are gradually being considered in the context.

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## **SPIRAL DYNAMICS: A VISIONARY SET OF VALUES FOR HUMANITY'S SUSTAINABLE DEVELOPMENT**

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### **ABSTRACT**

Wouldn't it be easier that we all agree on the perspective to tackle contemporary problems? That we have a clear vision on the future and based on it we choose our stand or react to a situation. If for instance, a caravan of thousands of migrants arrives to our country: what is the best perspective? What is the future that we want to create? What is the way of acting with full integrity? And more important, what are the values that guides us? Why are so many people choosing to become vegetarian, buying solar cells for their homes or rain collectors, choosing to use their bicycle over their car? Is it just a trend? Is the level of consciousness really rising in the society? Designers are taking a stand and working actively for proposing ideas into the wicked problems and driving social innovation. As a guild, there should be agreements and a shared heterogenic vision.

Key Words: Strategic Design, Spiral Dynamics, Awareness, Forecasting.

## 1. INTRODUCTION

Cruelty as entertainment, human sacrifice to indulge superstition, slavery as a labour-saving device, conquest as the mission statement of government, genocide as a means of acquiring real estate, torture and mutilation as routine punishment, the death penalty for misdemeanours and differences of opinion, assassination as the mechanism of political succession, rape as the spoils of war, pogroms as outlets for frustration, homicide as the major form of conflict resolution -all were unexceptionable features of life for most of human history. But, today, they are rare to non-existent in the West, far less common elsewhere than they used to be, concealed when they do occur, and widely condemned when they are brought to light. (Pinker, 2007.)

Following the idea of Harvard evolutionary psychologist, Steven Pinker, one might be able to agree that in our contemporary society is possible to see a wide common vision, perhaps rejecting violence, and conversely finding more diplomatic ways for conflict resolution.

Those times where we needed to sharpen our group skills to hunt mammoths are long gone. We might not understand the Mayan ancestors and their human sacrifices but surely we would not repeat those rituals in the main plaza. Bragging about how many people one killed, how many women one raped, and how many kids were enslaved is a difficult thought to even put in this paper. Considering a race better than other one, acknowledging how valuable is the opinion of a woman in a political context, having equal rights, having a kid lecturing about global warming at the United Nations, those are things that just started to happen less than a century ago. And it does not end up there, we are starting to question if it is all right to have a slaughterhouse where animals are just part of a production line. If eating their meat is really good for us at all. If delimiting borders between countries are really necessary or if the question was wrong since the beginning. If capitalism or socialism were really ever the answer or the target should be something else than increase money and production. If the meaning of progress really is industrialization, pavementation, and commercial potential.

Perhaps an ethos of our time is still undefined in the common imaginary. The proposal in these lines is to start to explore a basis for a manifesto. This common ground agreement might serve as a guideline for a zeitgeist in the efforts that designers and in general social innovators or sustainable developers must follow. Consequently, when confronted with the scenario of whether or not to build a train line in Yucatán, developers could agree if the values for sustainable development, or sustainability for all, are truly being met. Of course there will be always room for interpretation and efforts to bend the perspective. As an educator, the value seen in this hypothesis would be the code, a Hippocratic oath, that could be shared with design students.

## 2. RESEARCH PROBLEM

In the scope of working for a sustainable development designers often find themselves confused by the wide range of definitions, methodologies and goals for sustainability. It is known that a sustainable development should not only consider long term cycles of the environment, but also long term impact in a society, and if not financial long term stability, at least resources to keep the proposal running. Therefore, considering environmental, societal, and financial means or resources, are already enough complex situations to consider. As educators, academics seek to consider life-cycles and strategic forecasting of design proposals. Students are given a wide set of tools and methodologies to calculate the impact and measure the value for people, organizations and market. However, each situation needs to be considered individually. The education as designers gives professionals a mindset, the ability to work in a team, a research toolbox and critical thinking, at least until certain level. Educators are agreeing on a more strategic approach to problem solving and holistic thinking. Nevertheless, there is little discussion about the ethos of the profession. What should we include in Hippocratic oath for designers and social innovators?

The research problem digs in evolutionary psychology. In the way that values have been defined throughout time. And from there, how to define values for a truly sustainable future?

Rittel and Webber (1973) define the problems that were too complex to solve fast, from a single discipline perspective, and in just short term, as wicked problems. They realize how governments and organizations were struggling to propose solutions. And that these problems needed to be systematically attended with an strategic approach. Moreover, wicked problems cannot be solved within a day, it may take decades to change the tendency, they might never really end but just become under control. Therefore, if they can take half a century to be solved, and in those years human value system changes so much, how to establish a solution that would be valued and appreciated even after 50 years have passed.

Every day the wicked problems become more wicked than ever. Society is confronted by problems that have never been there before. As humanity, we are learning how to live in a connected world consisting in over 7 billion people. How do professionals guide themselves towards a sustainable development of the future? How do they decide between short-term benefits, status, gratification, reducing costs, or alternative solutions that does not follow productivity only? This theoretical research aims to address those problems and consider that spiral dynamics not only helps us to define the core values of our era, but allows us to forecast, educate, and transition towards the core values of a better future society.

### 3. THEORETICAL BACKGROUND AND CONTRIBUTION

This paper aims to be a conversation starter of the set of values that defines our contemporary era. Based on the work of Ken Wilber, a proposal of the evolution of values for a sustainable human society is analysed, mostly through the interpretation of Don Beck. This argumentation, along with the work of authors like Dustin DiPerna, Steven Kotler, Peter H. Diamandis, and Yuval Noah Harari, among others, is meant to give basis to an idea of ethical formation, positive (constructive) perspective towards the future, and awareness development as a compass for designers. These authors refer constantly to the works of Mihaly Csikszentmihalyi and Steven Pinker who were also reviewed in order to find the academic basis of their ideas. Kotler mentions that creativity is better seen as establishing new connections with the resources and information that one has. Therefore, the endeavour here is to put the pieces of this puzzle together in order to visualize the direction that human potential can take.

### 4. RESEARCH METHODOLOGY

The UNESCO has been making a proposal for world's sustainable development. This, following a vision of how would a better 2030 look like. The vision has been inspiring millions and educators are running jams and workshops around the subject. Collectively, it is giving clarity to creative management and understanding of the milestones needed in order to achieve each goal. The work of Ken Wilber has been proposing a similar forecast. Analyzing the history of humankind he has been noticing a spiral where we move from individual to collective in a constantly growing awareness. Based on this data, he forecasts a movement towards a conscious collectivity and specific set of values that are built on top of each milestone reached by the travel of human development and DNA information. Basically, the idea is that we are not isolated individuals trapped in a certain time of history, but that we are a collective organism that is passing information forward from one generation to the next one, building on the shoulders of giants. Each level of evolution is in every one of us, it is our responsibility as a generation to integrate the steps or "memes" of this evolution and integrate them.

Integral theory is Ken Wilber's attempt to place a wide diversity of theories and thinkers into one single framework. It is portrayed as a "theory of everything" ("the living Totality of matter, body, mind, soul, and spirit"), trying "to draw together an already existing number of separate paradigms into an interrelated network of approaches that are mutually enriching." Esbjörn-Hargens, S. (2010).

Over the following lines I will describe each one of the personalities included in the Spiral Dynamics theory. This description is based on the work, of Don Beck and Clare Graves. The following lines will be taken from the magazine "What is Enlightenment?" (2002) and the Audio Learning Course given by Don Beck himself on May 3, 2007. In order to start to review them, one should be clear that it is a view of human consciousness evolving throughout time. Since the moment that humans were hunters-gatherers to the contemporary society and beyond, establishing the basis of where the human evolution of consciousness, values, and social organization would lead.

At the very beginning, around 100 000 years ago human started at the Beige level. Beige it's a virtually automatic state of existence, driven by the imperative psychological needs that trigger the very basic survival equipment with which we are born. It is humans simply struggling to survive in environments where there are other animals. Yet we are more sophisticated and seem to have more conceptual skills for bonding into protective clans to preserve what we have and fend off predators. The father in the survival clan eats first because if the strongest dies, the family has no hope. So, the key to Beige is survival using instinctive intelligences, with a more heightened sensory system with which we can see better come here better we can sense things with the hair standing on the back of our neck. Simply staying alive is more highly valued than anything else.

One can find pieces of Beige in straight people who are basically hunter-gatherers, who get what they eat where they find it. And also, it's evident in newborn infants, who eat when they are hungry. And some people, when exposed to a catastrophe, may be regressed to Beige. Higher-order priorities suddenly vanished in the midst of personal tragedy, extreme suffering, or deprivation.

The second level of the spiral is Purple. Purple is animistic, tribalistic and mystical. In this world of Purple, we tend to have the first evidence of human bonding the sins of a kindred spirit, that I am someone because I belong to a certain clan or certain tribe.

In this stage a mutation occurred to awaken in the brain the first real ability to assign cause-and-effect. This was the first sense of the metaphysical. In the Beige mind event seems to be scattered, each one on two weeks have come without much predictability. But, for example if the moon is full and the cow dies the purple mind connects the two events one causing the other. So the awakening of the metaphysical system, together with the capacity to work more firmly in a team arrangement occurred in the transition from the dawn people (Beige) to the mystical people (Purple), precipitated by the change in life conditions that occurred in the Ice Age.

The Purple meme is heavily laden with such so-called right brain tendencies as heightened intuition, emotional attachments to places and things, and a mystical sense of cause-and-effect.

The Red zone is the first raw, egocentric self. I am someone. In purple we have become very successful. We had found food, we had to stabilize our lifestyle, and we had conquered what we thought were the dragons in our life. Everything was smooth, boring. So many of the youth became disconnected. They saw that there was something about the reason that, rather than being protected, was being contained, limited.

The Red is an elite individual beginning to move away from the bonding element in Purple, which had become overplayed. So what Purple produced, through with success, was the need for strong individuals who are sent to power, who dominate home for example, in a military environment where we don't have the time to vote. What begins to spring free is assertion of raw self, the renegade, the heretic, the barbarian, the Hedonist.

There are both positive and negative expressions to all the names, including Red. In red, we see how high crime rates, we see all kind of rage and rebellion, but we may also see wonderful spurts of creativity, heroic acts, and ability to break from tradition and chart a whole new pathway. And Red rebellion and impulsiveness could only happen because Purple, through bonding, stabilizes things. Also Red was a rebellion against the rituals and sacrifices forced on the youth by the Purple system, In painful rights of passage, for example. Memes are not free floating entities. Red is not better than Purple. It's different. So you have to ask first and foremost what are the life conditions if the life conditions requires you to be strong and self assertive, or to fight your way out of a horrible situation, then the Red meme is the way to be. Red is not an aberration, but a normal part of the human meme repertoire. This perspective is fundamental to Spiral Dynamics: you accept that the memes do not represent a hierarchy of "better," but rather that each can be expressed in a positive and negative way, and that the whole spiral with its assortment of meme codes is inside the person and may be called upon in response to the demands of the change in life conditions. The previous memes are not forgotten or left behind in the path, they are included and integrated in order to transcend into a collective evolution.

In the Blue, there is a search for a transcendent purpose, a recognition of the importance of order and meaning, a universe controlled by a single higher power. Society could no longer function with the constant presence of Red, which is war-like, gang-like, Warlord like entities, so we have to grow up, to solve the problems created by red success. Here for the first time is the capacity to feel guilt (red feels shame, but not guilt). In the Blue system, people gladly accept authoritarianism and self-sacrifice for the common good.

Blue is designed to handle the threat of Red. But as blue moves away from having to contain the violence in Red, it goes on its lifecycle towards its own healthier version, taking the form of more institutionalized systems, in which righteousness, discipline, accountability, stability, perseverance, and order prevail.

What also seems to occur in the brain is a heightened capacity of obstruction, and that abstraction ability attaches itself to a cause. This is where many of the religions and the "isms" started to appear.

Orange is about advancement, improvement, and progress. Once again you play out the Blue meme to its ultimate. You make it very, very successful. And then what happens, the individual gets restless. "But I am an individual. I want to assert my personal autonomy". "No", Blue says. "You must stay in line and conform to the dictates of the system. Don't you want to go to heaven? Don't you want to have a retirement? And Orange says, "Yes, but I think I can produce a heaven on earth. I think I can increase the size of the cake." Thus we had a great enlightenment which is simply the individual spirit breaking free from what had become very restrictive forces. The Orange meme started to appear as individuals striving to help, they invented the scientific method, they opposed the religious dogma, they believe in optimism, in changeability. A belief that we can, indeed, shape our future. The Orange meme is their free thinker, the mathematician searching for an explanation of the universe, the musician writing his best play, the left side of the brain at it best. As the others expression, The Orange could have a negative influence call me their capacity to engineer things can benefit the consumerism and capitalism over this sustainable development and a responsible use of the environment.

The Green meme is the final level of the Spiral's first tier. At its peak, Green is communitarian, egalitarian, and consensual. Without Orange we wouldn't have Green, because in Orange the inner being was bypassed and ignored. Our science left us numb, without heart and soul, and with only the outer manifestations of success. The so-called "good life" was measured only in materialistic terms. We discovered that we have become alienated from ourselves, as well from others. So Green, this fairly recent memetic code, emerged out of the ages of industry, technology, affluence, and enlightenment, to declare that in all of these undertakings, the basic human being has been neglected. The focus shifts from personal achievement to group and community oriented goals and objectives for green; we are all one human family. Green begins by making peace with ourselves and then expands to looking at the dissonance and conflicts in society and wanting to make peace there too, addressing the economy gaps and inequities created by Orange, and also a Blue and by Red, to bring peace and brotherhood so we can all share equally. Gender roles are derigidified, glass ceilings opened, affirmative action plans are implemented, and social class distinctions blurred. Spirituality returns as a nondenominational, nonsectarian "unity."

About 30 years ago the researcher Clare Graves started to notice a different pattern in the evolution of the tiers, transcending the previous colors. A growing curiosity about just being alive in the expansive universe. He finally came to the conclusion that something unique was happening and did not appear to be just the next step up from green level. It seemed to be a new category, the Second Tier. For the first time in human history we have photos of the planet taken from the moon, we began to understand the planet itself as a total ecosystem in a way that was never possible. The Yellow meme is the first level of the Second Tier, is years in the future. It is sensing the interconnection of everything. Yellow will have an enhanced vertical perspective with the ability to transcend and include and value what came before, and also to anticipate what will be next. The eight meme code, Turquoise, will rise in conjunction with the seventh, Yellow. They have been described as Yellow: "Left brain with feelings" and Turquoise: "Right brain with data". The Second Tier, through structures and platforms, will com-

bine elements of Yellow and Turquoise in searching for the quality and depth of thinking that can deal with complex problems.

Since Memes are not types of people but forms of adaptive intelligences in people, yellow and turquoise are still under development at this time. Different people possess different fragments, or components, or even versions and this makes the formation of what one could call “creative brain syndicates” with insightful interactions and dialogue even more important. It is going to require some deep dialogue, and it is about to be seen if humans will rise to the occasion.

## 5. RESULTS AND ANALYSIS

The Second Tier as described by Graves and Beck, is about to be seen in the upcoming generations, probably more clearly in the generation that is currently in formation. It is clearly an interconnected society, which is addressing and sharing quickly the problems of the environment. This generation has been given a world with problems but also a concern about the environment and some tools to start advert it. The characteristics of the memes in the second tier include interconnectivity, ability to work in group, a concern for the environment, they can see problems in a systemic approach, they are more flexible, spontaneous, and understand the nature of change. Not only is possible to notice these characteristics in the current university students, but they are also the abilities and competencies that are being shaped in design professionals, the “Move Fast, Break Things” that Facebook promotes in their employees, the “Flow” state that Google and Apple seek in their creatives, the difficulties that Amazon establishes in their policies for teamwork, like the rule of forbidding to reply with just a “No” to any proposal, instead of that they should always argument and discuss the point.

Spiral dynamics is a way to understand the evolution of human values and intelligence throughout time but also is an opportunity to foresee the better values that society can evolve into. Design formation is by definition a multidisciplinary approach that is taking a stand in this evolution, by specializing in fields like sustainability, social innovation, universal design, distributed economies, transition design, systemic change, living systems, biomimicry, among other examples. It is rising as a methodology that could be used in a wider scope, advising companies and organizations, influencing public policies, enriching the understanding of the urban environment and empowering communities for self- management.

Designers are always working with the future. Projects are rarely for the immediate moment or the past. A desired outcome of this work would be a call for a platform where creatives, designers, cultural agents, and visionary dreamers start to agree on the future that as members of the human race would like to build. The future should not only be forecasted, predicted or prospected, the future should follow the vision that we have as a collective. This platform should be a collective playbook with strategies for development that could direct the efforts of practitioners and educators. A tool for collective imaginary where we start to practice solutions, make mistakes in a controlled environment, prototype social action, and agree on common values that enrich the transition towards a Sustainability for All humanity.

## 6. IMPACTS ON SUSTAINABILITY

How do we inhabit that territory before we live in it?

Sounds like postmodernity, the nightmare of Korzybski, the map will become the territory. It is a fact that we are building the world together, constantly, every present minute. What if we learn to prototype reality more efficiently? As educators and foreseeing the possible impacts. Three main perspectives are leading the initiative of this research:

- 1). The future of sustainability education. Not only in academia but as an available tool for everyone interested in the subject or curious about future planning. The platform should be playful and the learning should become addictive. How are we going to share sustainable development insight to the isolated communities at the distant corners of the world? The most likely solution is: via apps, mobile access, video games, and YouTube channels.
- 2). Forecasting failure. To quote Sheryl Sandberg's book “Lean In”: Fail fast, fail better. Nasa astronauts spends years practicing mistakes and possible outcomes when things do not go as expected. This increases resilience when confronted with stressful situations in a harsh environment. If we become failure gurus like the keynote speakers of the “Fuck Up Nights, aka: FUN” we would be able to learn fast and try again. Prototyping solutions in a controlled environment would allow us to review possible failures and find means to avoid them.
- 3). Open design. A crowd sourced platform that can reach complexity. Understanding complexity as the increase in possible solutions of the variables in a given situation. As a participant, one will not only propose a project and foresee the possible outcome, but will combine it with the ideas of the other participants increasing the possible outcomes of the combination of variables, peer to peer style. A collective exercise of speculative design lead by an agreement of values that could envision sustainability for all.

## 7. CONCLUSION

The university is the place to start and experiment. Design education should be enforced to propose alternative in ever more complex problems. The epistemological definition of design should be stretched and design methodologies put into a test in different fields. In that sense, academia could become a repository, a collective playbook with strategies for development. Ken Wilber's vision and inspiring work is just an excuse to create a common vision for these strategies to develop further. His work will be enriched along the way, the important factor would be the creation of this roadmap for societal evolution. Designers should include in the user/people understanding more tools to understand what people values more, that would bring means to propose well being. If all you have is a hammer, everything looks like a nail to you, if you just build personas through marketing analysis tools then people will always be your customers and you will only design for profit. The question here is, what if we need to design with another purpose? What if well-being is more important than profit? If we are about to set on foot into a sustainable future it might be a good idea to start to imagine not only how it would look like but also who are ge going to be in that future in order to manifest it.

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## **CRAFT CHANGE: BEHAVIOUR PROGRESSION FRAMEWORK – EVALUATION IN QUASI PARTICIPATORY DESIGN SETTING**

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### **ABSTRACT**

Sustainability concerns often stem from human behaviour and practices, and needs sustained change. Product and service design, while driving solutions, are also influential in bringing about change in human behaviour. Yet most designers do not have adequate design guidance based on the established behaviour change theories. The proposed ‘CraftChange’ Behaviour Progression Framework enables designers through a choreographed process and toolkit of canvases and cards, to arrive at ideas and service concepts which facilitate a user’s behaviour progression—from an unaware state to being an advocate of change. The usefulness and effectiveness of this framework was evaluated through a case study aimed at designing a service design solution to “encourage continual learning within a multi-cultural setting”. Initial results are encouraging and show the promise of being the preferred toolkit for service designers aiming at sustainability initiatives like encouraging smart transport, promoting healthy food habits, and amplifying sensitivity towards the environment.

Key Words: Design for Sustainability (D4S), Design for Behaviour Change (DfBC), CraftChange, Service Design

## 1. INTRODUCTION

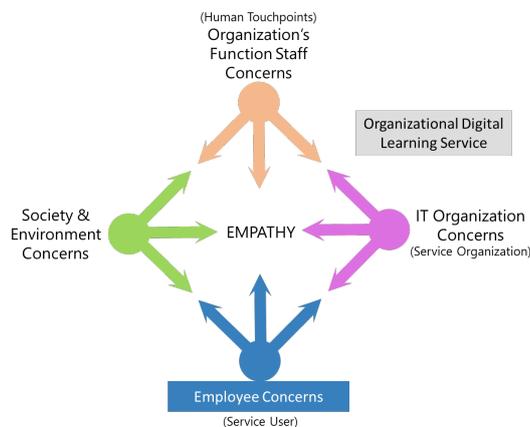
Human behaviour is a crucial aspect of sustainability (Fischer, et al., 2012) (De Young, R., 1993) (Lilley, 2009) and enabling design to facilitate the desired change in user behaviour is critical in envisaging a sustainable tomorrow. Design for Sustainability is not a single stakeholder centric approach but demands extensive participation from all the stakeholders in our living ecosystem, who maintain a symbiotic relationship with each other, such that their desires, concerns and constraints are taken into consideration from the initial design phase itself. Reflecting on the current design practices for ecosystem-wide sustainability, Design for Circular Economy (DfCE) (Ellen MacArthur Foundation, 2015) is globally accepted today as an approach to sustainable design by facilitating the industry to transition from being a linear-based economy to a circular or closed loop one, enabling multiple value streams and cascading resource usage by promoting ‘usership of services’ rather than ‘consumership of products’. Sustainability design directives such as DfCE envisions to change stakeholders’ behaviour at various stages of a resource life-cycle through services that facilitate effective and sustainable resource management. Developing functionally superior technology and infrastructure may not alone address the severe sustainability issues rooted in human behaviour. Achieving desirable behavioural changes at individual, societal, and organizational level is the need of the hour in order to design for a sustainable future ecosystem.

It is a well-established fact that design influences human behaviour (Fogg, 2009) (Lockton, 2010). Designers can consciously design products, services, and spaces in such a way that it facilitates the intended desirable change in users’ behaviour and eventually help them to sustain the behaviour change in a progressive manner. Service Design being a multi-disciplinary, human-centred, co-creative approach, can facilitate a holistic and practical outlook to behaviour change through its product-service systems. Design intervention approaches could be informed by ample of behavioural theories, principles and models from Behavioural Sciences to inculcate a sustained behaviour change. However, the designers and stakeholders need an appropriate actionable guidance to design interventions for a progressive behaviour change of users. Currently there are a few frameworks and toolkits available to guide the designers (Mummah, Robinson, King, Gardner, & Sutton, 2016), especially for designing services aimed at behavioural change (Mahamuni, Khambete, & Punekar, 2019).

CraftChange is a behaviour progression framework and toolkit (Mahamuni, Khambete, & Punekar, 2019) which intends to guide and facilitate designers to strategize, ideate and detail out design interventions for progressive behaviour change of users in a given context. In this paper we aim to evaluate the usefulness and effectiveness of this framework by applying it in one of our service design case studies explained further.

## 2. ‘CRAFTCHANGE’ FRAMEWORK

The CraftChange framework as shown in Figure 2, proposes a design intervention process from the perspectives of multiple stakeholders to progressively change user behaviour. The CraftChange framework is driven by the *Empathy Square* [Figure 1] where the four nodes represent different stakeholders– Service User, Society and Environment, Human Service Touchpoints such as Service Staff, and Service Provider Organization, for any given service-system and context for which Design for Behaviour Change is to be undertaken. The framework supports design interventions by addressing the concerns of all the four prime stakeholders in order to make design interventions more holistic and ecosystem based. Design can start from any anchor node and then move to the other nodes as shown in Figure 1.

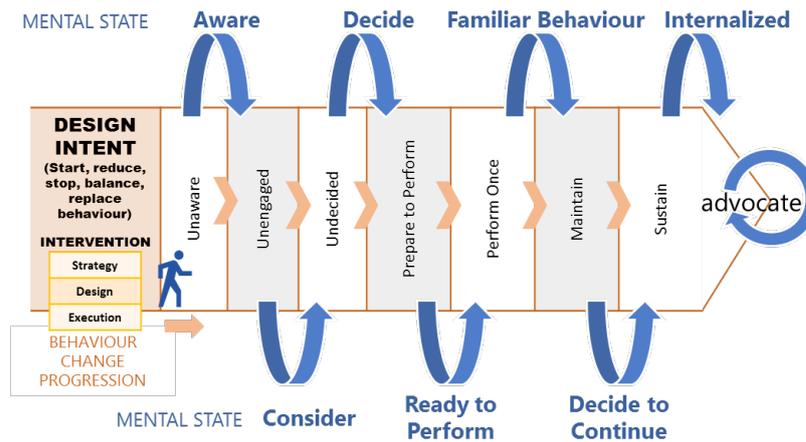


[Figure 1] CraftChange - Empathy Square (Mahamuni, Khambete, & Punekar, 2019)

Figure 2 also shows different mental states that the user goes through in the behaviour change process. A designer needs to ideate different sets of design interventions for each of the user’s behavioural stages from “unaware” state to “sustain” state.

CraftChange framework is operationalized through process, canvases and cards such as *Current Intervention Cards* for user research phase, *Ignite Cards* for ideation phase, *Challenge Cards* for validating and prioritizing ideas and *Enrichment Cards* for checking completeness of the ideas. Different kinds of cards are meant to provide design

guidance based on the behaviour change principles. The said framework is undergoing initial testing and found to be promising. The work is in progress and would be published shortly.



[Figure 2] CraftChange Behaviour Progression Framework (Mahamuni, Khambete, & Punekar, 2019)

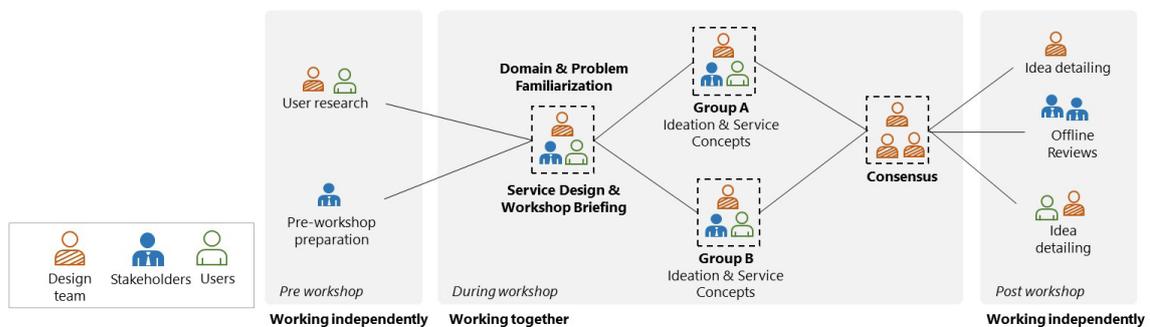
### 3. CASE STUDY – “ENCOURAGING PROACTIVE AND CONTINUAL DIGITAL LEARNING IN MULTI-CULTURAL SETTING”

We used CraftChange framework in one of our service design case studies, aimed at encouraging organization employees working in a multi-cultural setting, to learn proactively and continually using digital environments and revamp outlook towards learning. The latent intention of the design activity was to empower employees of a multi-cultural globally spread large organization, to enhance employee’s productivity and performance by offering personalized and adaptive learning services.

User research was done by the designers and design researchers to understand the concerns, constraints and aspirations of employees about learning. Existing interventions and initiatives were extracted to review the learning support offered by the organization. The key concerns derived through the user research are: Despite of a lot of training and educational digital platforms being available for the employees to learn, individuals focused on learning only when they were required to in the job, learning at organization was more of a compliance to the organization mandates rather than a proactive activity for gaining skills, the perceived importance of gaining domain knowledge was low among employees while they focussed on their existing areas of work expertise, time crunch during work hours was one of the distinct causes mentioned for not using the learning channels and platforms continually.

### 4. METHODOLOGY

The design activities were carried out in quasi-participatory (Mahamuni, Sharma, Lobo, Hirom, & Khambete, 2018) manner, as shown in Figure 3, where some of the activities like user research was done before the workshop by some of the participants. For the workshop, all the participants met together and got familiarized with the problem statement, service design and CraftChange framework. Then they were divided into two teams, wherein the teams worked separately on solving the problem. After the workshop, participants individually or within small teams developed the service components further, with the possibilities of engaging again as and when required.



[Figure 3] Quasi-participatory process

During the workshop aimed at ideation and creating solution service concepts, the two teams consisted four and five members each from multiple professional backgrounds - psychology, information technology, designers and design researchers. Incidentally all these team members were also the users of the service under consideration. One of the team members in each team played the role of the workshop facilitator. Facilitators also noted the observations during the workshop.

At the start of the workshop, service design overview was presented to both the teams together in order to

make them acquainted with service design. The CraftChange framework and the process was explained to the workshop participants. Further, the problem statement, the design brief and user research findings were discussed in details. The team was then divided into two ensuring trans-disciplinary participation in both the teams. The two teams simultaneously and separately used the behaviour change idea trigger cards and design ideation canvas to ideate under the guidance of facilitators.

The teams clearly spelled out the stated intention and latent intention of the service users along with the current and target behaviour of user. It was mutually decided that the team will first address the concerns of service users i.e. employees and then focus on other stakeholders as shown in Figure 1. The ideation was aimed towards identified employee target behaviour i.e. to inculcate proactive and continual learning behaviour among the employees, while also balancing other stakeholders' needs and concerns. The teams were familiarized with the concise personas created earlier on the basis of tacit knowledge (Mahamuni R. , et al., 2018) and refined with user research findings. The personas were – a bread earner persona from rural background, a confident and young persona considering life over work, an enthusiast niche skilled persona, a senior feeling monotony in his work and looking for a job or role change; identified through user research. The teams were allowed to choose one or many personas for the ideation.

For empowering the persona to progress from one state to another (as shown in Figure 2), a round of ideation session was carried out using one set of idea trigger cards from the CraftChange toolkit. From the user research, it was known that chosen personas intend to learn as and when required for their work, but the learning is not continual and proactive. Team 1 considered the scenario where the persona knows about the various learning services and resources provided by the organization and hence engaged in ideating for the subsequent progressive state of “maintain”. Team 2 chose the scenario where the employee is unaware of the learning services and hence intends to be in the behavioural stage of “unaware”. The cards were distributed within the teams to ideate for the given design brief. The cards were used individually by the team members and ideas were drawn on post-its. The cards were further rotated within the team and ideation was repeated using the exchanged cards. While using the cards, participants were encouraged to write their suggestions on improving the effectiveness of the content of the cards.

At the end of ideation phase, feedback was collected from the participants to know the effectiveness of the ideation process and the role of the cards. Participants appreciated the systematic ideation process and further proceeded with clustering of ideas. It was observed that though the teams initially focussed in ideating for the selected phase of the CraftChange Behaviour Progression Framework, ideas were also generated for other phases.

Then ideas were scrutinized for gaps in their relevance to the given user context, persona behaviour, and the concerns and constraints in purview of the other nodes of the Empathy Square. As a next step, the ideas were clustered based on their affinity to each other as a group exercise. Idea clusters like “Learning with Partners”, “Learning Lab”, and “Intelligent Learning Content Design” were valued to be innovative and effective, with respect to the other clusters for the chosen scenarios.

The selected idea clusters in both the teams were then detailed further using various service design techniques like offering maps, system map, touchpoint matrix, high level blueprint and journey map. This detailing of the idea cluster helped to connect the discrete ideas as one component service.

The detailed component services were further refined to implicitly attend to the various concerns, constraints and available resources of all kinds of stakeholders involved in its implementation. It was observed that the various component services were connected with each other to form a complete service.

## 5. OBSERVATIONS AND FINDINGS

Observations were noted by the facilitators of the two teams throughout the workshop. Oral feedback was also collected from the participants at intermediate stages of the workshop. The participants also made notes in pencil to provide feedback on the content of the cards in the toolkit.

The participants appreciated looking at the problem of continual learning from the lens of service, experience and behaviour change. Despite majority of the team constitution being non-designers and non-service designers, they were able to effectively arrive at a promising number and quality of ideas through the guidance of the framework and tools. Sharing behaviour principles and concepts with the team helped trigger rich ideas. This along with the framework and tools facilitated the team to think across the mental states of the users, from unaware to advocate. The combined ideas generated by the two teams exceeded 100 ideas within a span of around two hours. All mental states had sufficient number of ideas generated. The stages which had lesser ideas were revisited to add more ideas. The ideas generated were then clustered into three to five holistic and connected service concepts. Care was taken to revisit whether the ideas in the clusters were covered in service concepts.

The Empathy Square was seen as a useful construct towards balancing the concerns of the four stakeholders – the service users (employees), the support staff (HR, Learning departments, administration and other functions), the organization, and where possible appreciating the environment and society.

In general, it was observed that teams were able to use the guidance from the suggested process or deviate from it whenever needed. Participants liked the approach towards the problem as a behaviour change problem. None of the ideas were discarded. In fact, all the ideas were clustered to create meaningful service components and detailed

out to make it closer to realizable state.

Participants who were not involved in user research took longer time to understand the problem context. The workshop had provided a short period to showcase the current problems and constraints as findings from the user research to sensitize the participants. But it evidently needs more time and discussion to have all participants contribute effectively sooner. It was observed that participants who were part of user research were more active initially during the workshop as compared to others. There was also a time crunch situation seen during the period of detailing ideas. Here, a quasi-participatory approach seemed effective, where certain activities are done by part of the teams before and after the workshop. Mainly, here the user research was done before the workshop. The service concept clusters were further detailed and refined after the workshop too.

## 6. CONCLUSION

With the intent of evaluating the usefulness and effectiveness of the CraftChange Behaviour Progression Framework, we utilized it in a workshop setting to arrive at an effective service design solution to bring out sustained change in employees' behaviour towards learning, such that they proactively and continually learn. The participants of the workshop found the guiding process, canvases and cards to be useful in ideating and carving out innovative solutions for a learning service. The toolkit of canvases and cards were useful to trigger and channelize a large number of behaviour change solutions.

The Empathy Square provided guidance to focus on addressing the concerns of not just the employees, but also the concerns of staff that would be involved in providing the learning service, the concerns of the organizations, and where suitable the society and environment.

The CraftChange Behaviour Progression Framework [figure 2] provided a very structured guidance to the participants to think of ideas progressing systematically from a specific mental state (unawareness) towards sustained and internalized. Rather than thinking of the problem solutions from a high level perspective, the participants could now arrive at solutions which systematically take the user across the stages, from 'unawareness' (or other starting points) till 'sustenance'. This approach was found to be systemically informing and guiding the design intentions and interventions to achieve desirable behaviour change at individual and organizational level.

As evaluation of the process, few minor issues were noted such as communication challenges in the canvas and content, facilitating time, and team engagement and dynamics. With these inputs, we are in process of evaluating the framework further by also applying it on more number of small scale as well as large scale problems. Considering the usefulness of the framework, we aim at further improving the toolkit with findings from all the ideation workshops. In future, we intend to use this framework and toolkit for solving design problems in varied domains including public sector, private organizations, travel and hospitality etc.

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## **FOR AN AESTHETICS FOCUSED ON SUSTAINABILITY: STUDIES FOR THE CONFIGURATION OF ECOLOGICALLY ORIENTED PACKAGING**

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### **ABSTRACT**

The discussion about environmental damage caused by the disposal of packaging has led to a change in the design scope, promoting a new category of packaging, the ecologically oriented ones, that seek to reduce the environmental damages caused during the whole life cycle. In this context, the design has been presenting measures that focus, almost exclusively, on the adoption of technical measures, aiming at adding environmental sustainability. Reflecting on this situation, this article presents the need to expand the capacities of the design, from projects that allow the disclosure of ecologically oriented packaging as a solution more suitable for the public. The research tries to present the relevance of the differentiation between conventional and ecologically oriented packages from the visuality, as a means to improve the relation of consumption.

Key Words: environmental sustainability. packing design. aesthetics

## 1. INTRODUCTION

In 2017 the gross value of the physical production of packaging reached R \$ 64,3 billion (US\$ 17,3 billion in 02-15-2019), increasing approximately 6.6% compared to R \$ 60,4 billion (US\$ 16,3 in 02-15-2019) in 2015 [1]. This growth, although positive for the market, made it one of the pillars of the concern of environmentalists, since in less than a century they generated more domestic waste than all of humanity had produced until then [2]. According to the Ministry of the Environment (from Portuguese, *Ministério do Meio Ambiente*, MMA) (2015), 70% of the dry waste produced in Brazil is composed of packaging, which causes problems due to material used in production and subsequent inappropriate disposal [3].

Looking at these problems, the packaging defined as “sustainable” appeared in the market to “contemplates the ideal proportion of packaging versus product, optimizing its specific weight and providing the ideal conditions for product packaging” [4]. Although this term is commonly used by the market, it was decided to adopt the term “ecologically oriented packaging”, understood as those aimed at providing greater environmental benefits or environmental minors costs. [5,6].

In this scenario, the design has been concentrating his efforts on the adoption of technical measures that reduce the environmental damages caused by the adoption of natural resources and their disposal, but with little intention to visually evidence them as a differentiated solution for the consumer, a misunderstanding which an ecologically oriented product without being perceived as an improvement compared to obsolete solutions, “would not be enough”[7].

Although communication about visual quality oriented to environmental sustainability is an important strategic factor for the disclosure of this type of product, what is observed in the current context is the limited amount of strategies. Among them, the most common is the adoption of environmental labels and stamps. However, the Brazilian consumers recognize the symbols but do not know them [8]. This makes this resource insufficient, mainly because recent years there has been a decline in the reading of such items by Brazilian consumers [9]. In addition, generally the environmental stamps and labels are positioned on the side and rear faces of the product, leaving the information hidden due to inadequate provision in supermarket shelves, which usually expose only the front panel, not highlighting the ecologically oriented packaging in spaces for this category. These packages are thus compelled to compete visually with the others, having to individually transmit this information through other visual resources that highlight them as less harmful products [10].

Among these other visual resources, one can cite the visual composition itself, since every material product has an immaterial dimension of information that can be attributed through its appearance [11]. From this type of strategy, a great number of different visual compositions are verified, exempting a standard that can evidence to the consumers the ecologically oriented packaging as a product typology. This finding shows that there is no perceived sustainable visual quality used in a strategic and coherent way.

It is understood that this can occur due to several factors, among them, not to have sources that provide descriptive directives about perceived as sustainable visual quality for the visual professionals, which results in generating visual compositions made solely from the designer’s experience, while the ideal would be to search for more objective data on the needs of the project, through interviews and tests with users, which would foster the establishment of perceptible aspects in a more rational way [12].

These initial findings allow new possibilities of research, in which the designer can act in the design of ecologically oriented packaging not only in technical choices, but also in the form of configurational strategies that emphasize to consumer which products have better relation with the environment, through visuality. This is possible, “through visuality, the design is capable of suggesting attitudes, stimulating behaviors and equating complex problems” [11]

This article aims to discuss a possible path, indicating for this the association between the appearance of the packaging – visual quality – and the environmental theme perceived by the consumer, allowing the development of own indicatives for this category. It is still an initial research, presenting partial results of comprehension and planning about the visual aspects pertinent to the packaging design, as well as possible ways for the development of design guidelines focused on perceived environmental visual quality.

## 2. THEORETICAL BASES

To construct a visual typology certain aesthetic identifiers can be proposed, so as to be common to many consumer goods, and thus become collectively useful in distinguishing unsustainable practices [12]. The aesthetic it should play a fundamental role in the realization of sustainable solutions, favoring the distinction between these products and those still involved with unsustainable practices [7]. But, what would be the way to develop an appearance belongs to ecologically oriented packaging?

From the aesthetics of the object its visual characteristics of and its qualities are described, that can be investigated through empirical aesthetics. The data presented by this model provide the basis for the development of design guidelines applicable by the designer, making this mitter of messages in the form of industrial products. But for this to happen properly it is necessary that all the visual characteristics of the products be known and enumerated, making it possible to design an industrial product that meets the values set in the design process by the industrial designer and that corresponds to the perceptual needs of the user [12].

In this perspective, the consumer can contribute by indicating which strategies best represent the association between the visual aspects and the values involved in the perceived environmental quality, which in turn allows better results in the design practice of ecologically oriented products, since the appearances of objects are never neutral, but they are full of meanings, which are associated with a series of values and judgments linked to our individual and collective history [11]. This approach makes it possible to envisage the construction of an aesthetics of ecologically oriented products based on consumer perception, which allows the facilitation of communication between the product less harmful to the environment and the conscious consumer, through strategies related to configuration.

**2.1. Aesthetics of the object**

In this paper it is proposed that the visual indicators for the communication of ecologically oriented packages are based on their configurational arrangement, which “is determined by the set of configurator elements”, which can influence the sensitivity and users’ ideas. These elements can be described as carriers of the aesthetic information of a product, and their selection and combination, by the industrial designer, will define the reaction that the future user will present to the product [12].

The designer must experiment on the effects that can be obtained, because only on the basis of such experiences can you make the right combination and thus achieve the desired effects. This arrangement, comprises the “figure”, and is composed of the following main elements: Form, material, surfaces and color [12] . When searching within the scope of packaging, it is possible to expand the scope, to: logo; photography and illustration; symbols and icons; typography; label; Format; finishes and effects.

The union between these elements and their arrangement will be responsible for the constitution of the “Figure” of the product, which refers to “the type of configurative elements, their set, their quantitative distribution and their relation to the whole”, these in turn entail the factors of order and complexity [12]. The conscious use of these elements contributes to the construction of more effective messages to the public, visual communication occurs through various messages and can be intentional, through prior elaboration [15]. Based on this, it is possible to investigate what feelings the artifacts provide, and what qualities evoke such feelings, a factor often neglected by professionals, who from an academic formation and professional practice, end up distancing themselves from the expectations of the consumer. The contemporary graphic designer does not have to focus only on problem solving brought by briefings, but should also explore topics of interest, that aim to bring new visual languages into the field of knowledge , such as in the case of a language specific to ecologically oriented products[16].

**3. METHODOLOGY**

In order to advance the discussion about packaging orientation communication, literature reviews were initially carried out on the visual elements used in the package appearance design, in order to enumerate which visual aspects exist. The objective is to provide information for future development of a model and the application of methods proposed by empirical aesthetics, which can contribute to the understanding of which and how aesthetic visual aspects can be used to construct a visual quality perceived by consumers. The result of this article will be a picture of the visual aspects showing a panorama for future investigations on the subject.

**4. RESULTS AND ANALYSIS**

After surveying the aesthetic visual aspects commonly used in packaging configuration, it was possible to construct a framework of visual elements and variations that correlate in this product in order to create messages that can be interpreted by individuals.

FIGURE = PACKING	
CONFIGURING ELEMENTS	
Shape – Material - Textura – Surfaces – Color – Logo - Photography and illustration - Symbols and icons; typography – Label - Format - Finishes and effects	
CONSTITUTION OF FIGURE	
Order (small number of elements and sort characteristics)	Complexity (large number of elements and ordering characteristics)

*[Table 1] packaging as a figure*

It is understood that the choice between these visual aspects should be made in a way that allows the association between the visual quality and the environmental sustainability theme, facilitating the communication between ecologically oriented packaging and the consumer. The aforementioned table is presented as the starting point for the development of a model that allows public perception as an actor in choosing the best arrangements for packaging compatible with the communication about ecological orientation, favoring the understanding of each element and its potential to contribute with visual arrangements aligned to perceived environmental visual quality.

Investigating how these elements can be combined to represent the ecological orientation of the packaging, vis-à-vis public perceptions, can be an efficient path for individualization/recognition of ecologically oriented packaging. Thus, from the collected data and its experience in the configurational development, to construct a visual

aesthetic appropriate to the packaging design with content addressed, which in this case requires a plural and widely applicable aesthetic, due to the great complexity brought by the packaging design.

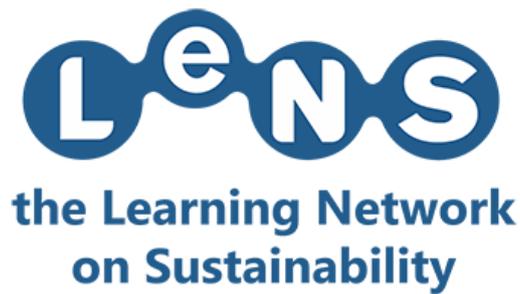
There is a need for research that focuses on the user as a participant in the change process. One must add the concern with the identification by the individual of the objects that consume, interrelating the visual language and the values of the society with the practice of the design [17]. In this way, we can see the relevance of the designer in the construction of messages that are aligned with the consumer's perception of the material artifacts, and it is possible to develop dialogues on themes of great importance in the current context, as in the case of environmental sustainability.

#### 4. CONCLUSION

For the construction of an aesthetics aimed at environmental sustainability to be effective, it is necessary for society itself to present its expectations about this category of products, allowing the construction of a visual aesthetic based on sustainable perceptual values. The research, still in the preliminary phase, seeks to understand, through consumer perception, which strategies can be used for the aesthetic development of environmentally sustainable products, favoring their recognition as a type less harmful to the environment. In this perspective, the consumer is the starting point to draw up strategies that promote the association between product configuration and the values involved in the perception of sustainability, which in turn, allow better results in the design practice of ecologically oriented products.

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## CRITICAL ZONE: THE EARTH BELOW OUR FEET

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### ABSTRACT

This paper reflects on an international collaborative project “Critical Sciencing Zone,” along with works from the Kochi biennale (2018), which responded to the flood and landslides in Karnataka and Kerala. The critical condition of the thin layer of the earth crust is of immense concern in this paper. I am tracing the inclination for vertical movements and aspirations to reach the sky that accelerated technology, to the detriment of the Earth. Postmodern theories that specifically use elements from nature, will be useful to frame radical shifts in perspective, and hence re-think our relation to the earth. This paper will speculate through art works and fundamentally emphasizes learning through cognitive, experiential and affective processes in order to acknowledge and recognize Nature. In short, my aim is to examine and discover perspectives and manufacture discourses.

*“The Earth,” he said, “has a skin, and this skin has diseases. One of these diseases is called ‘Man’.”*

*Friedrich Nietzsche, Thus Spoke Zarathustra*

## INTRODUCTION

The critical condition of the Earth is overwhelming and this is extremely and embarrassingly a very obvious understatement. As much as there is despair, yet it is necessary to find means to make amends to the blunders done to the Earth. My contribution in this paper is to look at perspectives and frameworks, in order to rethink them, so that our attitude, discourses and practices are renegotiated in order to foreground the Other and by that I mean Nature. To begin with, it should not be the Other, however, the othering has deepened so far that a repetitive deploying of post-structural and postmodern questioning of the foundations of discourses and knowledge systems will continue to be pertinent. An archaeology of knowledge unearths the apriori and discourses, or just simply assumptions that precede and preside silently behind logic, questions, frameworks and other normalized principles (Foucault, 1972).

A projects titled “Critical Sciencing Zone” (March 2018, July 2018) was a major source of inspiration for this paper. The occurrences that followed the projects was an array of related incidents with real and fictional concatenations. The disaster that immediately followed in August 2018 was a rude awakening to two southern States in India, one in Coorg, a district in the State of Karnataka and in several parts of the neighbouring State of Kerala. The unusually severe rainfall, and heavy floods, not witnessed in nearly a century, caused landslides that washed away not only the animals, vegetation and houses, but also the land itself which changed the geography of those regions. These occurrences unfolded the trepidations of the above projects. The calamity was incorporated into the Kochi Biennale Dec 2018- March 2019 (Kerala), at Kochi, a port city in Kerala. The ongoing Biennale titled “Possibilities for a Non-Alienated Life” includes several themes, and highlights ‘ecological disaster on the planet.’ Some of those works will be of importance to this paper and they bear an uncanny connection to the above mentioned projects at IISc. Indeed, I am writing this paper in the midst of raw natural occurrences and reflective aesthetic responses and resonances.

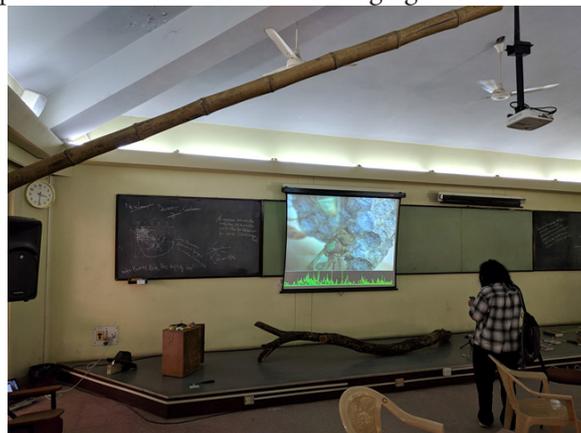
### **Critical Sciencing Zone—Work Shop and Performance—Frustrating Normal Expectations with Surprise**

Critical Sciencing Zone was comprised of two events: Workshop and Exhibition (March 2018) and Two Earths Lab (July 2018) and they are part of a larger project De/Globalization (India, Egypt, Germany). Link: <http://deglobalize.com> The primary participants are:

Daniel Fetzner, Professor for Design and Artistic Research and head of Media Ecology Lab at Hochschule Offenburg  
Dr. Vasanthi Mariadass, Srishti Institute for Art Design and Technology, India, Dr. Martin Dornberg, M.D., PhD Center Psychosomatics/Psychotherapy, Freiburg. Philosopher at Freiburg University, Ephraim Wegner, Electronic musician and artist at Media Ecology Lab, Hochschule Offenburg, Dr. Raghavendra Gadagkar and his Team from Indian Institute of Science (IISc), Indo French Cell for Water Sciences and The Earth Science Department at IISc, India.

This was an interdisciplinary workshop constituted by researchers from Science--Humanities—Design—Art—Social Sciences focusing on environmental question through the fundamental elements necessary for living: Air, Water and Earth. We engaged with Indo French Cell for water science, Wind Tunnel lab, and Earth Science departments at IISc. The participation and performance was by plants and animals (including human beings) along with questions concerning the Anthropocene; the exponential development in Technology and human activity was the primary concern of our project.

Critical and Theoretical concerns by Gilles Deleuze and Felix Guattari, Robert Smithson, Lyn Margulis and Bruno Latour are important here for the brilliant perspectives they recreate to undo the adamant sedimentation of perceptions that delimits other possibilities: To perhaps refresh, cleanse, and expand terminologies and thereby avoid cliché and finally limitations. Primarily, poststructural and postmodern theories will be of importance for my analysis here. They are simultaneously a fundamental and radical source for education, since they constantly engaged with critique and methods for reading, writing, and interpretation. In short, rethinking meaning making dictums and dictates, and hence the valorising games played by the elite through history, politics and religion is systematically unfolded by them. Smithson’s works provide instructions for his audience, but more specifically for Artists, Curators and Art Critics/Historians. His methods include fragmentation and “pulverization” of hardened ideology, similar to poststructural strategies and hence introduces the process of “leaky minds” that poststructuralism would call sliding signifiers.



[Figure 1] Critical Sciencing Zone Performance

Critical Sciencing Zone (March 2018) was a research process for 3 weeks, that culminated in a performance (figure 1). It was inspired by Latour's (2014) "Some Advantages of the Notion of 'Critical Zone' for Geopolitics" which was central to our discussions with scientists. The Critical Zone topic have been of great concern to scientists for a very long time, ever since the forecast of its fragility was speculated. It is the layer of the earth just below the atmosphere and it reaches below to the hard rock layer, also known as the mother rock—the continental crust. Critical Zone Observatories (CZO) exist in different parts of the world, equipped with sophisticated instruments where data is perpetually gathered and shared.

Discussions with scientists, found objects and living beings at the site of the Institute was used for the performance at a small auditorium at Center for Contemporary Studies (CCS) in IISc. It was an unusual staging and surprisingly the audience, predominantly constituted by scientists, performed consequently the whole auditorium became a stage, including the "intruding" bamboo stem that entered through the window out of curiosity, while a wasp hive was placed at the entrance. We the expected performers remained off stage, and the stage was populated by other critical protagonists: a freshly cut wood found around in the wooded areas, live streaming of the Wasp colony, a wasp hive and books used as reference material. The cut wood seemed to be reclining, and appeared like a dead being making the auditorium a funeral space. The puzzled audience must pay tribute to the dead and the living at once, although they were unaware of this predicament. The audience were asked to bring objects representative of their work to discuss, as a result they were forced to become the performers. Of course, we the so called performers were merely facilitators and performed to the extent that we introduced and reflected, along with synthesized background sound found in the surroundings; extracted and shaped to highlight sounds that are forgotten in the Anthropocene.

Here we were in a science institution, introducing a topic that the scientists have already engaged with for more than 30 years. Many have moved on after surveying, analysis and data collection that terminated in publications. And yet the performance impacted them, and included below is a palpable and moving e-mail response by Pascal Jouquet who was then based in IISc at the Indo-French cell for Water Sciences—a scientist who was an audience and performer at once, and reflected on the affects he experienced during and after the performance:

Dear all,

First of all, Sorry(s): Sorry to not have been able to send you a message before; Sorry in advance for all the weird, chaotic and perhaps incomprehensible message you gonna read (perhaps...); and finally Sorry to be so critical of a concept whose utility seems to be so uncontroversial... So... "in a few words", I take the opportunity of my holidays...to send you a message regarding our discussion and your performance. But first, let me introduce myself (again): I am working in a team called "Ecological Functioning of Tropical and Temperate Soils"... I couldn't remain insensible to your venue, our discussion and even your performance. You made me think - you made me read - you make me write now in the middle of a night... That's simply magic and a real pleasure, if not a therapy... ;-). After my many Sorry(S), now please acknowledge my so many ThankS! ... Thanks also for your fantastic and breath taking performance. I don't know if you remember but I challenged you. I wanted you to make me understand "things", I wanted to grow, to reach a new state of understanding. I don't know if I have been where you wanted me to go but yes, it worked. I went far, very far and I was so excited at the end by this incredible experience... I didn't simply understand it - I felt it!!! Then, SorryS and ThankS! ;-). As your videos of the swimming pool highlighted, an ecosystem (= a watershed) is made of many and incommensurable smaller and entangled ecosystems that are all Critical in the sense that they are crucial for many different organisms...but the "Zone" concept isn't too 'linear' for that? Let's be honest, we're destroying our environment and the environment of animals and plants that didn't ask for nothing - That's critical, terribly sad and unbearable... Thus, I'll simply repeat myself: Thanks for this discussion. But I am convinced by the need and richness of the feedback between philosophy, ecology and now even Arts! And by the need to question our approaches, concepts, symbols and why not feelings. A change in perspective (like the one raised by the round table and the final participation of Prof. Raghavendra) is a good example of what can be learnt from any change in perspective... Yours sincerely,

Pascal Jouquet, IRD / UMR 242 iEES Paris / Equipe "FEST"

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## VERTICAL ASPIRATIONS

Before discussing the next project "Two Earth Labs," a detour to the Kochi Biennale is pertinent here, because it sets the stage for the vertical aspiration of Humans: An egotistical, megalomaniacal assumption to oversee all that exists on the earth and sky. Beginning with Deleuze (1988), who made the remarkable shift from the Tree model, which is man-made and partial, vertical and hierarchical and more particularly a repressive structure constituted by a skeleton of a "tree" that hides the many inconsistencies within, and hence he re-assigns a rhizome structure in his introduction "Rhizome" to *A Thousand Plateaus* (1988). At any rate this tree structure is merely a skeleton, an impoverished version passing of itself as a form that fully and accurately represents the genealogy it sets out to demonstrate. In the rhizomatic structure the movement is horizontal and they branch out at unpredictable intervals, nonhierarchical and include localized nodes/centers that improvise, add and multiply, but do not produce an absolute, the Center.

Often such striking biological and geological forms are used in this paper that forces the theoretical paradigm to emerge out of earth, and not merely from a human mind. More than ever our knowledge systems are derived and appropriated from the environment, but we fail to acknowledge Nature, and the paradigms gleaned from it, since the earth is at our feet literally and must be at our service. Whereas, diligently we acknowledge fellow human beings and their contributions through bibliographies, endnotes, footnotes and credits. Human alienation from nature appropriates all achievements emerging exclusively from and by humans and will interdict acknowledgement of other living beings—a self-authorization that leads to the use and abuse of the Other. In rare occasions, a few like Jean-Luc Godard, the French New Wave Filmmaker, would acknowledge nature as a source of inspiration in his works. Those moments often seem absurd, but they contextually render the unthought acknowledgement of Nature.

Godard's visual essay *King Lear* (1987) includes extracts from two infamous essays "The Death of the Author" by Roland Barthes and "What is an Author?" by Michel Foucault (Lodge, 1988). But Godard stretches them further to include Nature as a tangible source of inspiration and collaboration. *King Lear* a postmodern appropriation of Shakespeare's work, includes a character who plays The Author/Writer figure, called Shakespeare Junior the fifth: a punk who is often found plagiarizing. On several occasions he seeks solitude to write and reflect on a sea shore. He is sitting on the rocks and oblivious to the waves splashing, spraying and washing over him and his book, while he is busy writing. In sum, there is no absolute solitude at all, since the sea, sand, rocks and most of all the waves are engaging with him and those are also the most inspirational moments. It is unthinkable to thank and acknowledge Nature for intellectual activity, from an anthropocentric logic, however, several works by Godard navigate the viewer to think the unthinkable and thank the unthankable. Certainly, a few religions continue to include nature and yet the abuse on the earth continues, overtaken by Techno-Scientific Capitalism.

Postmodern theories suggest that since the enlightenment the vertical drive to look at the sky supersedes the horizontal (Barthes, 1977; Virilio, (1997). Hierarchies, binaries continue with their schemes and advance those vertical concerns. The move towards the sky and space without a horizon or an ever expanding one, becomes the alibi and dissimulation of Modern man to efface the recognition of plunder done upon the earth and justify it—hence, forget and repress. In general, the human race is looking up at the stars, seduced by "heavenly" objects resulting in fabrications that reach and explore space. The prompt for such movement is not merely material, scientific and megalomaniacal but also cultural and theological. Tejal Shah's work at the Kochi Biennale 2019, illustrates a fundamental cultural aspect, such as stories, especially during full moon, that surrounds the mystery and the beauty of this celestial object. Those simple stories and songs generate discourses that incite the fire to find, reach, and possess the moon and stars. Her *You Too Can Reach the Moon* (2013) is an image of a transgender mother/father pointing the moon to a child (lord Krishna), where Shah weaves gender and ecological issues. Parents in general pointed to the moon and told stories to entertain and distract an irritable child, or while feeding a reluctant kid. Along with the food they feed them with limitless desire to reach the unreachable, and yes for sure we have reached the moon. Children are quickly distracted and enamoured by the moon or is it the cultural annotations of it? Later in life the annotations continue as a romantic setting, where the parent is displaced by the lover. Such entangled desire for celestial objects in the sky is sustained by their eternal mystery and distance.

On the adjacent wall is a video by Shah, titled *Moon Burning* (2012), where continuous and intense burning reaches a point to form a crescent, another beautiful and seductive early phase of the moon. The aspirations are incited and they burn through history, until it reaches those destinations where actual intense fire burns the ore, melts, smelts and purifies them to form tools and objects that realise those ambitions. Even if enormous amount of resources and funding is wasted again and again on space research, even by countries that cannot afford to do it – like India for instance—we continue to justify such prodigal waste. For sure they don't need to justify, since such heavenly endeavours are a cause in themselves. More justifiable with instruments of information management—satellites—the one eyed "Cyclop" (Virilio, 1997), for they are contingents to wars and war "deterrence." This latter possibility is a powerful reason to walk away with absolute assurance of doing the "right thing." So where is the need for justification out there in open space without a horizon?

#### **Man-made Disasters and the Suicide of the Earth**

Marzia Farhana, an artist from Bangladesh, multimedia installation and video work *Ecocide and the Rise of Free Fall* (2018) at the Kochi Biennale describes the vertical move and the process that converts the material of the earth to reach the sky. Her assemblage is composed of found material obtained abundantly in the aftermath of Kerala Floods Aug 2018: white goods, furniture, books and other valuables washed away in the landslides. Not only the biological habitat and houses with all its possession disappeared in the landslides, but the very land itself on which they stood does not exist anymore changing the geography and mapping of those regions. The installation was distributed in several rooms but not carefully like in a home. They look like they have tumbled down, crowding the space and inverse, since they are dangling from the roof on thin ropes. Movement is difficult in this installation signifying not only the enormous number of objects that got washed away but also the abundance of wealth, old and new, in most of these regions: particularly new wealth, neo bourgeoisie, who perhaps crowded their homes with the latest appliances and furniture. There was national attention to the Kerala calamity. Indeed, resources poured from several resources. This must have been a sharp contrast to Farhana who hails from Bangladesh, where the river Ganges flows both in India and her country. People are landless or marooned in newly formed islands, created by the erosion and due to the shifting river and this has become a way of life; for ever shifting and moving to the whims and fancy of

the river and rain. A film titled *Char-The No Man's Land* (2012) by Sourav Sarangi, was a screened in the recent Bangalore International film festival Biffes (2019), Nature's Fury category, is about one such newly formed island called Char. The people cut off from the mainland continue to live with literally nothing to survive on. To make things worse the India-Bangladesh border is drawn through this little insignificant land. The only way to survive is to improvise with the means found around, which happens to be smuggling rice, medicine etc. The border control vultures will not allow that very little they are striving for and relentlessly punish or just make it more difficult to get the very little that is possible. The Indian Government hardly supports them nor does it let them eke out a living for themselves and finally there is no public support for the very vulnerable.

It is pertinent to trace back to "Sedimentation of the Mind" (Smithson, 1968) and particularly to the segment 'From Steel to Rust' in order to connect with the work of Farhana. Her work resonates Smithson's, who first of all critiques artist who include technology in their work, and particularly the euphoric use of it as a medium. By suspending technology, he discovers the sub-stratum of the Earth, since the discourse of the industrial process is framed by the vertical reach away from the earth. His works highlights other processes of oxidation, carbonization, hydration that affect metals and rock weathering and prefers them for art making practice. Such processes are inherent to the Gaia model of the Earth established long ago by Paul Vernadsky a geologist in the early twentieth century (Arenes, Latour, Gaillardet, 2018). A model that remind us of the earth as a breathing and living organism and not an inert substance to be used in the service of Technology. Hence Smithson (1968) states:

By excluding technological processes from the making of art, we began to discover other processes of a more fundamental order. The break up or fragmentation of matter makes one aware of the sub-strata of the Earth before it is overly refined by industry, into sheet metal, extruded I-beams, aluminium channels, tubes, wire, pipes, cold-rolled steel, iron bars, etc. ...Oxidation, hydration, carbonization, and solution (the major process of rock and mineral disintegration) are the four methods that could be turned toward the making of art. (87)

Those torn and crushed household items in Farhana's work, are covered with mud, already rusting and slowly absorbed by the earth—justifiable return of 'man-made' material to the earth. Her anti-capitalist and anti-technology inclination dangles the rusted objects and illustrates its disintegration. She like Smithson recognizes how many artists are also grounded in a powerful ideology of the 'ideal' which incites human imagination and fires technological growth. Those artists therefore need the "refined 'paints' of the studio."

The smelting process that goes into the making of steel and other alloys separates "impurities" from an original ore, and extract metal in order to make a more "ideal" product. Burnt-out ore and slag-like rust is as basic and primary as the material smelted from it. Technological ideology has no sense of time other than its immediate supply and demand, and its laboratories function as blinders to the rest of the world. Like the refined "paints" of the studio, the refined metals of the laboratory exist within an "ideal system." Such enclosed "pure" systems make it impossible to perceive any other kind of processes other than the ones of differentiated technology. (Smithson, 1968, 86)

In one of the small rooms crammed with domestic objects, Farhana inserts a video screening running perpetually on the floor, while leaning against a vertical pipe. The video image is of a red hot fire burning relentlessly and slags of smelting metal sliding precariously. This room by Farhana is not creating a hearth with a fire cooking a warm meal, but a reminder of the industry and manufacture of the ideal material to make white goods and other traditional kitchen objects such as knives and ladles. A small boulder of rock is sitting next to the video as if it were looking at it. Perpendicular to the video and the rock is a mirror reflecting them—a necessary reflection on the smelting process, while the rock is sitting still in silence, unaware/oblivious to any ideology. At the upper end of the vertical pipe is an old rusty television with the image of an airplane silently and consistently swirling and hovering menacingly. The smelting metal on the ground has transcended to become the flying object in the sky. The image on the television is facing the floor and "looking" down at the smelting ore. Hopefully acknowledging the ore from which it was created, since once it floats into the sky it forgets the dirt it came from. Or is it ensuring that the fire continues to burn and smelt? Another adjacent television is also facing down, but it has a fantastical image of a flying horse, a mythical creature that made the planes a reality. The hearth in a home is not merely cooking an innocent warm meal, but various fantasies and thoughts simmer in conversations, and family and friends partake of food and thought. Perhaps the flying horse is the next novelty and technological upgradation, since the planes are not live enough? Fabrications and inventions are extractions of mental fantasy just as the necessary material are extracted from the ore, although based on a very irresponsible subjective-objective notion of the ideal.

Smithson's land art and writings, and Farhana's assemblage, poetically expresses the acceleration of technology as endeavours that move away from the earth. Technology itself is used to achieve this separation through the binary of Earth/Heaven which already implies the hierarchy. Therefore, although the ore found in the dirt below our feet is used for technological advancement, this very ore which is of the earth is forgotten through extreme refinement. Steel is one such "man-made" material that even if made from the earth it appears as man-made and not of the earth. The refinement of the ore exceeds itself to the point where the purified form of the material is not of the earth: refining is an erasure of the sediment that leads to amnesia, amplified by the desire to forget the plunder and assault on the earth that primarily induces denial and amnesia/Alzheimer. The highly refined materials including steel, aluminium, nickel, chromium including plastic a man-made material par excellence (also made from elements found in the earth) are used for making objects that reach the "heaven." Rockets, planes and satellites cannot be of the earth, because they must be man-made (not out of nature or God) in an absolute sense—like a god and beyond-

-The Uber Man. The Eiffel tower is by far the best example that illustrates the euphoria of steel and a symbol of Techno-Scientific aspirations that displaces the steeple of the churches, reaches the sky and visible from most part of Paris—a Techno-Scientific temperament and ideology consistently haunting the imagination (Barthes, 1979).

### CRITICAL SCIENCING ZONE—TWO EARTH LABS—VERTICAL TO HORIZONTAL

The second event “Two Earth Labs” of Critical Sciencing Zone at IISc, was based on Land art work by Smithson. While the first event “Workshop and Exhibition” was a performance inside the auditorium, “Two Earth Labs” was outside the auditorium in a small wooded area. One of them was nestled among the trees and a square piece of land of about 3m x 3m was cleared and dug out to a depth of about 6 inches. While the stage inside the audience was about 6 inches high, this dug out was an inverse of it and the performers sat inside the square and performed their respective research (figure 2).

The space itself resembled a Bower bird’s nest to the scale of human and just as they adorn them with colourful found objects we used serial lights that lined the entrance to the nest (Deleuze & Guattari, 1988). The male Bower birds (the stage bird variety) clip the leaves from a tree and drop them on the ground, and they also carefully turn the leaf over to get the right shade of green that they prefer. After setting the stage the male bird sings and performs. Nature continues to perform, come what may, and improvise from what is around, sometimes they even pick bright blue plastic corks to decorate their bower. The project continually improvised to include thoughts emerging from Nature.



[Figure 2] Two Earth Labs

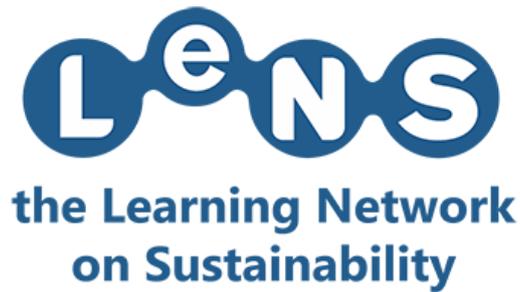
Within the square patch there were several mirrors on the ground facing the sky, but they hardly reflected the sky. Instead they reflected the foliage and soil. One of the mirror that faced the sky was strategically and partially buried in the earth and looked like a pool of water. The mirror in Farhana’s work and in “Two Earths Labs” are the pool of Narcissus. Egotistical, megalomaniacal and Narcissitic tendency gave rise to the overwhelming advancement in technology and ironically this has happened despite the several severe humiliations suffered by the human ego through paradigm shift that emerged since the beginning of 20th century, aggravated by 2 world wars. Radical paradigm shifts by Freud, Marx, Nietzsche et al along with socio-political re-hauling, contributed to a lack, and as a result the bruised ego reinstates itself through endless substitutions (Slavoj Zizek, 1992). Indeed, the exponential acceleration in technology according to Zizek is a result of this humiliation, surpassed by such extraordinary achievements. The first event of Critical Sciencing Zone introduced death on the stage, and the second by digging out square patches marked burial: the grave became a stage for further research by Scientists, Theorists, and Artists. Perhaps for the death and transformation of the ego. Nietzsche’s citation at the beginning of the paper is a sharp diagnosis of the Critical Zone that proscribes for sure, but also prescribes sustained investigation through denegation and de-alienation of man to find remedy for the disease called “Man.”

“...the great murders [destructions] have become the quiet game of the well behaved.”  
Michel Foucault

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## **SERIOUS GAME AS A NEW WAY OF HANDICRAFT INHERITANCE—A CASE STUDY ON “HUAYAO CROSS-STITCH MASTER GROWTH RECORD”**

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### **ABSTRACT**

With the development of digital learning, The local children are the “digital aborigines” of handicraft inheritance, representing the latest strength of culture. Nevertheless, traditional learning styles cannot stimulate local children’s interests. Our team takes serious game as a new way of learning crafts and proposes a serious game design model.

The purpose of the serious game is to help left-behind children in Huayao area to learn traditional handicrafts. According to Johan Huizinga’s Magic Circle theory, this game can help the rural children to learn their national culture, improving the identity of the rural children to their national culture by the elements in the game world. Taking the “control classroom” as a test. Through the game, the local children’s learning behavior which in the game world can be transferred to real world, which can help the inheritance of traditional crafts.

Key word: Serious game, Inheriting Handicraft, Magical circle, Octalysis Framework

## 1. THE DIFFICULTIES OF INHERITING TRADITIONAL HANDICRAFTS FOR RURAL CHILDREN.

Marc Prensky pointed out children who grew up as a network age are the “digital natives” generation. The future learning revolution is not the digitization of the curriculum, the ideal state of “learning in entertainment”. The methods of learning Handicraft are too traditional, leading to the phenomenon of “fault” in handicraft inheritance. Taking Huayao’s traditional handicrafts, in BaiShuidong Village, HuXingshan, Longhui County, Hunan Province, as a practical case, which in a remote area in southwestern China. Huayao cross-stitch is an unique handicraft of Yao nationality. The nationality named Huayao for the exquisite cross-stitch. They have no words, and Huayao cross-stitch is the “living history”. The patterns ranges from plants to ethnic legends. The craftsman does not need to draw drafts. When the craftsman complete the frontal pattern, the reverse side is also a neat and delicate pattern. In 2006, Huayao cross-stitch was listed as the first batch of national intangible cultural heritage because of its unique artistic and cultural value. In December 2017, we went to the BaiShuidong Village to do the research.

We investigated 66 Yao pupils aged 9-12 in the village. 66.6% of the students have elders who does well in Cross-stitch. 13.6% of the students only know a little of Cross-stitch. Most of the students stay in shallow understanding of it. There are three main reasons for local children’s difficulty in learning and inheriting the cross-stitch.

- Complex handicraft processes lead to low interest in learning.

Handcraft learning is a cognitive process that combines mental exploration with behavioral manipulation. The ways of learning Huayao’s cross-stitch crafts is: teaching by handicraft master, workshop and imitation practice. The traditional method can not stimulate rural children’s interest.

- Few Ways to Learn Handicraft.

As the older handicraftsmen’s teaching and the shortage of handicraftsmen, children have fewer way to learn. Most of the veteran craftsmen have traditional teaching methods and speak dialects, which lead to obstacles in teaching children—“digital natives”. With the increasing number of city-workers, the elder and children constitute the main population of the village. There are fewer can be taught to local children.

- Weak sense of cultural mission.

The weak-cultural environment cannot cultivate children’s sense of cultural mission. The primary school unable to teach systematic course of traditional culture. Traditional customs are weakened by the modern life, which led to the failure of children to establish a sense of mission to inherit traditional culture.

Therefore, the main objectives of serious games applying to traditional handicraft learning are: 1. Stimulate local children’s interest in learning handicraft; 2. Establishing the sense of mission of local children to traditional culture.

## 2. DRIVING BEHAVIOR TRANSFORMATION WITH CULTURAL MISSION

Serious game is an educational game, which aiming at transfer the learning behavior. Players need to accumulate enough ability to complete the game task, which fits the cognitive mode of procedural knowledge such as handicraft. Johan Huizinga proposed Magic Circle: The game elements can cultivate the behavior of users in the real world. For serious game design, game elements are used to cultivate players’ learning behavior in the real world.

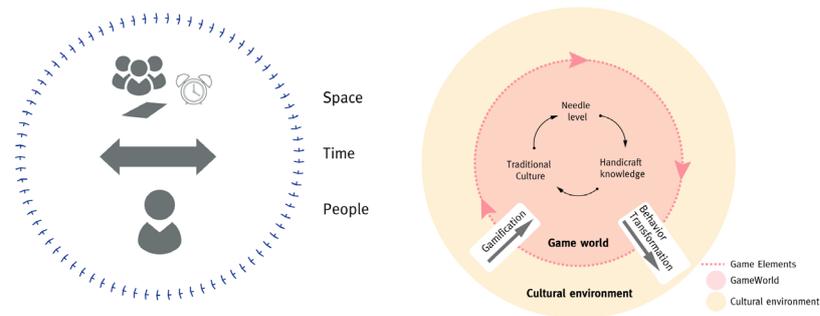
### 2.1 SERIOUS GAME MODEL WITH CULTURAL MISSION AS THE CORE DRIVING FORCE.

Yu-Kai Chou, in his book “ACTIONABLE GAMIFICATION”, said every successful game will be supported by a core driving force, which will affect players’ behavior and decision-making. He created a game-based design framework, Octalysis Framwork. It is used to analyze the balance of driving forces within the game. In this serious game, Epic meaning and Calling Mission are the core driving forces of the game. Jane Mcgonigal describes four elements of the game’s beauty and power: epic meaning, immediate optimism, blissful productivity and social fabric. The application of “epic meaning” in handicraft inheritance is the sense of cultural mission. For serious game of handicraft, it is not enough to help players learn skills. More important goal is establishing a sense of national mission to inherit national culture through the game.

### 2.2 SERIOUS GAME MODEL FOR BEHAVIOR TRANSFORMATION

Nielsen proposed that players, culture and games are intermingled in educational games. Understanding learners’ circumstance, cultural backgrounds are helpful to raise correct questions and find answers in design. As we researched, the volunteer teacher have touch the national culture in class, but children’s reaction is not positive. Most children have a weak sense of participation in ethnic activities such as “Taonianbai”. With the help of non-hereditary Tangmei Feng, we simplified the process of cross-stitch into three stages: 1. Learn the needle skills, like “one-line horizontal line”, “45 degree diagonal needle”, “cross needle” and “90 degree return needle”; 2. master the handicraft knowledge, like counting yarn needles on warp-weft interwoven coarse cloth, five yarns apart; 3. learn the traditional culture of handicraft.

Johan Huizinga’s said players can connect the real world’s environment through space, time and people in the game world, which can help players transform skills and experience in the game world into the real world, so as to cultivate players’ behavior in the real world. Combining the design concept of Magic Circle [Figure 1] with the learning process of Huayao cross-stitch, we designed cultural-heritage game model [Figure 2] can help the rural Children to learn handicraft skills, and improve their sense of cultural mission.



[Figure 1] Johan Huizinga's Magic Circle

[Figure 2] Serious Game Model Of Handicraft Learning

According to the serious game model, our team designed a serious game for the local children. The serious game is divided into three game learning clues: The story of Huayao cross-stitch, The skill learning and Creation module. Cross-stitch stories: The game sets up task cards, which are closely related to local children's life and culture. Cross-stitch learning: The game divides the stitching process into three stages: The primary apprentice, The superior handicrafts stage and the Master stage. Players are encouraged to make mistakes, but in order to avoid blind trial-and-error without thinking, we set up three trial opportunities. Fengxiaomei, dressed in Huayao national costume, will give tips as an assistant. Cross-stitch creation: In the "Decoration Workshop": Players can freely match different colors of embroidery, and change the cloth. Players can know the basic knowledge of Huayao cross-stitch by this way. Players can create patterns according to the skills they have mastered before, and sharing them with others.

### 3. CONTRAST GROUP: TESTING AND FEEDBACK FOR SERIOUS GAME

We carry out the "contrast group" with the help of a handicraftsman. (Figure 3) We randomly selected 30 students from the 5-6 grades of the school, and divided them into 6 study groups. Each group has an observer. "Contrast class" consists of two parts: learning from handicraftsmen and creating works. 1. Choose three groups to proceed in the first method: Learning from the handicraftsman (45 minutes). Inheritor Feng explained a classic cross-stitch work. After the basic study, Inheritor Feng joined in the study group. Children started stitching from basic yarn and stitching. Inheritor Feng took turns answering questions and guiding in each group. 2. The other three groups to study mode two: serious game learning mode (45 minutes): Each group provides a tested game Demo. (Figure 4) In the process, the inheritor Feng will still enter the group for guidance. 3. After the study, each group will give out stitching cloth and needles. Children will stitch on the cloth according to the learning of stitching skills in class. Compare two craftsmanship learning experiences, there are the feedback.

- Digital learning can weaken the stereotype and stimulate interest in learning. The adaptability of local children to digital technology is impressive. Children master the game rules fast. In the traditional study group, the traditional stereotype makes boys have obvious resistance to stitch: "All these are learned by girls!". In the game learning, the gender-free learning style makes boys more active in trying cross-stitch.
- Real cultural serious game is beneficial to the transformation of learning behavior. Students in the game group often excitedly say, "Look, she is wearing our clothes" when they see the game scene related to real life, they will have a sense of belonging. Children will still open the game when stitching on embroidery cloth, which can recall the operation mode in the game, and arouse the memory. The game, as a guide tool for practical operation, helps children transfer the learning behavior. (Figure 5)
- Serious games can make up for the gap of cultural mission education in the real world. The parents are weak in aesthetic education. Children find it hard to realize the cultural value of Huayao handicraft. When they saw Yao people's festivals in the game, like "Taonianbai", they were very emotional. The serious game has "Huayao Story" module, to make up for the gap of local children's understanding of national culture,



[Figure 3] Contrast Classroom



[Figure 4] Game Demo



[Figure 5] Take The Game As A Reference

which can enhance their cultural self-confidence.

### 4. DISCUSSION AND REFLECTION

Serious game can effectively help rural children learn handicraft and enhance their sense of cultural mission to tra-

ditional culture. Through the analysis of Magic Circle and Octalysis Framework, this paper puts forward a game design model of serious game applied in handicraft learning. Designing the “HuaYao cross-stitch Master Growth Record” according to the model. In the “contrast group”, the rural children’s interest is enhanced. The serious game simplified the learning process of traditional handicraft, reduced the learning difficulty, and enhanced children’s understanding of the national culture and sense of mission.

In the design process, it is necessary to avoid meaningless addition of game elements. Close to the user’s living environment. The learning behavior and skills in the game world can be transformed into real world by designed game elements. Serious games can be used as a learning tool, but can not replace the practice of craftsmanship. Serious games combined with off-line practice to mastering handicraft skills.

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## **7. PRODUCT DESIGN FOR SUSTAINABILITY**



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## **PROPOSAL OF RECOMMENDATIONS FOR DESIGN UNDER A SUSTAINABLE APPROACH: LCA CASE.**

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### **ABSTRACT**

A scientific literature review was carried out in relation to the topics of mechanical design, sustainability, product design, sustainable design, making a list of tools to design with sustainable approach; the information was analysed and diagrams and tables are presented Bonifaz Adonis, González Leopoldo | Proposal of recommendations for design under sustainable approach: LCA case. | 2 indicating: considerations, recommendations, and tools to design, methodologies and conclusions. The main topic that has been investigated is Life Cycle Analysis (LCA), so we have focused the work on it. The purpose of this work is that people who are involved in the field of design have an approach to sustainable approaches and can apply the tools making use of the recommendations to obtain better results.

Key Words: Mechanical design, sustainability, sustainable approach

## 1. INTRODUCTION

Sustainable development is one that meets the needs of the present without compromising the ability of future generations to meet their own needs [1]. Sustainable approach is gaining ground in the field of mechanical design; sustainability has become a global mega trend under the pressure of climate change. Designers are increasingly concerned with integrating sustainable objectives into their projects and products; organizations tend to increase their commitment to move towards more sustainable products and services; governments are also following the sustainability trend highlighting sustainable procurement policies; the world is changing towards the thought of social responsibility [1]. That is why, thinking about a revision of the current sustainable design tools and approaches is of vital importance, especially for design professionals.

As a concept, design for sustainability contributes to environmental, social and economic advantages throughout the entire life cycle of a product, while at the same time supporting health and well-being, as well as environmental conservation [2].

This study aims to help mechanical design professionals to include the sustainable approach in their daily professional practice, as well as to guide designers in the selection and implementation of sustainability tools, synthesized by means of tables, matrices and diagrams, to increase the solidity of sustainable approaches thanks to the implementation of the proposed recommendations and suggestions.

## 2. SELECTED TOOLS

In the literature review, several important tools were found for the deployment and implementation of design under a sustainable approach, we selected one of them to focus on it, because it has a lot of information and its deployment involves a great impact on sustainable topics related to political governments and international standards.

### 2.1. Life Cycle Assessment

It is an analytical tool that captures the general environmental impacts of a product, process or human activity from the acquisition of the raw material, through production and use, to the management of waste. This comprehensive vision makes LCA unique in the set of environmental management tools. It has become a standardized method to provide a solid scientific basis for environmental sustainability in industry and government. LCA provides a comprehensive view of the environmental aspects of the alteration or selection of products or processes and presents an accurate picture of possible environmental compensation [3].

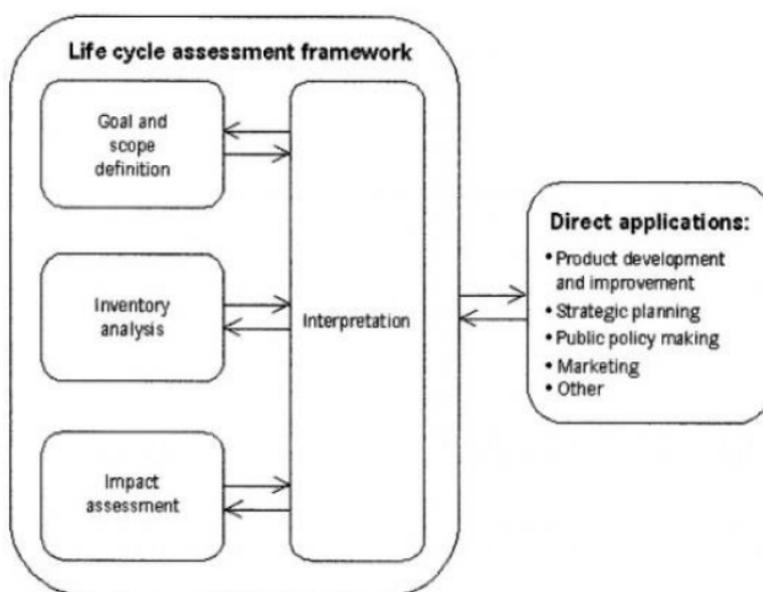
The current practice of LCA, regulated by the international standard ISO 14040 [4], follows four interrelated phases: Clearly define the objective and scope of the study (including the selection of a functional unit).

Compilation of an inventory of the relevant energy and material inputs and environmental releases (analysis of the Life Cycle Inventory (LCI)).

Evaluate the possible environmental impacts associated with the inputs and emissions identified (Life Cycle Impact Assessment (LCIA)).

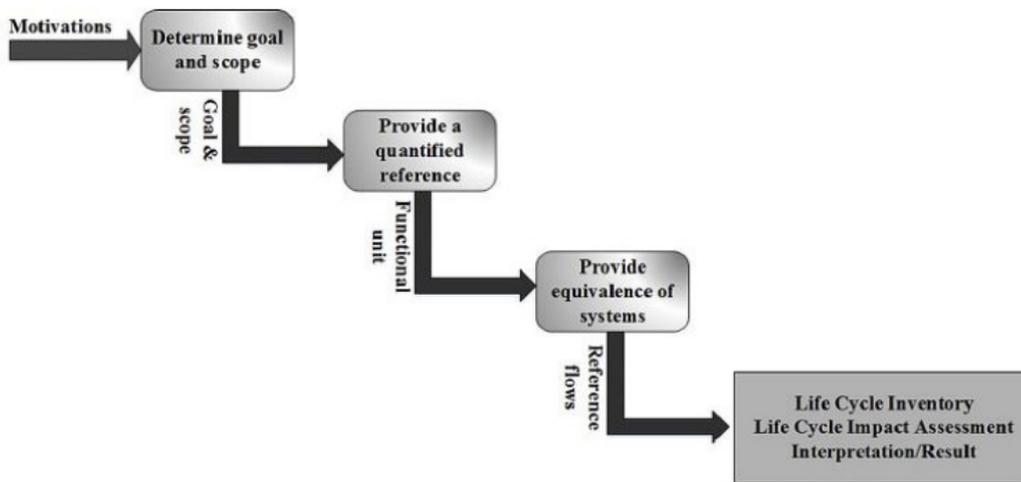
Interpret the results to help make a more informed decision.

The LCA evaluation framework is defined as shown in figure 1:



[Figure 1] LCA evaluation framework [5].

The objective and scope of each LCA study should be reviewed in great detail, using the interconnected step diagram as shown in figure 2.



[Figure 2] Steps in the goal and scope of an LCA study [2].

**2.1.1.1. Important recommendations for LCA.**

Although the ISO standard defines LCA and provides a general framework for carrying out an evaluation, it leaves much to be interpreted for the professional. There is much confusion about what the LCA can and cannot do, and how it fits into a strategic level approach to sustainability.

Below are ten important aspects of the LCA methodology shown in table 1. It describes each aspect and what users should keep in mind when preparing to perform an LCA or when reviewing an LCA made by another person.

Attribute	Explanation	Recommendations
Setting objectives and functional unit	A clearly stated objective will simplify the scope of the study limits and guide the data collection effort. The functional unit is defined by the service provided by the system under study and is given additional form according to the objective of the study. A functional unit is a quantified description of the performance of the product system.	Set objectives clearly. Set correctly the scale of the functional unit.
Assign environmental charges to the co products of a process	The ISO standard requires professionals to avoid assignment, although it cannot always be avoided, especially if the data for the sub processes or for the expanded system cannot be easily acquired.	Model threads Expand the system
Credit per load avoided	In a system expansion approach, limits are expanded to include the alternative production of exported functions. While the concept of system expansion seems reasonable on the surface, it can be problematic. Not only does it require the identification of a way of producing an alternative by-product, which in turn requires additional market and other data, it can generate negative emissions when the system is credited with avoided charges compensated elsewhere.	System expansion Consecutive LCA
Consecutive LCA	It consists of extending the limits of the study to cover the probable consequences of a decision. A consequential LCA is conceptually complex because it includes additional economic concepts, such as marginal production costs, the elasticity of supply and demand, and so on.	Make sure that the various results with respect to the different consequences can be explained using plausible arguments.

<p>Availability of inventory data and transparency</p>	<p>The lack of easily available inventory data remains a major obstacle to the practice of LCA. Often assumptions about the data must be made to sum them up to represent a sector of the industry.</p>	<p>Use of commercial software tools in conjunction with publicly available government databases.</p>
<p>Identifying data uncertainty</p>	<p>The uncertainty in the form of variability can be attributed to errors or fluctuations in the data. The uncertainty analysis is the process to determine the variability of the data and the impact on the final results.</p>	<p>Perform data uncertainty analysis for processes.</p>
<p>Differentiate the evaluation of the impact of the life cycle and the evaluation of risk</p>	<p>Risk assessment is a complex process that requires the integration of data and information in a wide range of activities and disciplines, including characterization of source, destination and transport, modelling, exposure assessment and response evaluation. LCA, on the other hand, expands the product system in space and time.</p>	<p>The LCIA models and the LCA results are adequate to evaluate relative comparisons.</p>
<p>Report qualitative and quantitative information</p>	<p>It is not possible to quantify all the environmentally relevant information, not all the impact data are available to model certain inventory data. When performing the LCA, it is necessary to apply several assumptions of modelling and engineering estimates. Sometimes, these choices are based on the values held by the modeller or the person who commissioned the study.</p>	<p>All options must be established and the impact on the decision must be clearly communicated within the final results in order to fully explain the conclusions drawn from the data.</p>
<p>LCA not always (usually) declares a 'winner'</p>	<p>The LCA interpretation phase involves the evaluation of the results of the inventory analysis along with the results of the impact evaluation to assist in the decision-making process, with a clear understanding of the uncertainty and the assumptions used to generate the results. Very rarely will the results of an LCA identify a clear 'winner' among the alternatives. In some cases, it may not be possible to affirm that one alternative is better than the others due to uncertainty in the final results.</p>	<p>LCA improves understanding of the environmental and health impacts associated with each alternative, revealing more fully the pros and cons of each alternative.</p>
<p>LCA is an iterative process</p>	<p>The interpretation of the findings is to compare the data and results with previous findings, and put them in the proper context of decision making and limitations. It is especially important to determine whether the results of the impact assessment or the underlying inventory data are incomplete or unacceptable to draw conclusions and make recommendations, then the previous steps should be repeated until the results can support the original objectives of the study.</p>	<p>If the uncertainties are too high, you can go back to collect better data. If the sensitivity analysis shows that some decisions are crucial, you can go back and do a more refined analysis.</p>

[Table 1] Important recommendations for LCA.

It is necessary to complement LCA with other tools or methods to provide a basis for decision making. These tools include risk assessment, site-specific environmental assessment, cost evaluation and others. As part of the scope determination process, it is useful to identify where and how these other tools will be used to increase the LCA findings [3]. Given that there is no correct way to carry out any of the modelling options found in LCA, the practice would benefit from the development of a harmonized guide and a global agreement on the part of LCA professionals and modellers.

### 3. RESULTS

A review of the state of the art of sustainable design was carried out, and what was found is that, although there is no specific and sustainable methodology for sustainable design, there are approaches and tools that help the designer mainly to evaluate the environmental impact of products during all its useful life and even after it. Such tools are implemented from early stages in the design process and can evaluate modelling and simulation, projections of the behaviour and performance of the products or systems to which they are being applied. However, these approaches are applied most of the time in isolation. The professionals working in the branches of LCA already present some recommendations and suggestions to delve into the implementation of several tools that complement each other. Recommendations that were collected and expanded are presented in this paper in such a way that the design professional who decides to implement them has sufficient bases to carry out sustainable approaches and obtain better results in practice.

### 4. CONCLUSIONS

There are several tools that help design professionals to apply a sustainable approach, such tools are responsible for guiding the analysis and studies on the ecological implications of carrying out a design, either of a product or a service. These approaches are being implemented in isolation, oriented to very specific design objectives, so it can be concluded that there is no guide that combines sustainability tools.

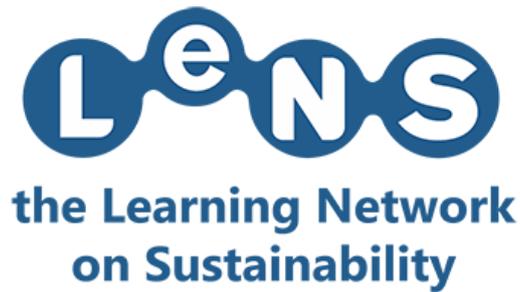
By combining design strategies with sustainable approach tools, better solutions are obtained to environmental issues, such as appropriate end-of-life treatments and an extended product life cycle.

However, one of the difficulties in applying sustainable tools is that they are complex when they are not carried out adequately or crucial steps are omitted during their implementation, so the search for recommendations towards the deployment of the approaches sustainable is of great value to the design community.

Since there is no correct way to implement any of the sustainable design tools, the practice would benefit from the development of a harmonized and complementary guide.

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## **CIRCULAR DESIGN AND HOUSEHOLD MEDICATION: A STUDY ON THE VOLUNTARY DRUG DISPOSAL PROGRAM OF THE CITY OF BETIM MUNICIPALITY**

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### **ABSTRACT**

Household medicines, like all types of hazardous waste, require proper disposal. However, that is often not the case. It is estimated, according to researchers, that roughly 20% of drugs consumed at home are disposed of in the conventional sewage system or simply thrown away. In the face of this problem, the present study intends to explore the disposal of household medicines in the city of Betim, Minas Gerais, with a specific focus on the voluntary proper disposal program created by the city. In addition, the research intends to explore the state-of-the-art relationship between circular design and the handling of residential pharmaceutical waste. The research takes a qualitative approach and includes a case study, descriptive in nature. The expected outcomes are a description of the home waste disposal program as well as a theoretical cross-reference of design and waste management.

## 1. INTRODUCTION

Sustainability is one of the most important contemporary demands and has been gaining more centrality since the 1990s with many different sectors of contemporary society (DIJON, 2013). To achieve sustainability goals, it is necessary to review the current models of development. As Vezzoli (2006) argues, the transition to a sustainable model requires radical changes in methods of production and consumption and, moreover, in societal practices. According to the author, taking a sustainable perspective places the development model under discussion.

The circular economy has been gaining force globally as a promising alternative to the conventional linear economic of extraction, fabrication, use and disposal. According to the Report on the Circular Economy in Brazil (2017), the new circular model is an opportunity for society to prosper and simultaneously reduce the dependency on finite natural resources and non-renewable energy sources. This would mean gradually disassociating economic activity from the consumption of finite resource and designing waste out of the system, aiming for a transition to renewable energy sources. According to the Ellen MacArthur Foundation (EMF), the circular economy is based on the principles of: (a) designing out waste and pollution (2) keeping products and materials in use; and (c) regenerating natural systems (source: <https://www.ellenmacarthurfoundation.org/circular-economy/concept>). According the EMF, economic activity in a circular economy builds and rebuilds the overall health of the system.

Design emerges as a space of opportunity to face the complexity of the world due to its interdisciplinary nature (Cardoso, 2012). Design as a discipline has been assuming the role of facilitator and innovator. Emerging trends have shifted design to a more sustainable approach that focuses on circularity in the product life cycle.

Considering the above, this study analyzes user adherence to the Household Medicine Disposal Program at primary care clinics in Betim with the objective of understanding how the initiative can help with the reverse logistics required to ensure that medicines used at home can be disposed of properly.

## 2. BACKGROUND

### 2.1 Design and the circular economy

The circular economy was born out of great schools of thinking (EMF, 2019). Among them and of interest is the “Cradle to Cradle” design philosophy developed by William McDonough e Michael Braungart. Cradle to Cradle concepts challenges the pervasive scarcity mindset and brings together such diverse areas of study economics and design, business and ecology, consumer product manufacturing and urban planning. (McDonough; Braungart; 2013)

The useful life of products is declining (Layarargues, 2008, p. 3) which leads to increased consumption of natural resources and, consequently, a large amount of solid waste. According to the RSA Royal Society for the encouragements of Arts, , “waste affects all aspects of our society” (RSA, 2016) and compromises the planet’s capacity to meet human needs as trash piles up. As supporting evidence, the Royal Society of Arts has shown a large decrease in biodiversity combined with an unsustainably increasing demand for natural resources.

Waste generation is of a concern from the very beginning of the production process. As Ribeiro and Krugliankas (2014) affirm, 80% of the factors determining environmental impacts and product life cycle are defined in the design phase. The Royal Society also states that 90% of extracted natural resources become waste before products leave the factory. The significant waste generation in the fabrication process extends through the chain and, according to McDonough and Braungart (2013) “what the majority of people see in their trash cans is just the tip of the materials iceberg; by itself, the product contains on average only 5% of the raw materials involved in its production and distribution.”

Sophie Thomas, Projects Director at The Great Recovery, affirms that design plays a fundamental role in the transition to a circular economy. To her, it is necessary to educate and inspire industrial design to accept the challenge (RSA, 2014). According to the RSA (2016), “in order to understand how to change how we teach, practice and utilize design in a more circular economy, we need to redefine the current thinking focused on the product to design approach focused on the system.”

Also fundamental is the need to expand the discussion around the process of “design” to consider all of the participants in the “design chain” in order to discover where things fail too early on and become waste. We have learned that design has a significant influence on how we make, consume, and dispose of our products (RSA, 2016) and that design has a critical role to play in the shift to a circular economy.

### 2.2 HOUSEHOLD MEDICINES AND REVERSE LOGISTICS

To Rogers and Tibben-Lembke (1999), reverse logistics is the process of planning, implementing, and controlling the flow of used goods from the point of consumption back to where they originated, including all the relevant information about the goods themselves. To these authors, the purpose of reverse logistics is to recapture the value or guarantee the appropriate destination. As it relates to household medicines in Brazil, consumption has been increasing driven by multiple factors, among them self-medication. Given the strong relationship between consumption and waste (WWF, 2012), the more medicine consumed in the home the more wastes are generated.

For Alvarenga and Nicoletti (2010), this rise in consumption will cause an increase in the amount of packaging and leftover medicines thrown away in domestic trash bins. The common waste stream is not an appropriate place for disposal of medicines. The Akutu Institute (2011) defends that medications should not be disposed of in

common residential waste bins since they contain chemical substances that may contaminate soil and groundwater. Alvarenga and Nicoletti (2010) corroborate this statement arguing that medications contain substances capable of impacting both the environment and human health. Falqueto and Klingerman (2013) affirm that the chemical industry, which includes pharmaceutical companies, generate large quantities of hazardous waste.

According to the World Health Organization, health wastes are those that originate from hospitals, medical research centers and laboratories and as well as small and dispersed sources like domiciles where health treatments occur (for example, home dialysis, self-administration of insulin, and recovery care) (World Health Organization, 2014). The handling and disposal of these wastes is of great importance, considering the associated risks to human health and the ecosystem. It is estimated that around 20% of the medications taken at home are disposed of in the sewage system or thrown away in the common trash stream (Falqueto; Klingerman, 2013).

According to Bila and Dezotti (2003), studies conducted in multiple countries identified the presence of pharmaceuticals in the environment. Hirsch et al., (1999), in a German study, affirm to have found a large variety of pharmaceutical residues in the effluents from the sewage treatment plant and surface waters. Kummerer (2001) emphasizes that ingested medications are excreted into wastewater and that unused medications are often disposed of down drains. According to the same author, studies show that the presence of pharmaceuticals in surface water, groundwater and potable water, however little is known about the significance of emissions from residences and hospitals.

### 3. RESEARCH METHOD

The current work is a qualitative study that aims to evaluate the effectiveness of the Voluntary Medication Disposal Program in the city of Betim, Minas Gerais (Brazil), with a focus on patients of primary health clinics, in order to explore how much they are aware of and participate in the Program.

Data was collected through a questionnaire containing questions of a socio-economic nature related to medication disposal habits as well as questions regarding knowledge of the Voluntary Medication Disposal Program in Betim. The municipality has 25 primary health clinics (Unidades Básicas de Saúde or UBSs) throughout the 9 regional areas in the city. (Fonte: <http://www.betim.mg.gov.br/noticias/43124%3B64878%3B06%3B8248%3B127298.asp>).

The UBS patients were chosen randomly at entrances or from the entrance halls. The study's authors explained the purpose of the interview to potential participants and request their participation with the survey.

The survey was supported by a Field Diary in which the authors recorded information that couldn't be obtained by the questionnaire or that arose from the interaction with the patients and was considered relevant to understanding the study.

### 4 RESULTS AND ANALYSIS

The field work was realized February 4 – 13th, 2019, during the morning and the afternoon, divided up as to reach the largest number of UBSs, resulting in visits to 9 clinics in 8 of the 9 regional areas in the city. The study amounted to 31 patients from 22 neighborhoods throughout the municipality.



Figure 1. Betim and regions, highlighting the regions that were visited and the respective number people interviewed.

Source: Elaborated by the authors

Regarding the socio-economic data of the interviewees, the majority are female (71%) and, in large part, concentrated within the 26 to 35 age group (35.5%), with 22,6% between the ages of 36 to 45 and almost a fourth of respondents above 56 years of age (19,4%). The average household income was predominately up to 3 times the minimum wage (90,4%), with the highest level of educational attainment divided up between high school (29%),

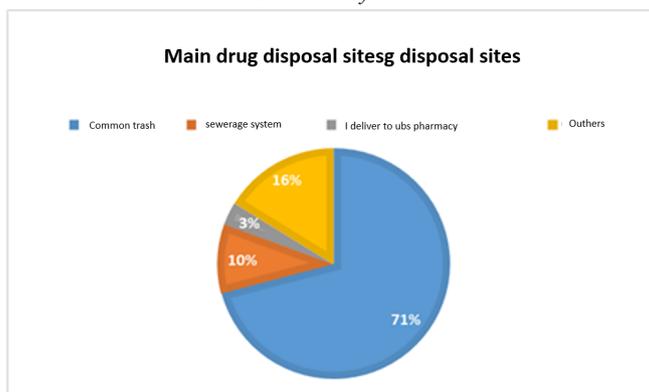
middle school (25,8.7%) and primary school (29%). Only four of the respondents had a college degree.

Most of the patients interviewed stated that “no” they do not undergo continual health treatment (74,2%). This is contrasted by the 41,9% that responded “yes” to regularly taking medications, indicating the possibility of self-medication, a common practice by Brazilians, particularly as it relates to over-the-counter medicines (Arrais et al, 2016).

Regarding home possession, 77.2% of the patients stated that they “always” or “almost always” have medications at home. This confirmation is in line with studies (Arrais et al, 2016; Laste et al, 2012) that is common for Brazilians to keep over-the-counter medications in their homes. The medicine cabinet or “little pharmacy” is treated as a back-up for eventual situations, including the sick’s dissatisfaction with “delays and low-quality treatment for health services” (Naves et al, 2010).

For the storage of household medications, most people said that they keep a small box in their closets or in cabinet drawers. The survey showed one case in which a medication – insulin – was kept in the refrigerator. With respect the habit of checking expiration dates, the majority said that they verify validity “always” or “almost always” (70,9%) as well as “sometimes” (9,7%), “rarely” (3,2%) and “never” (16,1%). It is important to stress that the percent of respondents who said that they don’t check expiration dates is significant.

Figure 2. Main drug disposal sites identified in the survey  
 Source: Elaborated by the authors



As you can see in the graph in Figure 2, the common waste stream is the destination of the majority of medications that are disposed of by the survey respondents (67,7%), followed by the sewage system (9,7%). Only 3,2% of respondents said that they drop-off unused medications at the pharmacy located in the UBS. These figures are concerning, given the problems of environmental pollution that result from inadequate disposal of medications. Given that the sewage treatment plants in Brazil are not capable of removing medications during the treatment of domestic wastewater (Souza, Falqueto, 2015), these effluents are released into bodies of water containing substances that affect fauna, flora, and microbiota, as well as human health (Bila, Dezotti, 2003). Likewise, when medications are discarded as general waste this can cause soil and groundwater contamination, encouraging the emergence of resistant microorganisms (Freitas Jr, Barros, 2018).

Regarding orientation about the disposal of medications, a large part of those interviewed (90,3%) did not receive any information and only two people said that they received some form of orientation. This result shows that lack of information is one of the biggest bottlenecks in the reverse logistics of medications, requiring increased attention by public health authorities. No reverse logistics program seeking excellent results can succeed without participant collaboration and legislation can be the principal tool for resolving this issue (Blanckstein; Philippi Junior; 2018). Article 255 of the Brazilian Federal Constitution of 1988 states that “all have the right to an ecologically balanced environment, a common good used by the people and essential to a healthy quality of life, imposing on the government and the community the duty to defend and preserve it for present and future generations.” The 2015 Brazilian National Solid Waste Policy (the Política Nacional de Resíduos Sólidos or PNRS Law #12.305) is considered the regulatory benchmark for solid waste management in Brazil and was the result of a wide multi-sector debate (government, private institutions, non-governmental organizations and civil society). The PNRS brings together principles, objectives, instruments, and guidelines for waste management in the country. (Linhares Maia et al. 2014) “The growing concern for the preservation of natural resources and the question of public health related to solid waste indicates that public policies to deal with these issues will tend to be demanded by society in an increasing fashion” (PNRS, 2010, p. 07).

The majority of the respondents (54.8%) said that they can see the negative aspects of disposing of medications in the trash or sewage and the remaining 38,7% responded that they can not see the negative aspects or that they do not know what bad could come of it. The interviewees that recognized the negative aspects of improper medication disposal were asked to cite some examples and, in general, the responses are divided in two groups: environmental contamination risk or access and incorrect consumption by children.

When it was asked where the appropriate place would be to dispose of expired and/or undesired medications the answers were varied. In general, the respondents’ suggestions can be grouped as: 1) drop off at the health clinic, 2) take to an appropriate place, not sure of where that might be, 3) the trash is still the best option. Many did not know how to respond regarding the appropriate discard location for medications. Among the responses were some

rather curious suggestions like: put them together with recyclable materials and burn them in the yard. These options present risks to individual health and need to be reviewed by the health authorities involved in the promotion of public policies about the reverse logistics of medications. Article 30 of 2010's PNRS instituted a shared responsibility for the life cycle of products. "Shared responsibility is instituted for the life cycle of products and should be implemented individually and throughout the chain, involving the manufacturers, importers, distributors, sellers, consumers, and those responsible for the public services of street cleaning and waste management, according to the attributions and procedures specified in this Section." (PNRS, 201). The lack of information regarding the adequate destination aggravates the problem, as defended by Tonet et. al., (2017, p. 1) "despite the elevated daily consumption of medications by the world population, there is a diffuse lack of orientation about the disposal of these products and the specific demands for the treatment of wastes"

The Voluntary Disposal Program in the city of Betim is not widely known by UBS patients, given that a majority (93,5%) stated that they had never participated in the city program and 90,3% mentioned never receiving any information about it. Among the patients that responded yes, three stated that they had dropped off medications at a UBS, either for donation (3,2%) or for disposal (6,4%). When asked if they were to find out about an existing program to collect expired or undesired medications whether or not they would stop bringing them to be disposed of at a UBS, 90,3% of the respondents stated that they would bring the medicines to be discarded at the health center, 6,5% stated that they might, and one person said that they would not take them to a health center.

As Gontijo and Dias (2014) state, there is still a lot of inefficiency and lack of sustainability in reverse chains. Sectorial accords or contracts between the government and the supply chain participants are required for certain products, as the PNRS from 2010 lays out in Articles 33 and 34. The intent of these agreements is to make environmentally adequate disposal viable (Gontijo; Dias; 2014). This situation is even worse given the limitations of municipalities most of which are still having difficulties implementing the propositions of the PNRS.

## 7. CONCLUSION

The theme being discussed is of great importance given the capacity for medications to contaminate the environment. Studying household medication disposal programs at the municipal level can contribute to the verification of the results of these public initiatives, as well as analyze the population's adherence to these programs. The results found here demonstrate that the patients of the UBS know next to nothing about the Voluntary Medication Disposal Program in Betim. Future studies could look at the gaps not covered under this study. Circular design and reverse logistics are directly linked to environmental management, seeing that the union of these two areas can contribute to the design of solutions for the adequate disposal of household medicines. In order to so, it is necessary to start working from the moment of conception to the final product and including its return back to the productive cycle or to an adequate destination.

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## DESIGN FOR SUSTAINABLE FASHION: A SUSTAINABILITY DESIGN-ORIENTING TOOL FOR FASHION

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### ABSTRACT

Fashion is recognised as one of the most unsustainable systems, being characterized by both severe environmental impacts and unfair working conditions. In this framework, the article describes the design support tool called Sustainability design-orienting scenario for fashion and its development process. The tool has the purpose to inspire designers during the creation of sustainable concepts for Fashion/clothing and to orientate companies in fashion towards a more sustainable path. It describes a sustainable design-orienting scenario for fashion, made by 4 different visions. For each of the visions, a short video (animatic) tells a representative story, i.e. 4 in total, one for each vision (Do-it-yourself home clothing care; Community clothing hub; Shared wardrobe centre; Full service for home clothing care) and 3 videos that explain further visions' potential in terms of possible applications and opportunities. The tool has been developed with the following process: a) Strategic Analysis: desk research on "clothing care" system's environmental impacts; definition of environmental design priorities; and S.PSS "clothing care" best practices analysis. b) Scenario design: S.PSS ideas generation applied to clothing care; promising S.PSS ideas clustering aiming at identifying the most effective polarity diagram; design and formulation of the scenario's 4 promising visions. c) Tool development: design and implementation of the scenario tool.

Key Words: Fashion/clothing, sustainability, design-orienting tool, product-service system.

## 1. INTRODUCTION

In the present context of growing debate on the problems of global climate and environment, lack of energy and resources and ethical production, there is a new sensitivity according to which this unbridled consumption of faster fashion must slow down. It is widely recognized that fashion system is un-sustainable, even though it is popular, among non-experts to refer unsustainability mostly to fibers and materials. The clothing fabric sector is a highly significant economic player; as far as earnings are concerned, clothes are much cheaper now than they were a few decades ago. Cheap fashion means accessible fashion and encourages greater consumption, creating a vicious circle. More important, fast fashion puts pressure on the textile industries and their suppliers to raise their output, impacting on those at the bottom of the production chain and those who actually make the clothes. In this context, many are the questions raised about the possibility of a sustainable fashion, since many are the elements involved and complex the sequence of events inherent in the production of our clothes and the fabrics that go to make them (Conti, 2011).

The Sustainability design-orienting scenario for fashion has the purpose to inspire designers and businesses for future Sustainable Product-Service Systems (S.PSS) applied to fashion/clothing. The tool is developed in the framework of the LeNSin Project: the Learning Network on Sustainability (LeNS), with the aim to form a new generation of designers with the right conceptual and operative tools to be able to contribute to the transition towards a sustainable society. The paper describes the development and possible applications of the tool, which is based on a sustainable fashion scenario composed by a polarity diagram and 4 different visions. The scenario is found on Sustainable Product-Service System (S.PSS) models described as “an offer model providing an integrated mix of products and services that are together able to fulfil a particular customer demand (to deliver a “unit of satisfaction”), based on innovative interactions between the stakeholders of the value production system (satisfaction system), where the ownership of the product/s and/or its life cycle responsibilities remain by the provider/s, so that the economic interest of the providers continuously seeks environmentally and/or socio-ethically beneficial new solutions” (Vezzoli et al., 2014 and Vezzoli et al., 2018). Firstly, the paper describes the tool, its possible application and use, as well as the tool design process. Then, it pictures the Sustainability design-orienting fashion scenario on which the tool is based and the sustainable win-win potentials enclosed in the S.PSS models.

## 2. SUSTAINABILITY DESIGN-ORIENTING TOOL FOR FASHION

### 2.1 Aims

Design-Orienting Scenario, a tool to inspire and inform designers towards possible futures on specific topics, has been adapted to Sustainable Product-Service System (S.PSS) applied to fashion/clothing system. The tool, (from now on) Scenario presents four visions narrated as interactive videos accessible through a navigator file. The Scenario is a tool to inspire designers and stakeholders to design radically new social, economic and technical solutions and as co-design strategic conversations and facilitating creative processes among different actors.

### 2.2 What it consists of

The tool allows to watch the videos to inspire towards Sustainable Product-Service System (S.PSS) applied to Fashion/clothing. The tool presents four visions within a polarity diagram of two axes. The horizontal axis defines the sharing level: individual or collective. The vertical one defines the service type: do-it-yourself or full service. Each vision is presented through one short video (around 90 s) that shows peculiar narration, highlighting the key points of the vision (e.g. stakeholder interactions, ownership. Three sub-videos (around 30 s each) help to achieve the understanding of a wider range of opportunities than presented in the video of the vision; these three sub-video show: all the possible offer and the related payment modality; all the possible stakeholders that can be involved and their possible interactions; all possible sustainability benefits (environmental, socio-ethical and economic).

### 2.3 How to use the tool

The Scenario requires the use of a slideshow software (e.g. Open Office PowerPoint). Each video and sub-video can be watched separately or a central button is available to run the whole videos as one. The suggestion is to watch a main video first and after the related sub-videos, then, the second main video and so on.

### 2.4 Integrating the tool into the design process

The Scenario can be used during the Exploring Opportunities. It can be used to inspire and inform designers and actors involved towards possible visions of Sustainable Product-Service System (S.PSS) applied to and to get new inspirations during the process.

### 2.5 Results

The result is a set of ideas favoring creative processes and co-design activities towards concepts of Sustainable Product-Service System (S.PSS) applied to Fashion/ clothing.

### 2.6 Tool availability and required resources

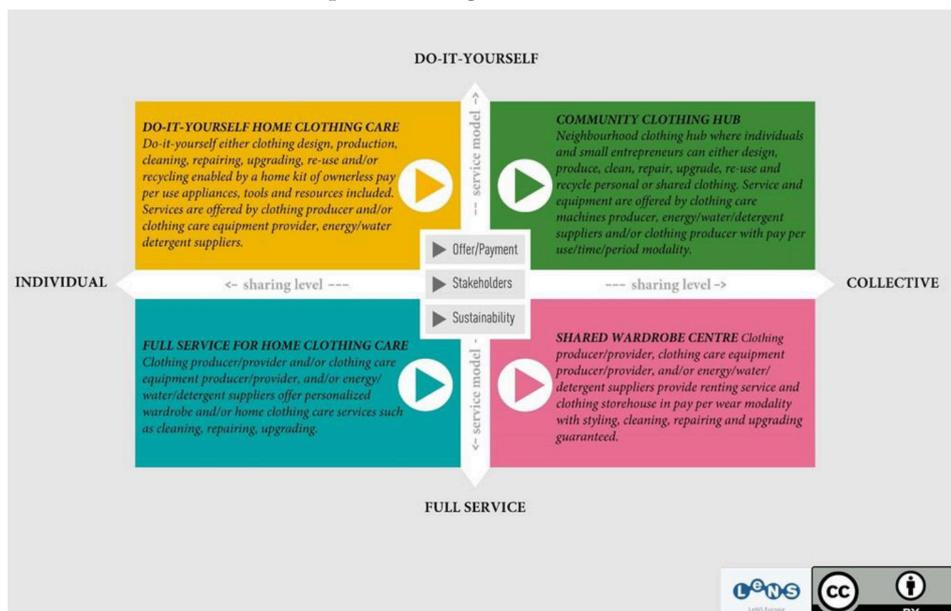
The tool is available for free download at [www.lenses.polimi.it](http://www.lenses.polimi.it). The tool has been designed to be used in workshops and co-design sessions, therefore a projector is preferable. The time required to visualise all videos is approximately 15 min (Vezzoli et al., 2018).

### 3. THE TOOL DESIGN PROCESS

The tool has the purpose to inspire and inform designers towards possible futures specific topics and it is in this case adapted to Sustainable Product-Service System (S.PSS) applied to fashion/clothing. The tool is also a source of inspiration for possible stakeholders' interaction to design radically new social, economic and technical solutions and as co-design strategic conversations and facilitating creative processes among different actors (Vezzoli et al., 2016 and Emili et al., 2016). The development process (part of the MSDS method) consists of: a) Strategic Analysis: desk research on "clothing care" system's environmental impacts; definition of environmental design priorities; and S.PSS "clothing care" best practices analysis. b) Scenario design: S.PSS ideas generation applied to clothing care; promising S.PSS ideas clustering aiming at identifying the most effective polarity diagram; design and formulation of the scenario 4 promising visions. c) Tool development: design and implementation of the scenario tool. The Strategic analysis phase is followed by the Scenario Design, which involves ideas generation. Ideas generated are also supported by the outcomes of the previous phase. The idea generation process comprehended a workshop that involved several experts in fashion/clothing and sustainable design; it also consisted of the use of the software Sustainability Design-Orienting Toolkit (SDO) (Vezzoli, 2014 and Vezzoli et al., 2016) which is based on six "eco-efficient idea generation tables", each of those related to the defined set of sustainability design priorities. The idea generation process also referred to the clothing care S.PSS best practice examples. In fact, S.PSS clothing care ideas together with the best practice examples are the building blocks upon which the scenario's two polarities are designed and defined, i.e. the polarity framing the same scenario. The tool is based on the Sustainability Design-Orienting Scenario (SDOS) which is composed by a polarity diagram with 4 visions (for each of the four quadrants drawn by the same polarity diagram). Each vision represents a sustainable win-win configuration; combines socio-cultural, organizational and technological factors, fosters solutions with a low environmental impact, a high socio ethical quality and a high economic and competitive value for both businesses and consumers.

### 4. THE SUSTAINABLE FASHION SCENARIO

The Sustainability Design-Orienting Scenario (SDOS) was developed following several projects such as SusHouse, EU project, 1998-2000; MEPSS, EU project 2005; Design 4 Sustainability, UNEP 2008-2009; LeNS, EU project, 2007-2010; LeNSes EU project, 2013-2016; LeNSin, EU project, 2016-2019. "A Design orienting Scenario is a scenario specifically built to favour sustainable stakeholder innovation; it is a synthetic proposition made of a general vision (a picture of a possible configuration of the system in which socio-cultural and technological factors are combined to produce possible state of being of the system) with some articulated proposals (a defined mix of product and services) positioned in global context" (Vezzoli, 2000). The sustainable fashion scenario developed is the one described as follows. On the vertical axis, the scenario is polarised by the type of S.PSS: do-it-yourself (use-oriented) or full service (result-oriented). On the horizontal axis, the scenario is polarised by the sharing level: individual and/or collective. The crossing of those polarities produced the following four visions, relative to the four quadrants (Fig. 1).



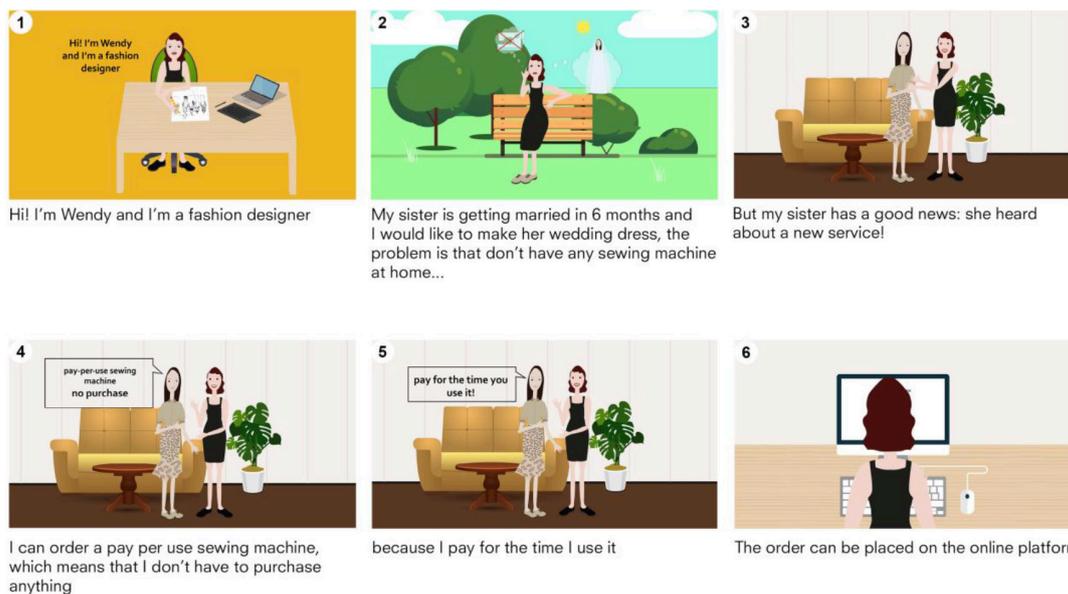
[Figure 1] Sustainability design-orienting tool for fashion

#### Vision 1. Do-it-yourself home clothing care

Do-it-yourself either clothing design, production, cleaning, repairing, upgrading, re-use and/or recycling enabled by a home kit of ownerless pay per use appliances, tools and resources included. Services are offered by clothing producer and/or clothing care equipment provider, energy/water detergent suppliers.

**Vision 2. Community clothing hub**

Neighborhood clothing hub where individuals and small entrepreneurs can either design, produce, clean, repair, upgrade, re-use and recycle personal or shared clothing. Service and equipment are offered by clothing care machines producer, energy/water/detergent suppliers and/or clothing producer with pay per use/time/period modality.



[Figure 2] Sustainability design-orienting tool for fashion-Vision 1 storyboard abstract

**Vision 3. Shared wardrobe centre**

Clothing producer/provider, clothing care equipment producer/provider, and/or energy/water/detergent suppliers provide renting service and clothing storehouse in pay per wear modality with styling, cleaning, repairing and upgrading guaranteed.

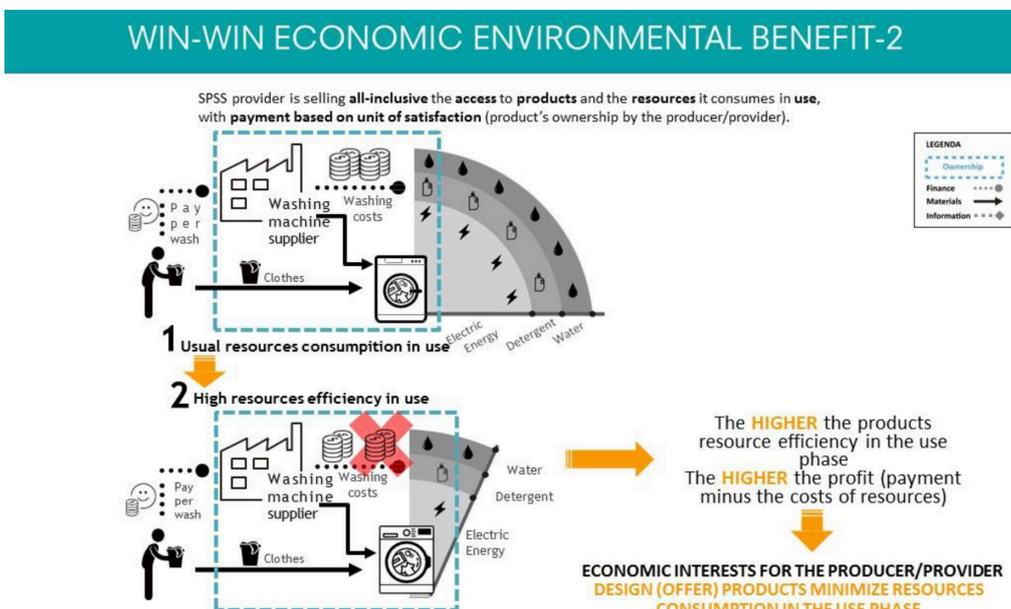
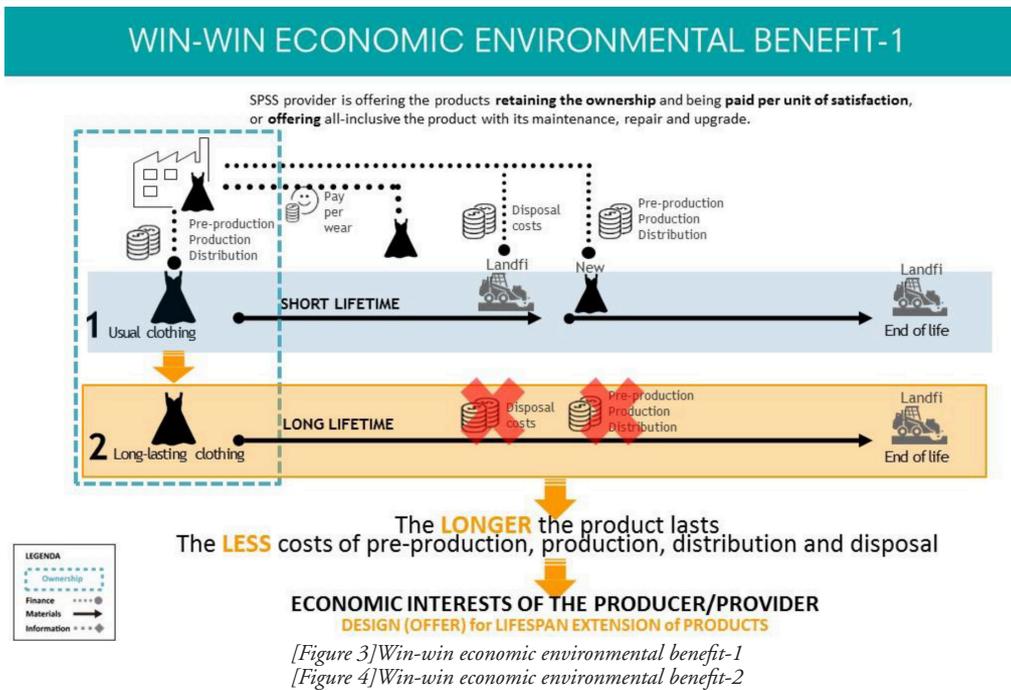
**Vision 4. Full service for home clothing care**

Clothing producer/provider and/or clothing care equipment producer/provider, and/or energy/water/detergent suppliers offer personalized wardrobe and/or home clothing care services such as cleaning, repairing, upgrading.

Visions are a starting point for several possible product-service system solutions, where different stakeholders are involved. A S.PSS is a win-win strategy because engages with different stakeholders and create a relationship between them with the intent of satisfying each interest. It is also an attempt to create designs that are sustainable in terms of environmental and social burden, developing both products and services to satisfy essential needs.

**5. S.PSS WIN-WIN POTENTIALS**

The scenario design is based on Sustainable Product-Service System models described as “an offer model providing an integrated mix of products and services that are together able to fulfil a particular customer demand (to deliver a “unit of satisfaction”), based on innovative interactions between the stakeholders of the value production system (satisfaction system), where the ownership of the product/s and/or its life cycle responsibilities remain by the provider/s, so that the economic interest of the providers continuously seeks environmentally and/or socio-ethically beneficial new solutions” (Vezzoli et al.,2014 and Vezzoli et al.,2018). S.PSS is based on new stakeholders interactions and is advantageous for all involved partners. Convergence of interest in the sense of interactions and partnership between stakeholders to achieve a common result(Manzini, 1999). In the long period, the S.PSS requires a shift of the stakeholders’ attitude towards the productive chain as well as it requires that all the stakeholders receive evident profit from the service-system approach. The potential eco-efficiency of the system innovation therefore depends on those economic interests of the stakeholder that favour product life cycle optimisation, materials’ life extension and intensifying usage. This means to design in order to valorise materials and to extend products’ life. Because the S.PSS provider retains the ownership of a product and sell a unit of satisfaction to the customer, the product is more likely to be long lasting and when it is possible, resources consumption is reduced. This is because the production of new products and consumption of unnecessary resources are additional costs for the S.PSS provider. When a product is used more intensely than others are and for a longer time, we have a reduction in the quantity (of this product) necessary to satisfy a given demand for a function; which would determine a reduction in environmental impact. Furthermore, the S.PSS benefits for companies is tied to the potential benefit perceived by clients. By focusing on product-service combination, the company discharges the client from the costs and problems associated to the acquisition, use, maintenance and disposal of equipment and products. Following tables summarize S.PSS environmental benefits that are consequences of the convergence between different parties’ interests.



It can be argued that within a S.PSS business model, there is an economic incentive for suppliers to reduce their environmental impact, for the following reasons (Vezzoli et al., 2018 and Azzi, 2018):

- a). As far as the S.PSS provider is offering either the garments and/or clothing care equipment, retaining the ownership and being paid per unit of satisfaction, or offering all-inclusive the product (with its maintenance, repair and substitution), the **MORE** the producer/provider avoids/postpone the disposal costs plus the costs of pre-production, production and distribution of a new product substituting the one disposed of (economic benefits). Hence the producer/provider is driven by economic interests to design (offer) for lifespan extension of either the garments and/or clothing care equipment (eco-efficient product LCD implications).
- b). As far as the S.PSS provider is selling a shared use of clothing and/or clothing care equipment to various users, the **MORE** intensively the product/s are used, i.e. most of the time (environmental benefits), the **HIGHER** the profit, i.e. proportionally to the overall use time (economic benefits). Hence, the producer/provider is driven by economic interests to design for intensive use of clothing and/or clothing care equipment (eco-efficient product LCD implications).
- c). As far as the S.PSS provider is selling all-inclusive the access to clothing care equipment and there-resources it consumes in use, with payment based on unit of satisfaction (product's ownership by the producer/provider), the **HIGHER** is the product/s re-source efficiency in use (environmental benefits), the **HIGHER** is the profit, i.e. the payment minus (among others) the costs of resources in use (economic benefits). Hence, the producer/provider is driven by economic interests to design/offer clothing care equipment minimizing resources consumption in use (eco-efficient product LCD implications).

tions).

- d). As far as the S.PSS provider is selling energy as all-inclusive access to the energy production unit and the source for energy generation to any of the clothing care system stakeholder, with pay per period/time/satisfaction (energy production unit ownership by the producer/supplier), the HIGHER is the use of passive/renewable sources of energy (environmental benefits), the HIGHER is the profit, i.e. the payment minus (among others) the costs of non-passive/renewable sources of energy supplied (economic benefits). Hence, the producer/provider is driven by economic interests to design (offer) for passive/renewable re-sources optimization (eco-efficient product LCD implications).
- e). As far as the S.PSS provider is selling all-inclusive the garments and/or clothing care equipment with its end-of-life treatment/s, the MORE the materials are either recycled, incinerated with energy recovery, or composted (environmental benefits), the MORE are the avoided costs of both the landfilling and either the new primary material, energy, or compost (economic benefits). Hence, the producer/providers is driven by economic interests to design for materials life extensions of either garments and clothing care equipment (recycling, energy recovery or com-posting) (eco-efficient product LCD implications).
- f). As far as the S.PSS provider is selling all-inclusive the detergents, dyes and other toxic or harmful product/s, with use and/or end-of-life toxicity/harmfulness management services, the LOWER are the potential toxic or harmful emissions in use and/or at the end-of-life (environmental benefits), the MORE are the avoided costs of both toxic/harmful treatments in use and/or at the end-of-life. Hence, the producer/providers is driven by economic interests to design (offer) for toxicity/harmfulness minimization of detergents, dyes and other toxic or harmful product/s (eco-efficient product LCD implications)."

Finally, the clothing care products and processes are framed under the S.PSS approach that, for economic reasons, adopts a product Life Cycle Design i.e. that follow the LCD design strategies we have mentioned in the previous chapter 3: material and energy minimization, toxicity minimization, conservation/renewability/biocompatibility, material recycling, composting energy recovery, product lifespan extension/use intensification (Vezzoli, 2018).

## 6. CONCLUSIONS

Fashion/clothing is one of the most polluting industry in the world. Together with environmental concerns, social iniquity in the clothing production has been in the spotlight during recent years. Disapproval towards the fashion system is also connected to nature of the industry itself; in fact, it encourages a consumerist relation with products due to its temporary trend correlation, which, for most of the brands, is also the foundation of their marketing promotion. Consumers' awareness is rising and more than the past, the society asks for more transparency about the production chain and further responsibility towards people and the environment. Experts in sustainability and fashion/clothing are collaborating with companies and young designers to raise people's consciousness so that sustainability does not only represent a trend but a real design behaviour. Today, some companies are building their own brand identity basing on social and environmental sustainability values, but this is still only a tiny part of the market. The research presented in this document adds a design-oriented point of view within the debate related to possible future business models, in a product saturated market, so much damaging the environment. The Sustainability design-orienting scenario for fashionable discussed and redefined in relation to various specific contexts and type of garment use. As since now the ambition is to orientate designers, producers, suppliers, governments, local institutes, district municipalities, organizations, customers and in general, all participants involved in the fashion system, to radically rethink the way into which the fashion production and consumption system is nowadays organised and structured. We can recognize that sustainability recently became a new trend and several brands are nowadays much more interested in alternative approaches to clothing production than the past.

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## **DESIGN PRACTICE FOR SUSTAINABILITY: DEVELOPMENT OF A LOW-COST ORTHOSIS**

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### **ABSTRACT**

The use of low-cost 3D printers, and other such technologies, has contributed to the development of sustainable products since they only use the material needed for production and are specifically customized for the person, reducing the cases of abandonment and increasing the product's life cycle. In this context we developed a wrist orthosis using the user-centered design approach along with the fundamentals of sustainability, ergonomics and the limitations of the low-cost production process. Using this product as an example we discuss the positive impact this method can bring to the three pillars of sustainability: the product is economically viable, considering the low-cost technology, socially just, both in terms of access, production and inclusivity and ecologically correct, from the minimization of material used for manufacturing and abandonment of the product. Finally, we propose a reflection about the product development process that balances functionality, sustainability and design.

Key Words: Design, Sustainability, Orthosis, 3D print.

## 1. INTRODUCTION

Design practice has evolved in terms of scope and approach (Suri, 2003). Its scope increases as it fits into medical and engineering contexts as a possible problem solver in ways not previously presented to the original developers. By having a role in the user-centered design practice (Ornelas & Gragory, 2009), design stands as an alternative project mediator within related areas, considering the context and the functional, aesthetic, social and symbolic needs of the product's users.

In terms of changes in approach to design projects, there is a confluence of the insertion of other areas into the design process and the natural evolution of the area itself (Suri, 2003). In this way, new possibilities for the realization of projects are inserted in a more effective and efficient manner, and concepts such as sustainability (Bhamra & Lofthouse, 2016, Vezzoli & Manzini, 2008), social design (Ornelas & Gragory, 2009; Margolin & Margolin 2004) and experiential design (Suri, 2003) that affect how a project is developed are included.

At the intersection of these new possibilities there are Assistive Technology (AT) resources, that refer to products, systems and services, developed to increase the autonomy and functional capacity of people with disabilities and reduced mobility for quality of life improvement and greater social inclusion (Brazil, 2015; Ornelas & Gragory, 2009; Margolin & Margolin 2004). These products are traditionally developed by skilled professionals (Moraes et al., 2018; Basso, 2012), generally with medical training (Marins, 2011), they normally only consider the functional aspects of the product, lacking solutions that meet all the users' needs, whether they are functional, symbolic and/or aesthetic. By using a user-centered design approach, it is possible, for example, to use specific techniques and tools that provide the most appropriate solutions to the global context and the needs of users and the society in which they are embedded (Basso, 2012, Ornelas & Gragory, 2009).

The main problems encountered in the development of AT products are: waste caused by the development process by "trial and error" (Beretta, 2011), the delay in the manufacture of equipments that quickly become obsolete (Moraes et al, 2018; Basso, 2012), and the inadequacy of products to users in aesthetic terms, which imply abandoning and early discarding (Basso, 2012). These problems are also related to sustainability issues as they stand in opposition to the pillars of economic viability, socially justice and ecologically correctness (UNGA, 2005).

AT products, as well as all others, should take into account not only the functional aspects but also the aesthetic and symbolic ones (Paschoarelli, Campos & Santos, 2015; Löbach, 2001) to improve the living conditions of people, both by reducing stigma, which prevents abandonment, and by increasing the identification of people with the product. In complement Pullin (2007) states that with design it is possible to change the perspective of social issues and the stigma of disability. Also, AT products that are inadequate in these aspects can affect user's safety, social opportunity, stress level, sense of belonging, self-esteem and physical health (Margolin & Margolin, 2004).

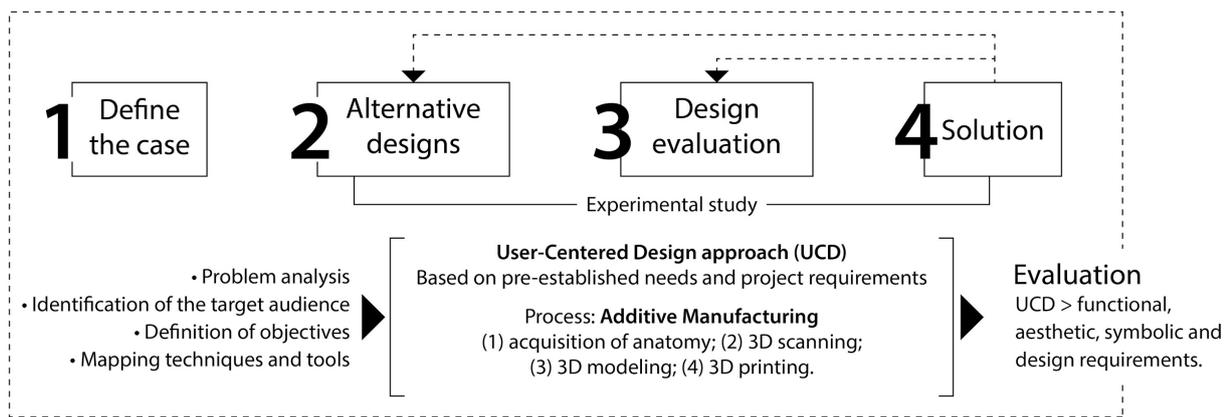
New technologies, when combined with project planning, contribute to the creation of more sustainable products. For example, the additive manufacturing (Volpato & Carvalho, 2017) facilitate the production process, spending less material needed for product development. In addition, it is possible to use materials such as PLA (polylactic acid), which is a biodegradable polymer constituted by the fermentation of starch-rich plants (Canessa, Fonda & Zennaro, 2013) which when converted into filaments can be used in 3D printing projects or reuse the materials into filaments for the generation of even more sustainable products. Nonetheless, there are also some setbacks and limitations of 3D printing such as the possible exclusion of people without the access to the technology, the energy use and the importation of materials and machines that may not come from local suppliers, these can be mitigated by innovative solutions, but are still points to be considered (Daly, 2016). In relation to 3D scanning technology, it contributes to the development of products in a fast and customized way, attending to the specific needs of the users (Beretta, 2011).

This paper presents the development of a assistive product (wrist-hand orthosis), which encompasses the principles of product development from a user-centered design approach and taking into account the principles of sustainability and new technologies available (mainly low-cost). It discusses the possibilities of the use of new technologies as allied to the development of sustainable and ergonomically adequate projects and the aesthetic influence of the product for its acceptance.

## 2. MATERIALS AND METHODS

The wrist-hand orthosis was developed based on the method proposed by Löbach (2001), and illustrated in Figure 1. From a user-centered approach, the process prioritizes the functional, aesthetic and symbolic requirements of the product, as well as design requirements that aim at sustainability, low cost and customization (Basso, 2012; Ornelas & Gragory, 2009). At first, the problem, the context and the target audience were identified.

Following, an experimental phase of the study was started, composed by the generation of alternatives, selection and prototyping. At this stage, from the pre-established needs, five design alternatives were developed for the design of the orthosis. Among them, one was selected as a final alternative to be prototyped. To do this, it was necessary to acquire the anatomy of the wrist, followed by 3D scanning, modeling, 3D printing and finishing. It is important to emphasize that the experimental study is not linear and that the link between methods, methodological approaches and productive processes depends on calibration and adequacy of theoretical and technological languages. In this way, it is possible to go back to the previous steps in order to verify the best design solution according to the problem encountered and the production limitations.



[Figure 1] Applied method (Font: the authors, 2019)

### 2.1. Materials

We used plaster bandages to acquire the wrist-hand morphology (Rosenmann, 2017) and the Recap software (Autodesk, 2019b) for 3D digitalizing. The mesh treatment and preparation (defect repair) was performed with Meshmixer software (Autodesk, 2019a). With the mesh repaired, the design changes were made using Rhinoceros (McNeel et al., 2019) and Solidworks (SKA, 2019). Finally, the file was finalized with Repetier (Hot-World GmbH & Co., 2019). For the production of the prototype, additive manufacturing process was used (Volpato & Carvalho, 2017; Canessa, Fonda & Zennaro, 2013). For this project we used 0.3 mm thick layers with PLA filaments with the low-cost 3D printer Stella (Good 3D Printing, 2019 - Figure 4).

## 3. RESULTS

The results of this work consist in the elaboration of the project and its consolidation in a final alternative as planned in figure 1 and shown below.

### 3.1. Characterization of the target audience - persona

A persona of a 43-year-old woman with chronic tendinitis in the wrist was conceived due to the excessive and constant use of the computer. Wrist immobilization with the use of a wrist-hand orthosis is a medical recommendation and should be uninterrupted. The user demands a wrist-hand orthosis that can be used during a social event. Her report shows difficulty in acquiring a product that offers, besides functionality, a pleasant look (according to her subjective judgment). In this sense, the briefing makes clear that this user wants to feel included in their social group, and that the use of a traditional orthosis in the market does not make this desire possible.

These characteristics translate to the following requirements:

Functional: safety, comfort, stability, respect to the anatomy and offer of an ergonomic product.

Aesthetics: pleasantness of form, sensitization, identifying characteristics of artistic movements sympathetic to the user; generation of desire to use.

Symbolic: inclusive in the context, disruptive of “medicalized” aesthetics and status through exclusivity.

Design: low cost, sustainable, customizable.

Next is the experimental study of the development of the wrist-hand orthosis for this persona.

### 3.2. Anatomy acquisition

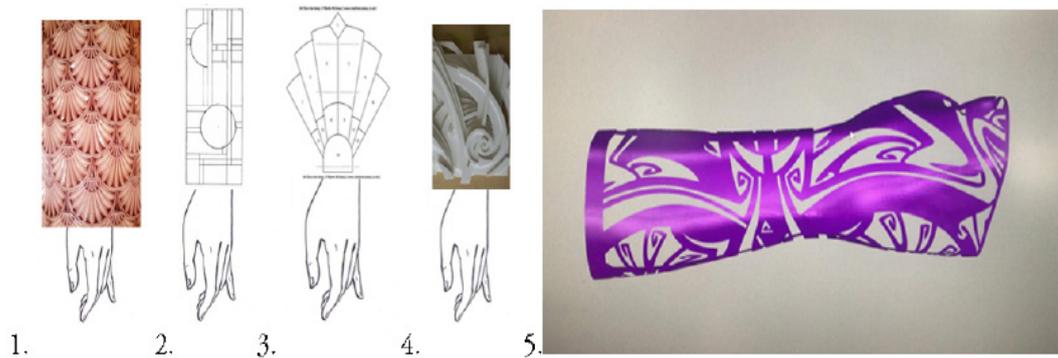
The user had the anatomy of the wrist acquired by means of cast bandage and the 3D scanning was done with Re-Cap software. The plastered model can be visualized in Figure 2.



[Figure 2] Anatomy acquisition (Font: the authors, 2019)

### 3.3. Alternative designs

The alternatives developed and the final solution can be verified in Figure 3. The choice was made by ranking the options considering the context of use and by the requirements and mainly by the choice of the user, who participated actively in the process.



[Figure 3] Alternative designs (1-4) and selected model (5) (Font: the authors, 2019)

### 3.4. Prototyping

Based on the chosen alternative, the three-dimensional model was developed (Figure 4), from the morphology collected in step 2 (Figure 2). Then the adaptation was done for 3D printing (Figure 5). Some printing problems were encountered at this stage given the complexity of the modelled form (Figure 6).



[Figure 4] Digital version of the orthosis (Font: the authors, 2019)

[Figure 5] 3D printing of the orthosis (Font: the authors, 2019)

[Figure 6] Problems with 3D printing (Font: the authors, 2019)

The orthosis was planned in two pieces, upper and lower (Figure 4), due to the characteristic of the material, which is too rigid to be worn. The closure is made by elastic couplings, using the holes as passages (Figure 4). A space is planned in the design so that an EVA layer can be introduced into the final product in order to increase user comfort.

## 4. DISCUSSION

The user-centered design method applied to the development of the wrist-hand orthosis was essential to identify the limitations and benefits found in the integration between design, new technologies and their contributions to project and product sustainability. We could address the main problems mentioned regarding the development AT: *waste* (Beretta, 2011) -with the reduced use of material and it being biodegradable-; *obsolescence* (Moraes et al., 2018; Sierra, 2017) -by rapid production and functional, aesthetic and symbolic adequation-; *high cost* (Marins, 2011) -through the use of low-cost equipment and materials- and *the inadequacy of products* that cause abandonment and early disposal (Basso, 2012) -by using a user-centered development methodology-.

The acquisition of the anatomy through the plaster bandage proved to be an economically viable process, providing a good physical three-dimensional model to be digitized. 3D scanning did not present measurable technical problems. The 3D modeling stage presented some technical limitations. Among the most important are the inadequacy of the software used to model organic lines, the need to transition between non-compatible software -surface modeling and solid modeling- and the inexperience of the developers on these software. The obstacles and failures during the 3D modeling of the product, made the 3D printing process difficult, resulting in unnecessary material expenses. With the improvement of skills in the area of 3D modeling and printing it is possible to obtain a product using less material raising its level of sustainability and making it ecologically correct.

The final issue to be discussed is the importance of the aesthetic and symbolic suitability of the product (Paschoarelli, Campos & Santos, 2015; Löbach, 2001). As it is a user need this factor that can reduce abandonment, early discarding (Basso, 2012) and the stigmatization brought about by the product (Pullin, 2007; Margolin & Margolin, 2004). However, adapting to the aesthetic and symbolic requirements tends to raise the complexity of the orthosis development process. Still, we recommend to consider these aspects from the use of appropriate methodologies and with the help of qualified professionals to ensure the development of a product that satisfies the user in all aspects.

## 5. CONCLUSION

In this work a wrist-hand orthosis was developed using a user-centered development method considering the sustainability issues, limitations of the productive process, and functional, aesthetic and symbolic needs of assistive technology products. We believe that, by allying such components one can achieve a product that is *economically viable*, considering the low-cost technology, that uses cheaper material than traditional methods; *socially just*, both in terms of access to the product that is easily produced, and inclusive of people with disabilities; and *ecologically correct*, from the minimization of material needed for manufacturing and the unnecessary disposal caused by the abandonment of the product.

Although this work is an experimental study, designed to discuss the articulations between design/sustainability/assistive technology themes, the fundamental problems of process adequacy suffered by the industry and product manufacturing are present. It means that the solution to these issues needs to be articulated at several levels and later expanded.

We acknowledge that this is a complex project because it requires the designers to seek and articulate concepts and technologies. Nevertheless, such solutions contribute to the popularization of 3D technology, which is currently expanding, to converge to customizable, sustainable projects and yet considering the subjective requirements of users.

## AKNOWLEDGEMENTS

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## **MECHANISM ANALYSIS AND APPLICATION STUDY OF SUSTAINABILITY EVALUATION TOOL FOR FURNITURE E-COMMERCE(ICSFE) <sup>1</sup>**

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### **ABSTRACT**

Since the 1990s all trades has been connected with Internet. Many furniture companies are transforming from traditional pattern to e-commerce. Linshimuye is the most representative furniture e-commerce company in China. The article will take Linshimuye as a case.

ICS for Furniture E-commerce(ICSFE)is a localization tool evolved from ICS toolkit, which is developed and adopted by DIS- Polimi. It considers Analytic Hierarchy Process(AHP)as main analytical method and the data comes from Expert Grading Method. The tool will calculate data through its program automatically. Then the users can get a result, and the tool will give recommendations accordingly. The tool can provide some advice on the improvement of furniture e-commerce in China. And it will be improved based on the feedback.

Key Words: e-commerce; furniture; Linshimuye; toolkit

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## 1. DEVELOPMENT STATUS OF E-COMMERCE FURNITURE INDUSTRY A CASE STUDY OF LNSHIMUYE

With the development of e-commerce, many furniture companies are in transition to e-business. However, many furniture companies failed, because they have neglected the improvement of the product service system. The article uses ISCFE to analyse Linshimuye as a case to evaluate and improve the development of China's furniture e-commerce.

Linshimuye has developed with Taobao and has been the No. 1 seller in the furniture category for five years. In recent years, Linshimuye is developing its offline experience mall and improving its offline services. Linshimuye is the most representative young furniture e-commerce company in China, and it influences many other companies.

## 2. ICS\_ TOOLKIT FOR FURNITURE E-COMMERCE (ICSFE)

ICSFE is based on the research of Chinese online furniture product-service system. It's improved by the research team of Dr . Han Shaohua of Wuhan University of Technology. It is a localization tool improved from ICS\_ Toolkit, which is developed and adopted by the Research Unit Design and Innovation for Sustainability (DIS).

### 2.1 Theoretical basis of ICSFE

ICSFE separates and extracts different development elements of the product service system in the three dimensions of economy, society, and environment. And then extract the criterion factors and index factors. Then import the data into the analysis tool after selectivity. When selecting sustainable development indicators, the tool uses Experts Grading Method to determine a more authoritative set of indicators. In the calculation of index weights, the tool uses the Analytic Hierarchy Process (AHP) and comparison method to ensure the scientificity of the weights. Finally, the final data is obtained by arithmetical average method. The feedback utilizes the data to evaluate the behaviour of the nodes in the system, and finally draws conclusions on the degree of sustainable development and gives recommendations accordingly.

### 2.2 Structure of ICSFE

ICSFE consists of four steps. First, determine the list of products and services of the system. Secondly, evaluate the product system and service system in the three dimensions of economy, society and environment. Third, the built-in program automatically completes the calculation and statistics to obtains the results of the system. The results show the degree of sustainable development of the whole system, the degree of sustainable development of the system in each dimension, the degree of development of the enterprise compared with other enterprises in the same industry. And it shows the indicators that are not consistent and partially consistent. Forth, improve them. With the help of corresponding improvement measures , the product service system can be improved and the new system can be re-evaluated.

### 2.3 Using steps of ICSFE

ICSFE has five steps as follows: "Homepage", "List", "Product Evaluation", "Service Evaluation", and "Improvement Measures".

STEP1 In the "Homepage"[Figure 1] section, four questions are asked and answered to help the user identify the object of the tool. The four questions are: What is furniture commerce? What is ICSFE? What is the object of ICSFE? What stage is ICSFE applied to?

STEP2 The tool lists some items to consider in the "List" [Figure 2] section, including the main and subsidiary products and services. It helps users to make certain of evaluation content. The users need to fill in the specific column of each product and service content.

ICSFE	Sustainability Evaluation Tool for Furniture E-commerce	Design Toolkit
HOMEPAGE	<ul style="list-style-type: none"> <li>What is online furniture business? 电子商务家具是指基于电子商务平台进行营销活动的家具。</li> </ul>	
LIST	<ul style="list-style-type: none"> <li>What is ICSFE? 该可持续性评价模型是对电子商务家具中产品系统设计和和服务系统设计的可持续发展状况进行评估的工具。可以用来检测电子商务家具企业某个产品服务系统设计发展问题的工具，能帮助电子商务家具企业根据发展的问题制定相应的设计策略。</li> </ul>	
PRODUCT EVALUATION	<ul style="list-style-type: none"> <li>What is the object of ICSE? 该可持续性评价模型的适用对象限定于电商家具产品服务系统设计，电子商务家具产品服务系统设计是指某个电子商务家具所包含的产品系统设计和和服务系统设计。</li> </ul>	
SERVICE EVALUATION	<ul style="list-style-type: none"> <li>What stage is ICSE applied to? 一是，概念形成的阶段。可以用来检测概念会存在的问题，从而制定相应的改进措施，规避概念推到市场后的风险； 二是，已将产品推入到市场后的阶段。可以用来检测现阶段产品服务系统设计的不足，从而指引相应改进措施的制定，以达到实现可持续发展的目标。</li> </ul>	
IMPROVEMENT MEASURES		

[Figure 1] Homepage



[Figure 2] List



[Figure 3] select evaluation indicators

STEP3&STEP4 It contains multiple dimensions and multi-level indicators in the “Product Evaluation” and “System Evaluation” sections. It mainly includes selecting evaluation indicators [Figure 3] and viewing the evaluation results. When selecting evaluation indicators, select “economic dimension”, “social dimension” and “environmental dimension” respectively. Each dimension contains several primary indicators. And each primary indicator contains several secondary indicators. Users evaluate different dimensions and different indicators by switching pages. After all the secondary indicators have been evaluated, users can switch to the evaluation results page to view the evaluation results. The evaluation results include two parts: “summary of indicator evaluation results” [Figure 4] and “comparison on industry level” [Figure 4]. The summary page of indicator evaluation results includes the development degree of all indicators in the economic, social and environmental dimensions. It shows the total number of all evaluation indicators, the number of responses, the number of fully qualified indicators, the number of partially qualified indicators, the number of non-conforming indicators, and the sustainable development degree of the system. The industry level comparison page compares the degree of sustainability of the system in the economic, social, and environmental dimensions with other systems or industry average to help users understand the advantages and disadvantages in the industry.





[Figure 4] the summary of indicators



[Figure 5] the comparison on industry level  
 [Figure 6] prioritization of improvement measures

STEP5 In the “Improvement Measures” section, there are two parts. One is “Prioritization of Improvement Measures” [Figure 6] and another one is “View Specific Improvement Measures”. In the prioritization interface of improvement measures, all the primary indicators are ranked according to the level of sustainable development in the three dimensions of economy, society and environment. In the specific improvement measures page, the secondary indicators that are evaluated as partially or non-conforming are listed under the primary indicators, and the system can be improved in these aspects.

### 3. EVALUATION OF LINSHIMUYE’ S SUSTAINABILITY

This article invites four experts who are engaged in e-commerce, furniture, environmental art design and product service system design. They both have a deep knowledge of Linshimuye. When dealing with every secondary indicator, experts can only choose one of the four choices including complete compliance, partial compliance, non-compliance and lack of understanding.

#### 3.1 Product system evaluation of sustainability

**Economic dimension:** According to the data in the table, the sustainable development degree of Linshimuye’ s product system in the economic dimension is 59.75%. Among them, the degree of sustainable development is 67.19% in terms of reducing materials and energy costs, 40.63% in reducing labour cost, 60% in reducing the cost of equipment, 60.49% in terms of improving customers’ satisfaction, and 70% in driving development in the surrounding areas.

**Social dimension:** The sustainable development degree of Linshimuye’ s product system in the social dimension is 56.09%. Among them, the degree of sustainable development is 57.50% in promoting the utilization of local social resources, and 54.64% in promoting the interests of marginal and vulnerable groups.

**Environmental Dimensions:** The sustainable development degree of Linshimuye’ s product system in the environmental dimension is 41.44%. Among them, the sustainable development degree is 46.88% in reducing materials and energy consumption, 46.88% in optimizing materials and energy, 40% in saving materials and energy, 48.44% in extending the system life cycle and promoting the utilization of product, and 25% in reducing emissions of toxic substances and pollutant.

### 3.2 Service system evaluation of sustainability

Economic dimension: The sustainable development degree of Linshimuye's service system in the economic dimension is 34.62%. Among them, the degree of sustainable development is 40.63% in terms of reducing the costs of materials and energy, 31.25% in reducing labour costs, 30% in reducing equipment costs, 31.25% in terms of improving customers' satisfaction, and 40% in driving the development of peripheral systems.

Social dimension: The sustainable development degree of Linshimuye's service system in the social dimension is 27.69%. Among them, the degree of sustainable development is 20.31% in improving the work of employees, 25% in promoting the development of stakeholders, 34.38% in promoting the utilization of local social resources, 18.75 in terms of promoting the interests of the marginalized groups, and 40% in strengthening the cohesiveness of the overall society.

Environmental dimensions: The sustainable development degree of Linshimuye's service system in the environmental dimension is 33%. Among them, the degree of sustainable development is 40% in reducing materials and energy consumption, 37.5% in optimizing materials and energy, 30% in saving materials and energy, 50% in extending the life cycle of the system and promoting the use of products, and 7.5% in reducing emissions of toxic substances and pollutants.

## 4. PRIORITIZATION AND IMPROVEMENT MEASURES.

### 4.1 Economic dimension

Priority 1: Control labour costs. It's sustainability degree is 23.44%.

Priority 2: Reduce equipment costs. It's sustainability degree is 45%.

Priority 3: Improve the satisfaction of the system. It's sustainability degree is 46.9%.

Priority 4: Reduce materials and energy costs. It's sustainability degree is 53.91%.

Priority 5: Drive the development of peripheral systems. It's sustainability degree is 55%.

### 4.2 Social dimension

Priority 1: Improve the work of employees. It's sustainability degree is 20.31%.

Priority 2: Promote the sustainable development of stakeholders. It's sustainability degree is 25%.

Priority 3: Enhance social cohesion. It's sustainability degree is 27.08%.

Priority 4: Promote the interests of marginalized groups. It's sustainability degree is 36.72%.

Priority 5: Promote the use of local social resources. It's sustainability degree is 45.94%.

### 4.3 Environmental dimension

Priority 1: Reduce emissions of toxic and pollutants. It's sustainability degree is 16.25%.

Priority 2: Make use of materials and energy. It's sustainability degree is 35%.

Priority 3: Add options of materials and energy. It's sustainability degree is 42.19%.

Priority 4: Reduce materials and energy consumption. It's sustainability degree is 43.44%.

Priority 5: Extend the system life cycle and improve the usage of products. It's sustainability degree is 49.22%.

## 5. FEEDBACK

According to the feedback of Linshimuye staff, all the secondary indicators in the tool are guiding the enterprise to comprehensively examine its own development from every detail. The evaluation results help them visually evaluate the development of the enterprise. Among the suggestions for improvement, some of the suggestions will play a role in the future development of the company. But other points may not be considered because of the company's own development plan.

However, during the communication with the staff and industry experts, it was found that there are some problems in ICSFE that need to be improved. First, the tool structure is complex. Users need to spend a lot of time understanding the tools before using it. Second, there are some descriptions in the tool that are vague, so users need to guess and trial to know how to understand and operate it. In the later stage, a sub-bar would be added to explain the operation items.

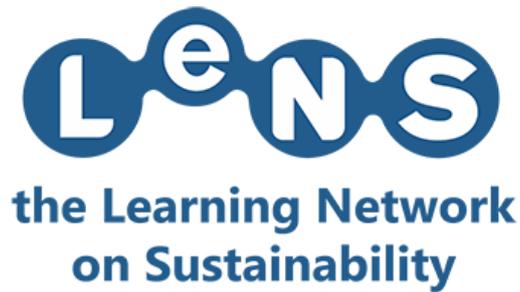
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## **ANUVAD: CREATING SUSTAINABLE SMART TEXTILES THROUGH THE MEDIUM OF TRADITIONAL CRAFTS**

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### **ABSTRACT**

This paper works on formulating and discussing a symbiotic integration of technology with traditional craft as a way of creating sustainable design practices. Craft as a medium allows for products created with emotion and love and hence are retained with care as opposed to other mechanically created products. Through combining e-textile technology with craft, this paper hypothesizes creating a two-fold impact on sustainability: by creating hand-crafted, slow produced products with longevity and by providing economic sustainability to traditional crafts by enabling them to create a wider product range that allows them to be relevant in the changing times. Eventually, the project 'Anuvad', which is the Hindi word for translate, is an enquiry into the combination of technology with crafts and specifically, textile based traditional Indian crafts. The pilot project under this took place in the village of Bhujodi in Kutch in the northern part of Gujarat. This concept hypothesizes, a higher functionality of the products created using e-textile technology. Through slow-production techniques the products created can not only be customised to meet specific needs but also create products that have a deeper meaning and value.

Keywords: E-textile, Indian Traditional Crafts, Technology

## 1. INTRODUCTION

'Craft' is being redefined and revalued in the digital age. Traditional crafts are experiencing a resurgence, with hand-crafted artefacts highly valued in a world of cheap mass production (Levine and Heimerl 2008). Smart textiles are still very new in their development despite having been around for a while. According to the report "The Global Market for Wearables and Smart Textiles to 2027", there is an emerging market for smart textile and related products. Crafts and especially crafts in the western part of India, on the other hand as stated in the web article by Paliwal, A. (2018) are facing troubles to keep on going with reducing demand and limited product range. The combination of the age-old skills of craft with the needs of experimental technology can enable a wide range of ideas and product possibilities. Often, crafts are demoted down to being mere production techniques. Finding the right tools and connections we can actually use crafts as a medium for prototyping and producing innovative and sustainable e-textile products.

What sounds like an extremely simple and uncomplicated question, is indeed rather complex question to answer. Craft, even in English language dictionaries, is not defined singularly. The term 'craft' can be associated with anything that involves skill such as 'handicraft' to 'crafted beer or crafted cheese'. The evolution of the term has led to its various meanings. Pye (1968, p.20), mentions in his book 'Nature and Art of Workmanship'; "Workmanship of the better sort is called, in an honorific way, craftsmanship. Nobody, however, is prepared to say where craftsmanship ends and ordinary manufacturing begins. It is impossible to find a generally satisfactory definition for it in the face of all the strange shibboleths and prejudices about it which are acrimoniously maintained. It is a word to start an argument with".

The table below explains the different views and definitions of the term 'craft':

Meaning / Description of 'Craft'	Source
"Craftsmanship is simply workmanship using any kind of technique or apparatus in which the quality of the result is not predetermined, but depends on the judgement, dexterity, care all of which the worker exercises as he works"	Pye, D (1968)(p.20)
"Craft only exists in motion. It exists in a way of doing things, not classification of objects, institutions or people"	Adamson, G (2007)(p.4)
"Handicraft or Hand-made are historical or social terms not technical ones. Their ordinary usage nowadays seems to refer to workmanship of any kind which could've been found before the Industrial revolution"	Pye, D (1968)(p.26)
"Textile crafts, on the other hand, are among the oldest crafts practiced by humans, having shaped the course of early civilization"	Beaudry M.C. (2006)

[Table 1] The different views and definitions of the term 'craft'

Our impressions and understanding of the word craft are highly based on our backgrounds and exposures. The focus of this paper is the relevance of the term 'traditional craft' which pertains to a skill, that is primarily hand-based but can be supported by some tools, has a deep cultural significance and is a skill that has developed over generations of practice, socio-cultural influences and has evolved to create its own identity. The contextual definition of Craft here is a hand based skill, set in a traditional and cultural environment, mostly undertaken by a certain community. For e.g. The craft of Kutchi weaving, is a counted thread extra weft technique undertaken in Kutch, by the Vankar (weaver) community. This craft has been performed since generations by the weaver community for the nomadic community. In the broader sense of the term Buechley & Perner-Wilson (2012) talk about traditional craft communities and demographics by mentioning "While academics explored the decorative and psychological aspects of craft, in popular usage, the term was increasingly identified with the vernacular. [...] The term retained its association with pleasurable labor but was stripped of its seriousness, its association with excellence, and its political implications."

The term e-textile should also be defined here. The book 'Designing with smart textiles' Kettley (2016) very aptly defines the various definitions related to the term innovative textiles, such as smart textiles, SFIT (smart fabrics and interactive textiles), wearable technology, interactive textiles, and e-textiles. One piece of innovative textile can fall under one or more than one of these categories. Some technical textiles are also sometimes confused with smart textiles. Technical textiles may or may not be 'smart'. Jute used as a geotextile to mitigate erosion is not a smart textile, even though it has a very technical purpose.

This paper hypothesizes craft techniques as being the perfect medium to explore and prototype innovative product ideas. Crafts are hand-done, supported by physical tools that aid in the process. Smart or e-textile technology often needs hand- prototyping before converting it into products. The need for hand-work in smart textiles and the hand skills of crafts combine well with each other. This makes it the perfect medium to work with. The use of the medium of traditional craft for prototyping makes it a part of the design process and not a substitute of the same. As idealistic as this idea may sound, working with craft communities require more than just ideas. This paper aims to find the right tools to communicate with craftspeople for effective collaboration.

## 2.METHODOLOGY

This concept brings together different disciplines that have distinct languages. Languages in this context represents an organized syntactical structure that is adhered to by a particular profession community. The craft community and the tech community both have their distinct, individual languages. The methodology adopted in this study was to understand the concept of hand-done traditional craft of Bhujodi/Kutchi weaving, conducting qualitative interviews with the craftsman and experts in the field and analysing their responses into arguing the hypothesis.

## 3.FOCUS AND LIMITATION OF THE STUDY

The scope of this study meets a variety of other topics which in themselves have a potential to be investigated in detail. Hence, it is important to define the focus. It defines the terminologies of craft and e-textile briefly to set the tone for the rest of the text. This paper examines the craft of hand-weaving in Bhujodi as a potential entry point to explore and create sustainable hand-woven e-textile products. Through examining contemporary craft practices, we reflect on and explore the generative design potential imbedded in the making process, and ask whether the making process can be a way of generating new design knowledge. Loh, Burry & Wagenfeld (2016). The focus of this thesis is not only to define and discuss the value of using traditional craft as a medium to translate technology into products and prototypes; but to look at this concept as a practice in sustainability not only for the environment but also for preserve and prolong the craft practices.

What if now that new techniques emerge, in order to craft a more sustainable future, we would get inspired from ancient techniques and meanings as well? Many rules for life, ways of living and making things got changed during industrialization. Certain decisions and directions towards efficiency and standardizations killed older and long-lived principals of quality, individualized approach and value of handwork. Crafts were considered too time demanding for mainstream in that period, but now re-considering some decisions that led us to mass production, they sound inspiring and worth looking into. Kuusk & Wensveen (2012). Most traditional crafts have evolved their production and aesthetic expertise over years of practice, compiling generations worth of wisdom which is a gold mine to be carried into the future.

This paper limits its focus to studying the craft of Bhujodi, through the eyes of innovative e-textiles and examines its potential as a craft that can enable one to create sustainable e-textile products.

## 4.BHUJODI: THE LAND OF WOVEN MUSIC

The study in India was conducted in a small village called Bhujodi. Bhujodi is in the Bhuj District, in Gujarat, India. According to the Census 2011 (2011), Bhujodi has a population of 3,484 persons out of which 1,876 are males and 1,608 females. In comparison to the population of India this is a rather small village. The village of Bhujodi is most known for its art of weaving. The art of weaving particular to this region derived its popular name from this village called “Bhujodi weaving”.

Chhatopadhyay (2010, p.192) in the book *The Craft Reader* talks about the repertoire of Indian crafts “Handicraft is rightly described as the craft of the people. In India it is not an industry as the word commonly understood; for the produce is also a creation symbolising the inner desire and fulfilment of the community. The various pieces of handicrafts whether metal ware, pottery, mats or woodwork, clearly indicate that while these are made to serve a positive need in the daily life of the people, they also act as a vehicle of self-expression for they reveal a conscious aesthetic approach.



[Figure 1] photo showing the look of a modern day bhujodi shawl

The craft that is popular to this region is an extra-weft patterned weaving. Simply explained, this is a patterned weaving technique. A supplementary extra-weft is used to create patterns while weaving the fabric. This is done through manual lifting. This means that the weaver could lift the threads they knew would create a pattern by inserting an extra coloured weft into the cloth while weaving. By planning the pattern beforehand the weaver lifts the threads that would create a pattern, after which he inserts a supplementary weft that creates an embossed pattern

on the fabric while weaving. Shamjibhai Vankar (2018), states in his interview, that Bhujodi is the skill of creating embossed patterns by hand-lifting warp and weft threads. Vishrambhai Vankar (father of Shamjibhai) emphasises on the word Kutchi instead of Bhujodi, mentioning that the craft is practiced overall in the region and not just in the village of Bhujodi, and hence shouldn't be called Bhujodi weaving but instead should be called Kutchi weaving.

## 5. SUSTAINABILITY THROUGH CRAFT AND TECHNOLOGY

The further we move into the future our needs for consumption increase exponentially. Our increased need for technology also reveals that smart and e-textile will eventually become an integral part of our lives. Increased needs result in increased production and eventually increased consumption and eventually disposal.

The cycle goes on. What if we are able to create products that not only provide for our evolved needs but are also products with increased longevity and aesthetics? We as human beings tend to care for and cherish products that have been created by hand or have a story or memory attached to them. For e.g. a piece of heirloom clothing though old and tattered holds more value and significance in our lives than a new garment purchased from a store. We are less likely to let go of the heirloom piece because of its attached emotional significance. Traditional craft techniques have the potential to create products that are handcrafted with love and affection. Shamjibhai Vankar, a weaver from a village called Bhujodi near Bhuj in the north of Gujarat, explained in one of his interviews that emotion and love is at the center of all crafts. This study explores the possibility of creating sustainable smart textiles by combining traditional hand-done craft techniques with technology.

Handicrafts or hand-done traditional crafts are usually crafts that have evolved through a certain culture and tradition, often by addressing a local need. With evolving times, these needs dissolved making way for the crafts to be interpreted into new products and ideas to address new needs and markets. Smart textiles and e-textiles is a market that is suspected to grow exponentially by 2020. It is only natural in that case that we allow traditional crafts to evolve with the so called 'digital era'. The concept of combining e-textile technology with crafts techniques is an idea befitting not only to create sustainable products but also as new methods of prototyping, providing exposure to crafts communities and as a method of expression for makers and crafters. E-textile technologies available today are still experimental in nature and require a lot of hand-work. The existence of hand-skill in craft processes fits well to this need. The structure of traditional craft processes allows for intervention and is thus also a very good medium for prototyping. New technology, as mentioned by Mili Tharakan in the interview, is also like a new material that is being explored in different ways from different perspectives. Crafts on the other hand have very fluid and organic processes. The qualities in this sense, of both crafts and technology, is a good combination for exploration and innovation. For e.g. In handloom weaving the process is slow and time-taking, thus, one can use a variety of different threads as wefts to explore new ideas. The same is not possible in quicker weaving processes such as automatic looms or power looms.

Bhujodi is a craft where the weaver uses his dexterity to create inlaid patterns while weaving using a supplementary weft. At every step the process involves the weaver thinking, planning and imagining his final design. This process through structured allows for intervention at every step. The process of such hand-done weaving is very open.

Bhujodi weaving has a very quintessential aesthetic that among the textile craft enthusiasts is not only recognisable but is popular. It is a technique that through counted hand-lifting can enable the weaver to create inlaid woven motifs. In principle this inlay can mask the circuitry to create products with a higher aesthetic qualities. As developed and evolved the aesthetic strengths of this craft may be it is facing trouble in today's times to have its deserved recognition. Slow-production of this process may enable a designer or a crafter to take and alter decisions while working with the weavers implementing a sense of learning by doing. This craft enables new knowledge to be created through the process of production and making. Just like the weaver visualises the product as he weaves, a designer can make design decisions while the production is happening making the process all the more interactive. The hand-skill the craftsmen have, has developed over years of practice. This not only makes them very precise and neat with their work but also increases the speed of work. One may think that working with hand-loom and crafts is a slower process and would result in more time taken while prototyping. But, working on field with the craftsmen in India proved this notion to not be true. The speed of the craftsmen in this case was fast enough to see quick results but also slow enough to give time for thinking and discussing the next steps. Posch (2017, p.81) puts it very aptly, "For engineers this is an invitation to include those new materials and processes into their practice. For crafters it is a potential entry point to electronic making, recognizing their knowledge as valuable to the field". Zoran & Buechley (2013) talk about retaining the authenticity of craft "We attempted to preserve the essence of craft while experimenting with techniques that are at odds with this very premise."

The keyword here is 'organic'. The organic nature of crafts allows one to have a sense of play and exploration which they wouldn't find in static and fixed production processes. This is of special significance when it comes to textile crafts. Discussing weaving, the freedom one has when they work with the handloom is higher as compared to the fixed production processes. Not only that, in an unorganised sector such as craft, there is freedom to organise man-power and skill as required for the project. For example, during the case study in India, we had two weavers and two looms. On specific days, when the two weavers didn't have enough work, within short notice they could change the warp on their loom to work on a different project. This would not be possible in an industrial set-up with fixed processes and systems.

Combining the classic Bhujodi aesthetics with e-textile components may also ‘de-alienise’ the aesthetics and the visual impact of e-textile products. Hereby, meaning that a lot of e-textile products because of the components embedded in them look extremely different to the textile products we are used to seeing around us. Combining them with craft may bring back the human-factor in the aesthetics of e-textile products.

## 6.CONCLUSION

Smart textiles as a field has been widely discussed by the textile community. There are opposing views to this topic. Some feel that adding electronics to textiles is not desirable because it doesn't add any value. Smart and e-textiles are also expensive currently because the technology isn't as extensively developed. This is why also smart textiles are not as easily available in the market as one would expect. Developing these products requires a lot of in-depth research & development. However, other opinions feel that textile is a field that is wide and ever evolving and it is only natural that textiles too as a discipline evolves with time. Smart textiles can raise the functionality of regular textiles exponentially. Textiles are a very core part of our day to day life. When a baby is born, he is first wrapped in a cloth also when someone dies they are wrapped in a piece of textile. Every stage of our lives has textiles at the very core. It is therefore obvious that in the ‘digital age’ our textiles too will have technology embedded in them.

Working with crafts and especially on field with the community requires a lot of different skills. It is very different from working in a studio on an artwork on your own. Designers need to be sensitive to varied factors when engaging with craftsmen. As opposed to the standard or classical design processes, being on field and working with different communities requires very quick and spontaneous thinking. Compared to the conventional design processes like the ‘design thinking process’, the process of working with crafts is very spontaneous. It requires quick decision-making, reacting to current situations and people skills. It is a process that is very organic in nature and this is exactly what allows intervention and innovation. Right from the schedule, to the output, to the deadlines cannot be planned to the hour. The standard design thinking processes followed by most industrial set-ups don't allow for intervention and experimentation. While on one hand it is difficult to assess the outcome when working with crafts but it also allows for more flexibility in prototyping. It demands ‘thinking on the feet’. Depending on the situation and the circumstances, spontaneous and clever thinking is often needed. This is also highlighted in the insights and learnings from the field. Being flexible and accommodative is one of the key tools when working with such industries or set-ups. Craft is all about emotion and emotion cannot be forced or planned. Because of this trait, craftsmen working with their craft are often very closely attached to their work and treat it with respect. Thus, it is very important to deal with them with respect not only for their work but also for them individually.

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## **DESIGN FOR SUSTAINABILITY FRAMEWORK APPLIED TO THE PROBLEM OF GARMENT WASTE: A BRAZILIAN STUDY**

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### **ABSTRACT**

In this paper, we present a brief overview of the garment waste situation in Brazil, the potential design-based strategies for minimizing the environmental, social and economic problems caused by the incorrect disposal of this material and for revaluing it. Based on our own nine years' experience investigating this problem, we then situated our activities in an evolutionary framework of Design for Sustainability (DfS), built based on a previous model proposed by Ceschin and Gaziulusoy (2016). As result, it was possible to present a clear and comprehensive overview of how design can contribute to the garment waste issue, in terms of evolutionary innovation levels.

Key Words: Garment Waste, Design for Sustainability, Design Strategies, Framework.

## 1. INTRODUCTION

### 1.1 The problem: Garment waste in Brazil and in the state of Paraná

Garment waste represents around 2,6% of urban solid waste in Latin America, including Brazil (Hoorweg t Bharda-Tata, 2012). This means approximately 1,8 million of tons/year of garment waste produced in Brazil, and 9,1 kg/year per person. Even if this average is lower than countries like the United States (70 kg/year per person) and the UK (30 kg/year per person), the consumption and disposal of the garment in Brazil are growing. Fashion (including textile and garment industries) is the fourth largest economic activity in the world and concentrates 5,7% of manufacturing and 14% of employment in the globe (Uniethos, 2013). Brazil occupies the fifth position among the textile manufacturers and fourth among the garment producers (ABIT, 2013). Textile and garment sector is responsible for significant environmental impacts, being the waste of materials the most relevant. Cut phase is the most determinant for the waste, whose rate is around 15-20% in the Brazilian garment industries (Perez & Martins, 2016; Mcquillan & Rissanen, 2011; Guimarães & Martins, 2010).

Although the textile and garment waste is considered inert and in spite of that not directly contaminant, they are related to several other problems including the depletion of non-renewable resources (like fossil fuels), habitat destruction and soil depletion (landfills and irregular disposal), toxic and GhG emissions (from burning, a practice still common in Brazil). The problem is aggravated in Brazil because of the lack of effective and efficient collection and destination systems for this type of waste in the cities, despite the country have approved a Solid Waste National Policy in 2010 (Brasil, 2010); unfortunately, this policy does not include specific recommendations for the textile and garment sector, although other sectors are cited.

In Brazil, only 13% of urban solid waste is recycled or composted, the rest is sent to landfills or even dumps, and the selective collection programs do not include textile and garment waste as recyclable material. In the state of Paraná, we identified about 800 companies in the garment sector, and by combining fragmented data of different researches (Stutz & Martins, 2015; Honorio Et Al, 2016; Senai, 2016; Lourenço, 2018; Homse, 2017) we could estimate around 10.300 tons/year of garment waste, being 5.900 from post-consumption and 4.400 from industries (SAMPAIO et al, 2018).

We also identified recycling of garment waste as an interesting strategy that is now subexplored, but with a high potential for innovation. Beyond that, we identified the development of new materials from solid waste recycling as a potential solution not only to help to face the problem of garment waste, but also for revaluing it, and so, creating new value chains. So, in this paper, we present different DfS approaches for the textile waste problem we have investigated in the period of 2009-2018, in a chronological and evolutionary way. Considering our own previous research experiences, in this study we searched for a THEORETICAL STRUCTURE that could allow us: to look for our own research in a critical and retrospective way; to organize the research history and evolution; to identify lack of theory, methods and tools; to see opportunities for new studies.

## 2. THEORETICAL BACKGROUND

Ceschin and Gaziulusoy (2016) proposed an interesting framework that allows visualizing the potential contributions of design for sustainability in different levels of action. In this structure they positioned the main relevant DfS approaches, organized in four levels:

- **Product**, that includes strategies of Green Design, Biomimicry, Ecodesign, Cradle to Cradle (C2C) Design, more focused on the environmental aspects of the products, or even Emotionally Durable Design, Design for Sustainable Behavior or Product Design for the Base of Pyramid (BoP), that emphasizes respectively behavioral, emotional and/or socioeconomical aspects of the user/consumer;
- **Product-Service System**, including eco-efficient Product-Service System (PSS), PSS for the BoP (Base-of-Pyramid), and the Sustainable PSS Design;
- **Spatial-Social**, that involves strategies more focused on environmental aspects, like Systemic Design, or on the social dimension, as found in the Design for sustainable Social Innovation;
- **Socio-Technical System**, that includes the strategy of Design for System Innovations and Transition, dedicated to developing solutions that imply in new ways of production and consumption;

Due to the simplicity and clarity of this framework, we adopt it as an initial structure to positioning the different possibilities of design action we have experienced in our research projects, as it follows.

## 3. RESEARCH METHOD

Beyond the literature review of the garment waste problem in the world and in Brazil, we used in this study two main methods: first, a chronological and evolutionary exploration of our own experiences in research projects for the problem of garment waste in the state of Paraná/Brazil since 2009; second, the critical appreciation of the Ceschin and Gaziulozoy's framework for the DfS approaches (Ceschin & Gaziulusoy, 2016), its complementation with three additional levels and positioning the DfS approaches we adopted in our research projects.

## 4. RESULTS AND ANALYSIS

### 4.1 Chronological and evolutionary history of research projects

Since 2009, we have explored the problem of garment waste in the state of Paraná in different levels of study, in an evident evolutionary but spontaneous way. We can present this history in terms of four phases: In Phase 1, we started by investigating the possibilities of reusing the waste to create handicraft products (2009-2010); In Phase 2, we started to explore new techniques of reusing the garment waste to produce industrial products, and zero waste methods to reduce the waste in industry (2010-2012); In Phase 3, we perceive that these solutions were not enough to deal with the amount of waste produced by the companies, so we started to investigate solutions by recycling the waste and converting it in new materials, in partnership with chemistry researchers.

This resulted in four different methods of recycling a specific type of synthetic textile waste, made of PA66 and elastane. In parallel, we developed products with these new materials to verify its innovation potentiality (2013-2015); From the success obtained in Phase 3, in Phase 4 we started to investigate how to improve the collection and destination system for the garment waste, both industrial and post-consumption. At the same time, we collaborated with the state of Paraná's government to build up a preliminary reverse logistics plan for the garment sector, using design in a more strategic way to plan more systemic solutions (2015-2018).

From this very brief description, and using the Ceschin and Gaziulosoy's framework as reference, we could then organize the design actions we have explored in a more comprehensive and evolutionary way; this work involved two main phases and allows to visualize the big picture of possible DfS approaches for the garment waste problem.

### 4.2 Phase 1: Adapting and complementing the Ceschin and Gaziuluzoy's framework

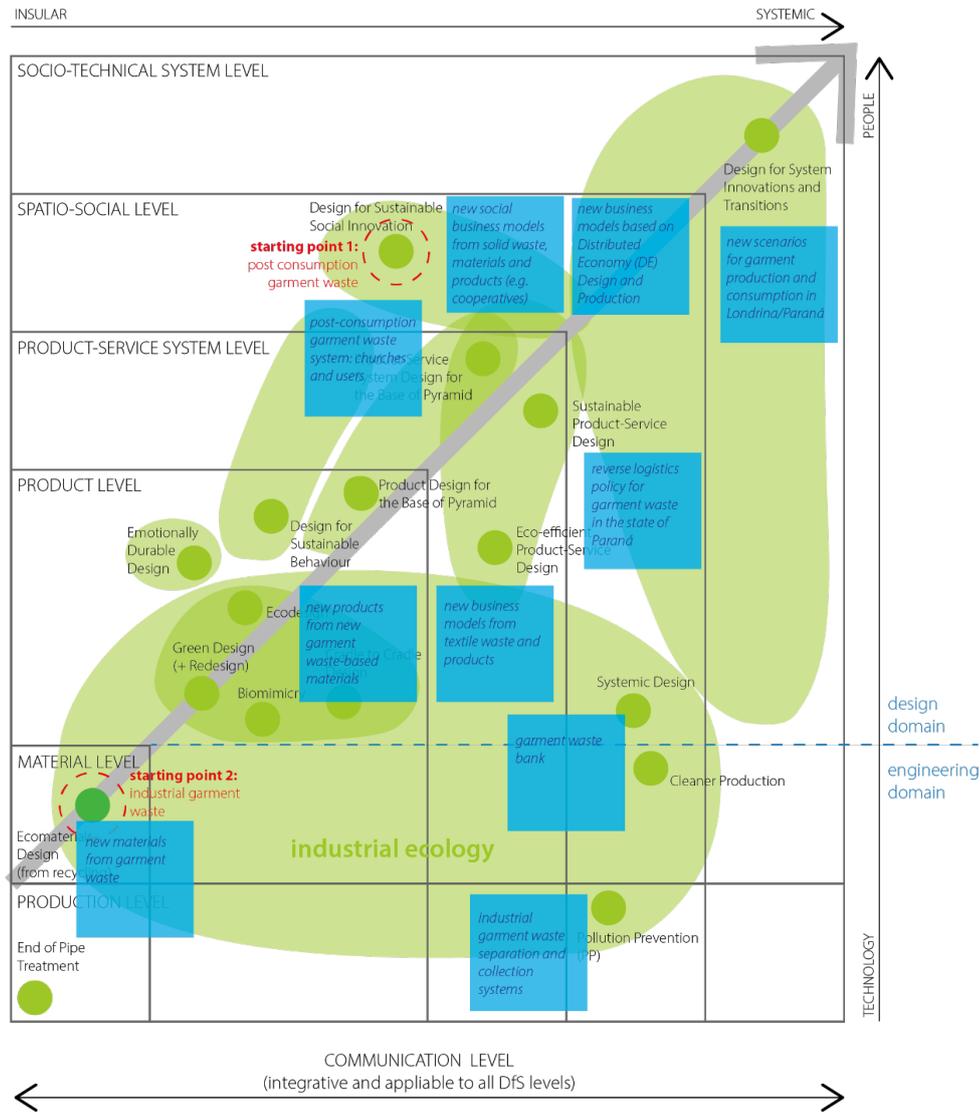
To separate, collect, destinate and revalue the garment waste, we consider here the material life extension and revalorization as the main life cycle design strategy, that can be applied in six different levels of intervention: Production Level, Material Level, Product Level, Product-Service System Level, Spatial-Social Level, and Socio-Technical System Level. The two first levels are proposed by the author based both on the experience obtained in the four phases of research previously described and in his doctorate investigation, in which he developed a methodology for innovation from solid waste (Sampaio, 2017); the other four levels are based on the DfS Evolutionary Framework, as proposed by Ceschin et al (2016). The two complementary levels - Production Level, Material Level, and Communication Level - are described as it follows. The adapted framework is presented in Figure 2.

The first level - Production - includes the improvement of the inputs flow (materials, energy, water, technology, etc.) necessary to the manufacture of garment products, and the output at the end of the process (garment waste and emissions). This is a technology-centred level, in which design usually does not intervene, containing the strategies of end-of-pipe and pollution prevention techniques; however, we consider that designers can also act in this level by proposing improvements in the flow of the inputs (materials, water, energy) and outputs (emissions and waste).

The second level - Material - is related to develop solutions for the waste using the Materials Design approach, combined with recycling processes. Here, we propose to consider the development of new materials from recycling solid waste as a design activity, that can be developed in partnership with other knowledge areas like chemistry and materials engineering. In our own research experience, we could confirm the effectivity of this interdisciplinary approach. Recycling is an activity related both to the strategies of pollution prevention or P2 (reduction, reuse, recycling, treatment, and disposal) and cleaner production (P2 plus Design for Environment and Life Cycle Assessment), and the industrial ecology as a whole; thus, we also propose here the design of new materials from solid waste as a design activity integrated with these strategies. It is important to highlight that cleaner production is a wider strategy that encompasses not only products but also services, in an integrated, preventive and continuous way (UNEP, 2013).

We also propose to align the material development with the approach of systemic design, considering aspects like local networks and involvement of stakeholders, and wastes as resources. Complementarily, we propose a seventh level - Communication - that pervades all the previous levels, dedicated to the application of Design for communicating the sustainability aspects of the project. This level was included based on our empirical experience in the research projects, and on the model of Four Orders of Design (Communications, Objects & Artefacts, Interactions, Systems & Environment) as proposed by Buchanan (1982).

In our previous experience, we could note the importance of having effective and efficient communication along the project, informing the project partners, scientific community and society about the evolution and results of the investigation. This requires different depth levels of information, and language adaptation for each type of audience.



[Figure 2] Design ideas in each level of the framework

#### 4.3 Phase 2: Generating and positioning ideas from the framework

In figure 1, we also present how the framework was used as a tool to generate and organize design ideas of solution we have explored for the problem of garment waste, considering each level of action. At the first level – Production – we proposed the intervention of designers to improve the process of quantification, separation, storage, collection, and transport of the garment waste; At the second level – Material – we considered garment waste as the starting point to interdisciplinary development of new materials guided by design, in parallel to product development (3rd level); at the third level – Product – we adopted a combination of active experimentation with the materials waste in the laboratory (producing what we called “material prototypes”, or “protomaterials”) applying a user-centered design method for the products (producing product prototypes).

As result, we obtained many viable ideas for three different applications for living spaces: decoration, surfaces, and lightning. At the fourth level – Product-Service System – we designed business models proposals for exploring the material and product innovations in the market and submitted them to a selective process for incubating new business in the university innovation agency. In this process, the researchers (most of them undergraduating design students) developed a deeper understanding of issues like business models, management, market positioning, corporate identity, and other related themes. For the fifth level – Socio-Spatial – we developed both top-down and bottom-up strategies focused on the post-consumption garment waste. In the first case we collaborated with the Paraná’s state government to develop a ideas for a reverse logistics plan (policy and strategy) for the garment sector, based on the Solid Waste National Policy (BRASIL, 2010); As a bottom-up strategy, we proposed in this plan to include the existent structure of catholic and evangelic churches as social agents to receive and destinate the garment products disposed of by the users/consumers, an evident social innovation initiative.

Another proposal, now focused on the industry waste, was the planning and implementation of an organiza-tion destinate to collect, separate, classify and send the garment waste to various useful applications, or at least to energy recovering. This venture, “Banco de Resíduos de Londrina” (“Londrina Waste Bank”) was inspired by the “Banco do Vestuário” (“garment bank”) of Caxias do Sul” and “Retalho Fashion” of São Paulo (Sinditêxtil, 2017), two similar Brazilian initiatives (BRASIL et al, 2014), and included the low-income workers that collect solid waste

as an important socio-economic agent (Sinditêxtil, 2013). The sixth level – Socio-Technical System – is the only we are just beginning to explore and can include the development of new scenarios for the production and consumption of garment in the city Londrina and its metropolitan region, and the state of Paraná in general. At this level, we are starting to explore the potential and limitations of the Distributed Economy concept, including both Distributed Design and Distributed Production, and specifically, its applicability in the garment waste reverse logistics and garment waste bank for the state of Paraná (Ramos, Sampaio, Martins, 2018). This type of exploration demands the participation of other system actors that we still did not could integrate into our projects.

#### 4.4 Analysis

As it can be seen in Figure 2, the adapted framework was a useful, clear and effective tool that allowed us to position and visualize the many design initiatives we have proposed for the problem of garment waste along the last nine years of research and development. By complementing the 4-level model of Ceschin and Gaziulusoy (2016) with the three additional levels that resulted from our own empirical experience, we consider that this paper contributes to growing the body of knowledge in DfS in two main aspects: 1) Expanding the Ceschin and Gaziulusoy's framework with other levels that allow to include other possible design interventions, namely the improvement of production and distribution flows and the design of materials; 2) Applying this expanded framework to a particular problem of sustainability, in this case, the garment waste. Fortunately, we believe these contributions are aligned with the conclusions pointed out by Ceschin and Gaziulusoy at the end of their paper, when they propose: *"Finally, from a design practice perspective, the framework might be used by practitioners and organisations to navigate the complex DfS landscape, or to identify the appropriate approaches to be adopted in relation to specific sustainability challenges"* (Ceschin & Gaziulusoy, 2016). We believe this is the case in which we could not only navigate but adapt and identify a relevant application for that tool.

### 5. IMPACTS ON SUSTAINABILITY

Considering the extent of the different design interventions in each level of the proposed framework, a lot of benefits can be pointed out. Environmental benefits include: reducing raw materials needed to produce new garment (if the waste is recycled and reapplied in the garment sector) or other products (if the waste is used to substitute current materials); reducing the pressure in the landfills and dumps, by delaying the disposal of materials in these places; reducing the toxic emissions and soil depletion and contamination associated with the disposal in these places; avoiding the toxicity for human, animal and environment health, and global warming effects related to the GhG (greenhouse gas) emitted by burning the garment waste; reducing the indirect impacts caused by the transportation of the garment waste to landfills and dumps, usually located far from the urban spaces. Economic benefits can be seen both in terms of cost reduction of treating the garment waste and potential profit derived from the new value chains created to revalue the material. Finally, social benefits can be seen both in terms of the reduction of impacts on human and animal health, as well as the living spaces in which they live, specially the low-income people, and the new opportunities of labor and income associated with the creation of new value chains.

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## **LIFE CYCLE DESIGN (LCD) GUIDELINES FOR ENVIRONMENTALLY SUSTAINABLE CLOTHING CARE SYSTEMS: AN OPEN AND OPERATIVE TOOL FOR DESIGNERS**

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### **ABSTRACT**

This paper presents a set of Life Cycle Design (LCD) guidelines to operatively support fashion companies to design low-environmental impact cloth. The LCD guidelines for environmentally sustainable clothing care systems has been developed with the following process adopted since several years in company/organization consultancy by the LeNSlab of Politecnico di Milano: desk research of the fashion system and its environmental impacts and sustainable best practices analysis; identification of the environmental design strategy priorities; definition of cloth-specific guidelines. i.e. a process of specifying the general LCD strategies: material minimization, energy minimization, non-toxic harmful resources selection, renewable and biocompatible resources selection, product life optimization, material life extension, design for disassembly; tool development both as a handbook and a digital tool. The result is both an open access handbook and a digital tool of LCD clothing care guidelines and checklist to support and orientate the future designers and companies to an environmentally sustainable design of clothing for fashion.

Key Words: Design for Sustainability, Life Cycle Design, Sustainable clothing; Fashion system

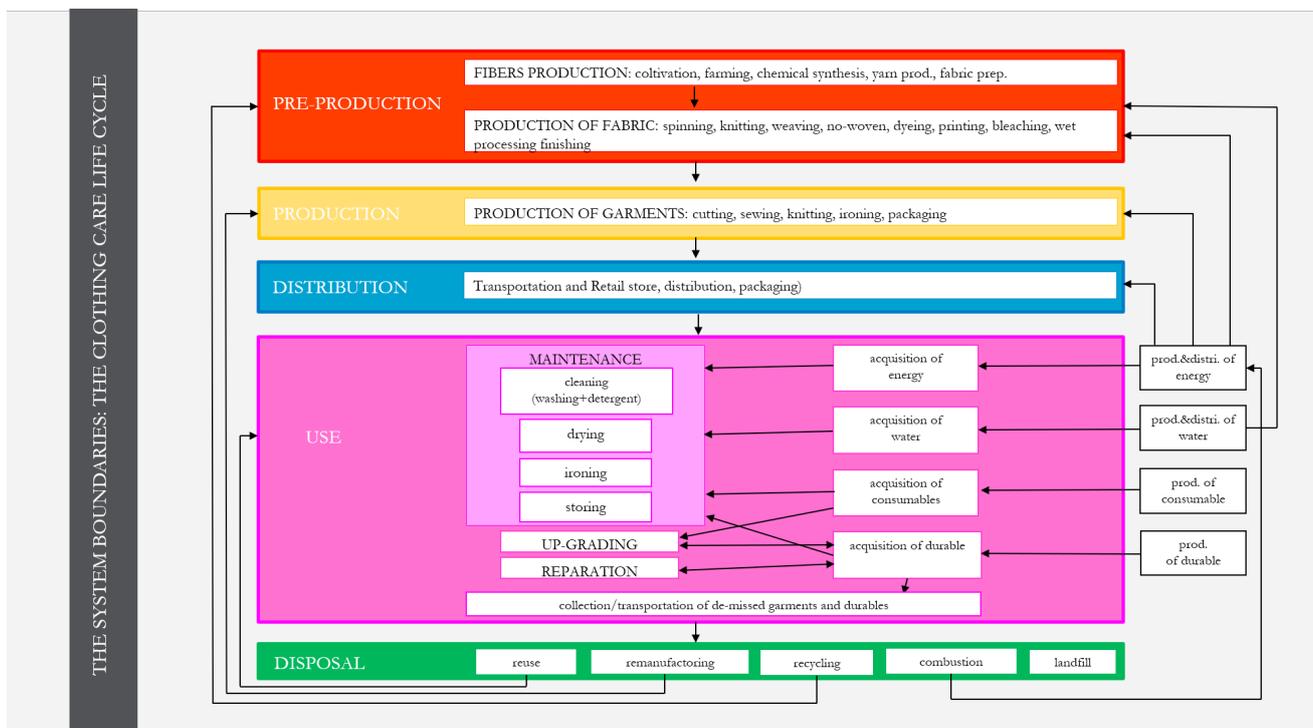
## 1. INTRODUCTION

The fashion industry is one of the industrial systems that contributes the most for global growth and development, but at the same time the industry has a very high environmental impact, that increase year by year, due to the industry's continuing growth. The apparel industry is the second highest user of water worldwide, producing 20 percent of global water waste, the 10 percent of the global carbon emissions and cotton farming is responsible for 24 percent of insecticides and 11 percent of pesticides despite using only 3 percent of the world's arable land (United Nations Economic Commission for Europe 2018). Most of the companies, design without thinking about the consequences of the clothing care life cycle and as a result the impact of their products on the environment is very high. On the other hand, the demand for clothes are every day higher, consumers aren't getting enough to own useful products because they are driven by trends which follow fast marketing and therefore each product is often use just half long as their real life. The main goal of this project is to inform companies and designer regarding the importance of sensibilities and furthermore to give them an instrument to contribute to have less polluting world, through the realization of a handbook and a digital tool of LCD clothing care guidelines and checklist.

## 2. THE CLOTHING CARE ENVIRONMENTAL IMPACT

### 2.1. Environmental Analysis: system boundaries and the satisfaction unit

The environmental analysis is necessary to define the clothing care environmental impact and to discover and analyse the best practices. At the beginning, the system boundaries need to be defined based on the product life cycle phases. Taking under analysis the clothing care system, the product life cycle phases are pre-production, production, distribution, use and disposal (Fig.1). Then, as the satisfaction unit (or functional unit), has been designated the use of a garment for one year.

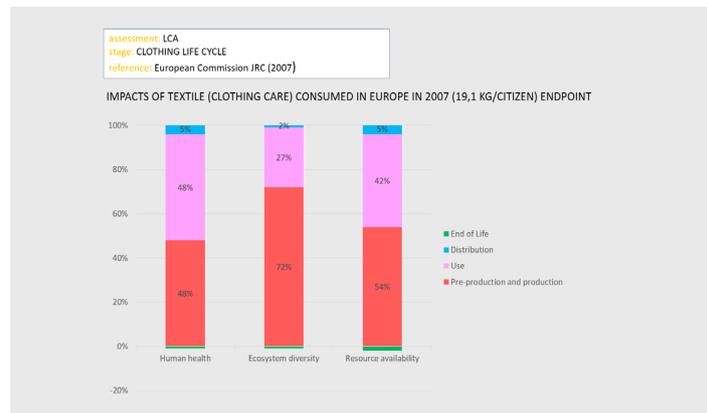


[Figure 1] The system boundaries: the clothing care life cycle

Each phases of the clothing care life cycle have been deeply analysed through desk researches. As shown in the following graph (Fig. 2) re-elaborated from the European Commission JRC (2007), considering the impacts that have been clothing care consumed in Europe in 2007 (19,1 kg/citizen) on Human Health, Ecosystem diversity and resource availability, the phases that impact the most are pre-production and production and use. In the following paragraph, each of the life cycle phases have been explicated.

### 2.2. Pre-production and production phase

The first phase is the pre-production phase which includes the fibres production and the production of fabric. Analysing the fibres production, first it is necessary to know that fibres can be divided into natural fibres (that has origin from living organism) and synthetic fibres (that has origin by chemical synthesis made by human), consequently different methods of fabric production are use, based on the materials. For example, a process that concern natural fibres might be the cultivation, whilst a process that affect the synthetic fibres might be chemical synthesis. Then these fibres, both natural or synthetic, turn into a yarn.



[Figure 2] Impact of textile (clothing care) consumed in Europe in 2007 (19,1 kg/citizen) endpoint.

Authors re-elaborated from European Commission JRC (2007)

In the same way fabric production could involve different process, depending on the fabric, if it is knitted or woven. Different processes such as dyeing, printing, bleaching and finishing, have a very high impact on the environment due to the high requirement of water, energy and chemical treatment done to obtain the desired results. At last there is the production phase, which consist of garment production; this phase includes processes such as cutting, sewing, knitting, ironing and packaging. Analysing the pre-production, the environmental impact depends mainly on fibre type and technological approaches (Wiklund S, 1984). Based on a carbon footprint comparison of different fibres in pre-production and production from Wrap (2009) we can assume that the high carbon footprint level during pre-production and production phases is given by the fabric production; in addition, it is shows that natural fibres impact more on the environment, compared to synthetic fibres.

While natural fibres such as conventional cotton have a critical environmental impact for the large consume of water, fertilizers and pesticides during the cultivation, hem, flax and organic cotton, could be valid alternative. Considering the high use of pesticides in pre-production, it is important to know that organic cotton is made avoiding the use of pesticides and chemical fertilizers and hemp and flax do not need pesticides for their nature, since their fibers are not made from the plant flower but from the wood-like part of the plant. Considering that natural fibres impact more than synthetics one, analysing toxicity we can observe that the situation changes (Fig.4). In this case comparing different fibres during pre-production, synthetic fibres such as acrylic, has the highest impact. Different regulation for harmful substances has been instituted for different countries. In Europe, there is the REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) the European Union regulation for harmful substances created to protect human health and the environment from the risks caused by chemicals harmful substances.

### 2.3. Distribution phase

Distribution phase considers both transportation during pre-production, production and post production phase. Even more often, clothing companies move to countries with a cheaper manufacture cost like Bangladesh, Vietnam and Philippines, shipping from countries like India and China the raw materials needed. When the garments are ready, they are sent to retail by rail, ships and trucks in shipping container. It is fundamental to know the impact of different transportation methods and to try to reduce the environmental impact through conscious decisions like maximize transport, utilizing transport solutions with minimum pollution and try to work as much as possible with local companies, to be eco-friendlier. However, in life cycle phases, the distribution phase does not have a very relevant environmental impact, compared to the other phases, like the use and the production one.

### 2.4. Use phase

From an accurate analysis, we can assume that strong environmental impacts are caused by the consumers during the use phase. The maintenance activity that affects the environment the most is the cleaning, which include washing and the use of detergents (Fig. 5). Washing and drying clothing alone are estimated to account for 120 million tonnes of CO2 equivalent (Ellen MacArthur Foundation, 2017). Consumers most of the time wash their garment too often and at high temperatures. Unfortunately, most of the energy used for washing clothes goes into heating the water, for this reason encouraging consumers to wash at low temperatures could reduce water and energy use. Commonly it is used too much detergent without the correct dose and some detergents could be dangerous and harmful. Even through there are people that still prefer line drying and increasing number of consumers use tumble dryers without thinking that it is a high consuming method that could easily be avoided. Customers need to be informed about the consequences of their actions and at the same time need to be encouraging to do the right choices concerning the maintenance routine. At the same time, it is essentials that companies start to design also thinking about the use phase, in order to reduce the high environmental impact of this phase.

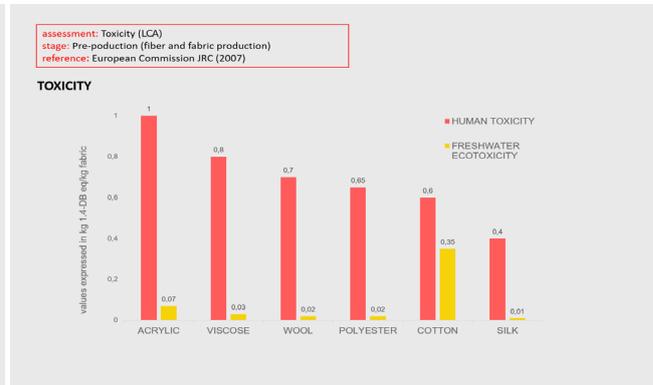
### 2.5. Disposal phase

At the end of life of a garment, the product could be reuse it (starting a new use phase), remanufacturing (being part of a new production of garment), recycling (being part of a new production of fibres), combustion (produc-

ing new energy) or send it to incineration and landfill. Analysing the textile industry in Europe about 15-20% of disposed textiles are collected (the rest is landfilled or incinerated), where of about 50% is downcycled and 50% is reused, mainly through exporting to developing countries (Textile Recycling Association, 2005). Increasing the practice of textile reuse, remanufacturing and recycling could potentially decrease the production of new textile fibres and therefore reduce environmental impact. WRAP has developed a specific methodology for quantifying the benefits of reusing products. For example, analysing the reuse of 120 million T-shirts (ca 30,000 tonnes) in the UK every year, it is possible to avoid 450,000 tonnes CO<sub>2</sub>-eq per year.



[Figure 4] Human toxicity and freshwater ecotoxicity. Re-elaborated from JRC (2007)



[Figure 5] Use phase environmental impact. Re-elaborated from JRC (2007)

### 3. ENVIRONMENTAL SUSTAINABILITY DESIGN STRATEGY PRIORITIES

At this stage, due to the previous analysis, the design guidelines' priorities were individuated. For every single design strategy, it was defined a priority indicator, based on their potential environmental development. Three main priorities are recognised: high priority, medium priority and low priority (Fig. 6) The design strategy with high priority are: Resources conservation which intent is the reduction of products environmental impact through the responsible use of earth's resources; Toxicity reduction which intent is the reduction of products environmental impact through the minimization of toxic emissions; Use extension/intensification which intent is the reduction of products environmental impact through the extension and/or intensification of the life span of the product or of a single part of it. The design strategy with a medium priority are: Energy consumption reduction which intent is the reduction of products environmental impact through the reduction of the use of energy consumption; Material consumption reduction which intent is the reduction of products environmental impact through the reduction of materials consumption. The design strategy with a low priority is Material life extension, which intent is the reduction of products environmental impact through the materials efficiency.

### 4. SUSTAINABLE BEST PRACTICES ANALYSIS

Various case studies of sustainable best practice examples, related to the fashion system, has been studied. The objective of this analysis is to learn from the cases the most excellent solutions and to use them as an incentive during generation of ideas for the workshop. This paper describes some of them. Timberland has created a boot builds with a 42% recycled rubber outsole, upper leather from greener tanneries and organic cotton shoelaces. Once you returned, Timberland will take the shoe apart and the soles will be send to a factory in Georgia to be made into new Timberland shoe outsoles; The leather's sent to the Dominican Republic to be refurbished, the metal hardware's either unscrewed and reused in new footwear, the polyester lining's recycled into new products in Japan. For this reason, is also in the interest of the company to have a Life Cycle Design strategy approach, based on extending the lifespan of materials. Threadmiths is another example, a technical apparel company based in Australia that design basics garments with high performance fabrics. They collaborate with a fabric technology company to make a durable stain-resistant technology that is naturally self-cleaning. The fabric can repeal water-based liquids, and this means durability, less washing and detergent and at lower temperatures making it more environmentally friendly. Their Life Cycle Design strategy approach is based on optimizing resources renewability and bio-compatibility.

### 5. METHOD OF DEFINITION OF SPECIFIC LCD CLOTHING CARE GUIDELINES

All the previous results were the solid basis for the definition of specific Life Cycle Clothing Care guidelines. In this section are described the main phases followed to obtain the tool development both as a handbook and a digital tool.

#### 5.1. Workshop

A workshop was organized with the support of fashion system and design for sustainability specialists. The main purpose of the workshop was to delineate a draft of specific clothing care life cycle guidelines, supported by both, input for the desk research on environmental impact of clothing care, best practices of environmentally sustainable

cloths and the general LCD strategies and guidelines. In the first part of the workshop was made a presentation of the results of the strategic analysis and were discussed the best-case studies solutions; moreover, the definition of design strategic priorities was presented. Subsequently, the product life cycle design ICS qualitative toolkit (developed by the LeNSlab of Politecnico di Milano), has been used to work on the core part of the workshop, i.e. the guidelines specification. The qualitative tool orientates the design process thanks to the eco-ideas tables, with guidelines, which are a set of general design guidelines divided per priority. During this phase the following process has been adopted: specifying a guideline for any type, one or more clothes; erase a guideline for any type, one or more clothes; add a new guideline for any type, one or more clothes; add note/remainder for any type, one or more clothes. After the workshop, a draft of the guidelines was developed; then correctly reformulated and improved for the final handbook.

### 5.2. LCD specific guidelines

Based on the workshop, the final Life Cycle Design guidelines was been written and organized into a handbook (Fig. 7) and a digital tool (Fig. 8). The project starts with a short introduction on the clothing system and is followed by the environmental impact caused by products, how to evaluate it and the Life Cycle Design method.

The main part is composed by the guidelines, organized by environmental priority. The seven guidelines are the following: 1. Renewable and Bio-Compatible Resources; 2. Minimising Toxic Emissions; 3. Extension of Product Lifespan 4. Minimising Energy Consumption; 5. Minimise Materials Consumption; 6. Improve Lifespan of Materials; 7. Design for Disassembly. In each of the seven main guideline there are specific group of LCD strategies, supported by graphics and tables, that are useful to support the designers during the decision of design making process. Finally, for each guideline has been prepared a check lists, to help the designers and developers to verify to which level the given guidelines have been pursued.

Types of clothes: jackets and coats. trousers and shorts. underwear. skirts and dresses. shoes, sweaters and waist-coats. shirts, t-shirts and tops

## 6. CONCLUSION

As discussed in the previous paragraphs, we can assume that the fashion system has a very high impact on the environment. This project is based on the studying of environmental impact caused by the clothing life cycle and outlines the efficacy to use the specific guidelines to support the most promising process to design clothing care with the lowest environmental impact. For the companies and the designer is essential to be consciousness about the envi-

**Checklist**  
**Minimising Toxic Emissions**

	YES	PARTLY	NO	NOT APPLICABLE
Did you avoid the use of toxic or harmful materials for product components?				
Did you minimise the risk of toxic and harmful materials?				
Did you avoid the use of additives that cause toxic or harmful emissions?				
Did you avoid toxic and harmful finishing materials?				
Did you replace chemicals with enzymes for desizing or scouring?				
Did you minimise the dispersion of toxic and harmful residues during product use?				
Did you consider digital instead of pigment or traditional printing?				
Did you select energy resources that minimise toxic/harmful emissions during pre-production and production?				
Did you select energy resources that minimise toxic/harmful emissions during distribution?				
Did you select energy resources that minimise toxic/harmful emissions during (PRODUCT) USE?				
Did you select energy resources that minimise toxic/harmful during end of life treatments?				
<b>NUMBER OF ANSWERS</b>				
<b>PERCENTAGE (nr. applicable checklists / nr. answers x 100)</b>				

[Figure 7] Handbook: a frame from the checklist chapter about minimising toxic emissions

POLITECNICO DI MILANO  
ECO-IDEAS BOARD  
TOXICITY REDUCTION

DIS Design and system Innovation for Sustainability

**SELECT MATERIALS WITHOUT OR WITH THE LOWEST TOXICITY/HARMFULNESS POTENTIAL**  
AVOID THE USE OF TOXIC AND HARMFUL MATERIALS IN PRODUCTS  
IF USED, MINIMIZE THE RISK OF TOXIC AND HARMFUL MATERIALS  
AVOID THE USE OF ADDITIVES CAUSING TOXIC AND HARMFUL EMISSIONS  
AVOID TOXIC AND HARMFUL FINISHING MATERIALS  
REPLACE OF CHEMICALS WITH ENZYMES AS FOR DESIZING AND SCOURING  
MINIMISE THE DISPERSION OF TOXIC AND HARMFUL RESIDUES (DURING PRODUCTS' USE)  
CONSIDER DIGITAL INSTEAD OF PIGMENT OR TRADITIONAL PRINTING

**SELECT ENERGY SOURCES WITHOUT OR WITH THE LOWEST TOXICITY AND HARMFULNESS POTENTIAL**  
SELECT ENERGY RESOURCES THAT MINIMISE TOXIC/HARMFUL EMISSIONS DURING PRE-PRODUCTION AND PRODUCTION  
SELECT ENERGY RESOURCES THAT MINIMISE TOXIC/HARMFUL EMISSIONS DURING DISTRIBUTION  
SELECT ENERGY RESOURCES THAT MINIMISE TOXIC/HARMFUL EMISSIONS DURING (PRODUCT) USE  
SELECT ENERGY RESOURCES THAT MINIMISE TOXIC/HARMFUL IN END-OF-LIFE TREATMENTS

IDEA

USE EFFICIENCY P: HIGH  
MATERIALS RED. P: HIGH  
ENERGY REDUC. P: HIGH  
WAT. LIFE CYC. P: HIGH  
TOXIC REDUC. P: HIGH  
RED. CONC. P: HIGH

[Figure 8] Digital tool: idea generation board with specific about minimising toxic emissions

ronmental impacts caused by the creation of its products and they have to be conscious regarding the importance of their role. The use of the Life Cycle Design cloth-specific guidelines and checklist tools, it is suggested to be adopted and eventually redefined by both fashion company's and fashion designer in their design and development processes. This project brings from general to product specific Life Cycle Design guidelines, offering a completely new tool for the fashion design system. This tool could be useful for fashion designers and companies to have a support to implement since from the earliest phase of the design process, the correct strategies and to avoid high environmental impacts. Working with this tool could help companies to be orientated and inspired to develop and to choose design solutions that are environmentally friendly. Thinking about future step, it is important to know that the guidelines could evolve, based on the evolution of society, needs and new technologies solutions and this is facilitated by being the same guidelines and the two tools open access.

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## **THE RESEARCH OF YI ETHNICITY FURNITURE DESIGN BASED ON ARCHITECTURAL SPACE**

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### **ABSTRACT**

Yi furniture market has a great role in promoting the economic development of Yi region. In modern society, science and technology, education, social productivity and rapid progress of the research on the Yi Furniture Design Based on the analysis of architectural space, the purpose is to explore the ways to make the Yi area lost precious traditional culture of Yi ethnicity in the steady development at the same time. The relationship between the architectural space and the furniture design of Yi ethnicity is to innovate the design method, to guide the life style, and to promote the harmonious development of the society. This article aims to find out the development of Yi ethnicity furniture and put forward the main line of solution, and to promote the healthy development of Yi ethnicity furniture design and production by integrating resources.

**KEYWORDS:**Yi Ethnicity furniture; Design analysis; Ethnical characteristics Inheritance and development

## 1. INTRODUCTION

The Yi Autonomous Prefecture in Liangshan is carrying out the work of “precise poverty alleviation” in full swing, and the state attaches great importance to the Yi Autonomous Prefecture in recent years. The doubled growth of new housing has increased the demand for furniture. At the same time, the state’s emphasis on Yi culture has reached an unprecedented new height. Since the birth of Yi furniture, it has been interacting and complementing with architecture and indoor environment. Therefore, the study of Yi furniture can not be separated from the space environment in which furniture exists. Therefore, based on the architectural space, the Yi furniture design is studied.

## 2. DESIGN METHOD OF YI FURNITURE BASED ON ARCHITECTURAL SPACE

From the traditional wood structure to today’s multiple materials mixing, from a single living space to modern multiplicity space coexist, Yi interior furniture and architecture still have a “similar structure, decorative homology, material consistency” relationship. Through investigation and discussion, it is concluded that the essence of Yi architectural space is an activity place integrating material structure and spiritual behavior. The design method is obtained by logical deduction based on “for human use”.

### 2.1 Based on the View of Vertical Space

In the space view of the Yi people, both the outer space and the interior space are “vertical space”. Through vertical spatial organization, the space is effectively partitioned. Modern people are more pursuing diversification and individualization, so functional zoning is particularly important.

The design of modern Yi furniture should follow the vertical space concept of the Yi nationality, that is, to adapt to multi-functional space zoning. As far as furniture itself is concerned, functional zoning should also be emphasized. Taking Gaji (the name of the Yi storage cabinet) as an example, it also reflects the top-down distribution of “god space, natural data space and living space”.

First of all, we should have a comprehensive understanding of the architectural space and living system of the Yi people, and then start the macro planning and design, aiming at strengthening the interrelationship among people, furniture and space. Different spatial functions have different requirements for furniture design. Various functional spaces stimulate the development of customized furniture, thus promoting the diversity of furniture types. Many classical furniture at home and abroad, originally because a good building space can not find the right furniture matching or the owner is not satisfied, so it needs to specially make furniture for a space. Such as offices, hotels, school buildings, etc., and then mass production as consumer goods.

### 2.2 Taking the Decoration of Spatial Structure as the Source Point

Yi architecture is a typical structural space. The bare arches, grids, tenons and mortises form a rhythmic and changeable three-dimensional space point, line and surface decoration. The natural totem pattern in the plane reflects the natural worship of the Yi people, “All things are spiritual”, and the color also has its unique significance in the Yi culture. The structure, totem and color constitute the national attribute of the visual image of the Yi nationality.

#### (1) Planar vision

##### Color

“Black, red and yellow” are the three most distinctive colors of the Yi people, which are called “three primary colors of the Yi people”. Black symbolizes land and blood, representing solemnity and dignity; through generations of inheritance of the Yi people, red has become the symbol of holy and omnipotent fire, and has an irreplaceable function of exorcism and protection in the life of the Yi people; in the philosophy and culture of the Yi people, yellow is the representative of human beings, the sun is the source of the growth of all things, and also the foundation of human survival, and the Yi people define yellow as good. Friendship, harvest and prosperity remain unchanged. These three colors were first used on the lacquer-ware of the Yi nationality, and later developed into the representative elements of the characteristics of the Yi nationality in the living room.

“Green, white, yellow, red and black five colors” is called “Yi people’s five colors view”. These five colors symbolize the Yi ancestors’ understanding of the world’s most superficial things, and fully reflect the process of Yi ancestors’ understanding of nature and the world. “Southwest Yi Zhi” describes the Yi people in Ming and Qing Dynasties as “the blue sky is covered with green ribbons, red ribbons are paved with red ground, yellow ribbons are painted dragons, meticulously embroidered, embroidered with red sun shadows”. From this we can see that color is the way for Yi ancestors to understand the world. Various colors have been given different meanings by Yi people since ancient times.

##### Patterns

There are different patterns and pictograph symbols on Yi people’s clothing, architecture and lacquer ware. Because they are generally continuous patterns, they can also be used cross-over. Early Yi furniture was decorated with color patterns. Modern decoration techniques include direct printing and sticking of stickers on the surface of furniture with pure plane decoration. In the process of design, many elements of the main color composition, characteristic patterns, pictographs and characteristic display of the Yi nationality are simplified, refinement and innovation are

closely combined with the space structure and use function of modern architecture, and the traditional culture of the Yi nationality is sublimated into design cultural symbols in every design link.

## (2) Three-dimensional morphology

### Modeling

The bucket-piercing and beam-lifting structures of traditional Yi buildings are used at the entrance. Thus it can be seen that the shape of the piercing bucket is the extraction object of the main shape elements, supplemented by the characteristic shape elements of fire and utensils. Tenons and mortises are fitted with decorative accessories with horns of cattle and sheep to form a complete wooden structure, forming a unique Yi fighting style. Every shape of the Yi people's construction structure has its special meaning, such as the horns of cattle and sheep implying wealth, wine and fire symbolizing a good life. Designers need to convert some concrete elements into abstract elements, which can be used as points, lines and surfaces, and control the rhythm and level among them, so as to achieve the right level. Integrating the materials with strong identification of the Yi nationality into the basic composition of furniture design, so that the space of furniture has both the locality of the Yi nationality and the trend of modern city.

### 2.3 Based on the connotation of spatial accommodation

The spatial effect of natural environment between mountainous areas is the initial source of Yi people's taking vertical space as the main body. In the planar space of settlement distribution, it also reflects the understanding of "coming into being with the tide". There are mainly ancestor worship, totem worship and nature worship of the Yi people, which are linked by family branches. Bimo is the inheritor and disseminator of Yi culture. The social and cultural forms of the Yi nationality embody a strong compatibility with nature, totems, life and death, and people. Every spiritual and cultural element belonging to the Yi people blends with each other in people's lives, such as the persistence of fire, the calmness of life and death, and the respect for nature. The houses and buildings of the Yi nationality are places of spiritual sustenance even in their living space. The furniture design of Yi nationality also needs to embody the balance between multi-dimensions. After distilling the elements of the Yi nationality with strong recognition, the premise of design deduction is created. On this premise, furniture design and integration space can be orderly carried out, so that the space can be created with both abundant Yi culture and humanization.

### 2.4 Respect for Nature

Faced with the environmental problems of globalization, green design should be advocated. The design of Yi furniture advocates the application of new materials and environmental protection materials. The whole life cycle of furniture should ensure that the waste of resources can be reduced.

The materials used in Yi architecture are mostly natural materials, mainly including wood, raw soil, stone and so on. The architectural form is simple and natural, and the internal components of traditional buildings have few or no colors, which fully reflects the aesthetic concept of Liangshan Yi nationality, which regards nature as beauty and plain as beauty. When the production level is poor, the natural environment has many restrictions on Yi people's life. In the harsh environment, it stimulated the Yi people to conform to the natural production, life style and architectural planning methods

## 3. SUSTAINABLE DEVELOPMENT OF YI FURNITURE INDUSTRY

In Xichang and other places, due to the increasing number of middle-class and above Yi families, the requirements for the diversity of Yi special items or products are also raised, such as the Yi wedding celebrations, Yi simple meals, modern Yi furniture in indoor furnishings, and so on.

General Secretary Xi Jinping pointed out at the Central Conference on Poverty Alleviation and Development that "to develop production, to guide and support all people with working ability to create a better tomorrow by their own hands, and to realize poverty alleviation on the spot based on local resources". The characteristics of sustainable development of traditional wooden knot Yi furniture industry are as follows:

### 3.1 Cultural Inheritance

Nowadays, with the globalization of society, sharing resources has created a convenient platform for human beings. Then people begin to pursue their own differentiation, especially the younger generation, which advocates individualization. As a precious wealth with distinct characteristics, ethnical cultural resources should not be buried by the trend of great harmony, but should shine in the new era. Yi furniture not only reposes the emotions of the Yi people, but also can be used as a cultural output to convey spiritual value.

### 3.2 Growing in the Ground

Rising into a well-off stage, the beauty and comfort of living places have been required. On the other hand, Liangshan, as the largest inhabited area of the Yi ethnicity, has broad prospects for tourism development, which has prompted the emergence of supporting facilities in scenic spots, and the emergence of buildings with other functions but ethnical characteristics, such as hotels, restaurants, theatre and other extremely regional characteristics of the building space.

Therefore, there is a huge potential market in the Yi area, whether it is the home-used furniture of the Yi ethnicity or the custom-made furniture of the Yi ethnicity used in specific places. In 2018, Liangshan Prefecture completed the task of housing construction for 112,000 people. In 2019, 120,06,000 people were assigned new relocation tasks, and the preliminary work is being carried out. From “bench project”, “four sets” to “matching production of new rural furniture”, it can be seen that furniture purchase is also an important part of livelihood projects such as new rural construction. Furniture purchasing process is also gradually changing from external purchasing to local production.

### 2.3 Social Promotion

The development of Yi furniture industry can effectively promote the development of traditional excellent handicraft industry in minority areas, promote the prosperity and development of Yi costume industry, help to achieve precise poverty alleviation, poverty alleviation and fortification in Liangshan Yi area, build new Yi villages, eradicate poverty, improve people's livelihood and gradually realize common prosperity.

Consumption upgrading, meeting spiritual needs, life aesthetics guidance. People began to re-focus on the comfort of life, and gradually learned to express their personality through home decoration, which is very obvious in the “post-80s” and “post-90s” consumer groups. The rise of new Chinese style, the popularity of Nordic style home, and so on, all reflect consumers' rational pursuit of a higher quality of life.

## 4. CONCLUSION

Furniture, as a carrier, connects time, environment and culture, which is regional and contemporary. All the discussions hope that the Yi furniture design can highly respect the cultural tradition and play a positive role in the present and future social development. According to the industrial design process through the concept of the design concept and design methods to demonstrate, so summarize the design principles of the Yi family. Let the existing furniture design work be more standardized, and make a preliminary exploration for the future design practice. The purpose is to make the Yi furniture products reasonably and effectively used in production and sustainable development of the Yi furniture industry.

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## **DESIGN FOR SUSTAINABILITY AND ICT: A HOUSEHOLD PROTOTYPE FOR WASTE WATER RECYCLING**

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### **ABSTRACT**

ICT can play a role in environment preservation, to face degradation of the ecosystem, and innovation, to satisfy emerging needs. This research focuses on experimental application of interaction design methodologies and digital technologies to foster the transition towards sustainability in the framework of a wider interdisciplinary research about the development of a system for recycling water at home to grow edible plants.

An iterative design process, articulated in prototyping-evaluating-improving cycles, has been implemented, with the involvement of different stakeholders, to develop the interaction system applied to manage waste water and information flows needed to control water decontamination, plant irrigation and lighting. The paper reports the main features of the system and the main outcomes of the user studies.

Key Words: Interaction Design, Internet of Things, User Centred Design, Environmental design.

## 1. INTRODUCTION

The paper presents a research project aimed to experiment the application of interaction design methodologies and digital technologies to foster the transition toward sustainability. To this purpose, we developed an interactive prototype based on a domestic water recycling system drawn up with life science experts. The system consists of a dishwasher integrated with an indoor planting device, where the wastewater is treated to make it available for the cultivation of vegetables or for the reuse in following washing cycles (Costa, 2018).

The potential of ICT is exploited in an ecosystem approach, overcoming the current application, often reduced to the restyling of old-fashioned products. In fact, a new user centred interactive product typology is designed to create a living space fulfilling the requests of a society focused on environmental needs and quality of life.

This new product will stimulate the development of healthier eating behaviours in users. In fact, the in situ production of edible plants will increase their contribution to the diet, reducing simultaneously the environmental impact due to the transport of food, produced and marketed in a standard way (Bhamra, 2008). In addition to aesthetic perception and indoor air purification, broader sustainability is achieved in a circular economy meaning, since what is left from an application (washing water) will become a resource for another (irrigation).

## 2. RESEARCH BACKGROUND

The theoretical background of the presented research is manifold comprehending natural science, socio-cultural matters and technological issues.

Zero-mile food production is gaining popularity worldwide. Beside healthy eating habits trends, this renewed interest is due also to the environmental benefits it can provide. These benefits include increased urban and architectural greening, reduction of food transport, and recycling of nutrient in wastewater. Innovative forms of green urban architecture include rooftop gardens, rooftop greenhouses, indoor farms, and other building-related forms, defined as “ZFarming” (Walk, 2014). Domestic Wastewater streams are often nutrient-rich, and urban agriculture could absorb these nutrients and has historically done so. However, the reuse of kitchen wastewater is no more practiced in modern society despite the high nutrient content and the low presence of pathogens, heavy metals and pharmaceuticals. The integration of domestic edible plants production in homes with the exploiting of kitchen wastewater for irrigation represents a promising strategy to reduce water consumption in households, to decrease the amount of wastewater to discharge, to produce healthy plant food and to enhances the environmental awareness of citizens.

Regarding socio-technical aspects, the success of the system relies on customer acceptance. As Norman states, technological innovation is simple; on the contrary, social, cultural and organizational changes are difficult. To this end, household appliances must turn into “info-appliances” to support users controlling energy and water consumption (Norman, 1999). According to User Center Design guidelines, involving the end-user in all phases of the design process, from the requirement analysis to final evaluation, is needed to achieve a high level of usability efficiency and pleasantness.

Following an Interaction Design approach, the development of innovative product/services requires user studies since the very first phases of the design process (Benion, 2013), so to orient the design toward a solution capable to produce value and satisfaction. The investigation of the context is even more important in the creation of solutions for the domestic environment, since most people see home as a personal territory, a place of intimacy, wellbeing, safety, and expression of self (Pillan, 2017). Authors such as Claire Rowland (Rowland, 2015), introduce four different ways to look at a context: operational, behavioral, ecological, and socio-cultural. The operational context refers to the characteristics of the physical world where the product/service will be located (thermal factors, presence of wet/dust, spatial arrangements, ...). The behavioral context includes time and space factors related to the interactions of users with the product itself and its surroundings. The sociocultural factors are related to the motivations, expectations, value, psychological and relational needs of users. Finally, the ecological context concerns the products ecosystem and involves the organization model between stakeholders related to the solution, also including the economical and transactional factors. For this reason, the research presented in this paper includes several activities aimed at investigating attitudes, needs, expectations and constraints of users, with respect to planting at home, reuse water and to the availability of adopt such a system.

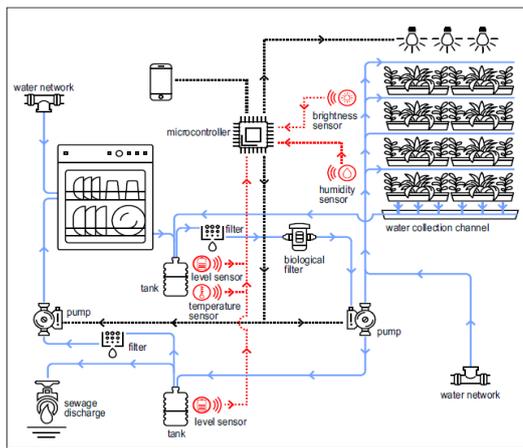
## 3. SYSTEM DESCRIPTION

The system represented in Fig.1 consists of a dishwasher integrated with an indoor planting device, to recycle wastewater from dishwasher for two parallel purposes: (i) making available the organic nutrients present in waste water for the cultivation of vegetables in home environment; (ii) reusing the recycled water for following washing cycles.

Wastewater is treated by a biological filtration, taking advantage of bioremediation techniques: selected algae and microorganisms mineralize nutrients from the wastewater, enriching the filtered effluent, ‘fertilizing’ water and, therefore, supporting zero-mile plant cultivation.

IoT technologies are applied to support the interactions between user, functions and surrounding environment.

An experimental in balance prototype as shown in Fig.2 was built considering: a) the mean Italian dishwasher uses around 4 times a week; b) the amount of wastewater discharged, approximately 12 lt. per washing cycle; c) the daily water consumption per plant, around 40 ml for salad.



[Figure 1] System



[Figure 2] Prototype

#### 4. RESEARCH METHOD

The methodological process consisted in 6 main steps.

At the beginning, we conducted benchmarking through an internet-based research using key-words (such as: green wall, growing plants appliance, cultivation system indoor, green kitchen) and performed field-research during Eurocucina, Milan Design Week 2018.

A mixed methodology, including secondary analysis of quantitative data and focus groups with consumers and stakeholders, has been applied to understand consumer habits regarding water recycling, home cultivation and eating preferences.

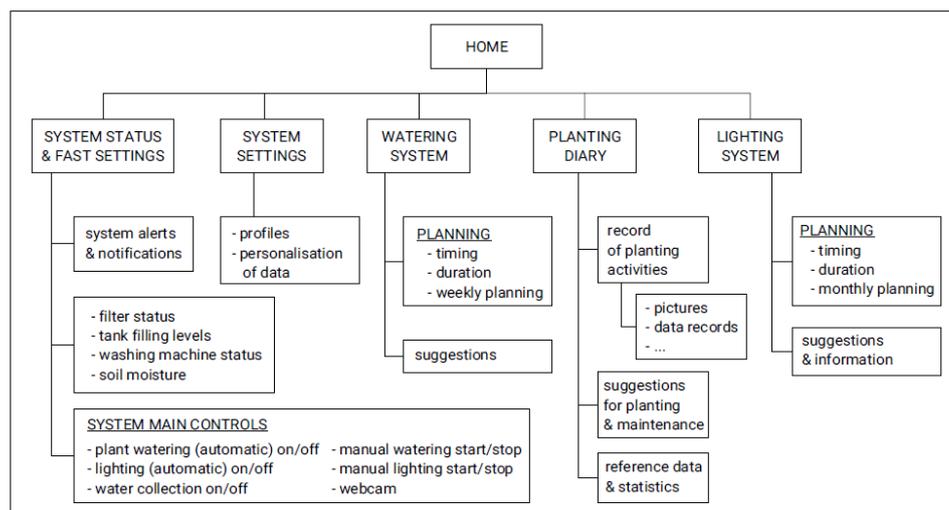
On the base of the results of the previous steps and the biological experimentation, that was conducted in parallel, we organised a co-design workshop to generate the system concept.

The final user interface was developed according to the workflow represented in Fig. 3.

An experimental prototype was then built to test plants growth and interaction modalities through an iterative process, articulated in prototyping-evaluation-modification cycles, with the collaboration among different professionals and the involvement of expert users.

The collaborative development of the interaction system is in progress thanks to the use of software and prototyping platforms such as MIT App Inventor and Arduino.

User trials are planned to test the prototype's interface usability.



WORKFLOW OF THE FINAL USER INTERFACE FOR SYSTEM CONTROL

[Figure 3] Workflow of the final user interface for system control

#### 5. USER NEEDS

People representative of possible final users have been involved up to now through a questionnaire, a focus group and interviews to investigate attitudes and opinions about the system. The research involved people, of different age and personal disposition toward environment issues, none of which had a preliminary knowledge of the concept.

The focus-group (7 people), reported the motivation of users toward a better use of water and a diffused awareness of the advantages of using domestic appliances selecting the ecological program. The core phase of the focus-group was based on the presentation of the concept with the support of some images reporting the scheme of the system and the experimental apparatus. The impact of the presentation was positive, and it created a fertile conversation between the participants about potential and critical factors of the concept. We schematically condense the outcomes in terms of critical, positive features and other relevant issues.

To begin with criticalities, the discussion evidenced space constraints (dimensions, encumbrance and positioning); maintenance and hygiene (management of leaves and organic wastes, insects, smells); safety regarding breakdown of the electric or water system and risks related to behaviors (as an instance, kids climbing on the plant-shelf); consumptions and economic impact (initial costs, consumption of electricity for lighting and for feeding the watering system).

The list of positive factors includes elements of gratification related to the adoption of behaviors giving a convenient contribution to environmental issues; the pleasure of gardening at home; availability of pot herbs; the flexibility of the system with respect to different uses of recycled water; the opportunity to distribute the components of the system (e.g. locating the planting shelter out of the kitchen); the symbolic impact of hosting the system at home.

The focus-group revealed also a trusty attitude of users toward recycled water: while the research team is paying much attention on the possible impacts on health and is dedicating several research activities to the monitoring of the quality of the veggies, users showed a positive attitude with respect to the safety of the process and positive expectations about the impacts of plant facilities in domestic environments. Users consider positively the requirement of using only eco-friendly detergents.

Target interviews with professionals were dedicated to the discussion of technical and maintenance requirements of the system and to its potentials with respect to other contexts, such as restaurants and canteens.

The conversation with users pointed out also the importance of a suitable communication apt to better explain the potentials and the 'reasons why' of the system: while the attitudes of the people involved in the survey showed interest and curiosity, it is also evident that innovation as such is not considered as a value in its own, and it is important to accompany the development of the new domestic solution with a broad conversation about its potentials and criticalities. This result is of general importance and it is coherent with a general principle of Interaction Design, i.e. that innovation requires social engagement to discuss the impacts and verify consensus. (Erwin, 2013).

## 6. CONCLUSIONS AND FUTURE DEVELOPMENTS

The experimental development of the integrated system reported in this paper was conducted following a research method based on a design driven creation of a scenario and concept that were shared with the project partners since the very first phases of the concept generation, through the design/experiment cycles, so to enable co-design and progressive improvements based on independent contributions of researchers from different disciplines and collection of hints from potential users. The research is still going on and the next steps will focus on the iterative prototyping and refinements of the digital interfaces for control, on the investigation of the quality of the final organic products and on the technical characteristics of the system.

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## OPEN-ENDED DESIGN. LOCAL RE-APPROPRIATIONS THROUGH IMPERFECTION

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### ABSTRACT

Design for Sustainability (DfS) focuses on wicked problems that cannot be modelled in reductionist ways. Furthermore, when bottom-up local interventions prove to have positive effects in their context, they remain hard to spread and might face failure if transferred the other contexts. Here, a researchthrough-design approach is presented for highlighting a new paradigm, that questions the very nature of both design process and outcomes. Specifically, Open-ended Design (OeD) is introduced pursuing the creation of unfinished and ever-evolving outcomes (imperfect by intention), embracing the out-ofcontrol local instances. In this approach balance between openness and over-design is sought, to facilitate both the global diffusion of design outcomes and their local re-appropriation. The aim of the research is to highlight existing connections between OeD and DfS, listing its values and limitations through some reported cases. In conclusion, designers might start designing for emergent aspects of the designed solutions, supporting multiple local re-appropriations.

Key Words: Open-ended Design, Re-appropriation, Design for Sustainability, Design for Change.

## 1. INTRODUCTION

Nowadays, Sustainability for All is one of the most crucial global goals and it encompasses a broad variety of sub-goals (often referred to as “Sustainable Development Goals” drafted by the United Nations). These sub-goals reach full potential when seen as a unity, in their interconnectedness and as parts of the broader ecosystem within which we live and design. Furthermore, Design for Sustainability (DfS) can be seen as the broad set of design-driven activities that help the transition to more sustainable futures, by challenging very complex problems (Bhamra & Loft-house, 2016; Ceschin& Gaziulusoy, 2016; Vezzoli, 2018). These problems have been defined as “wicked”, meaning problems that cannot be solved and not even represented (or modelled) in reductionist ways or adopting linear causality (Rittel & Webber, 1973). At the same time, the expression “Sustainability for All” strongly resemble the widely spread expression “Design for All”, being a design for “human diversity, social inclusion and equality” (EIDD Stockholm Declaration, 2004). One of the potential threats underlying these approaches comes from the engagement with terms as “all” or “universal”, this conflicts with the widely recognized need to “think globally, act locally”. In fact, even if the concept of “appropriate alternatives” as contrary to providing a single solution for everyone is clear in the Design for All movement, it is not always clear how this is implemented in the design outcome, especially when produced for high volumes of production that intrinsically require some standardization (Ostuzzi, Rognoli, Saldien, & Levi, 2015)(De Couvreur & Goossens, 2011). Sustainable solutions are far from being universal, or definitive. On the contrary, once agreed on recognizing sustainability related problems as wicked problems, it becomes important to embrace the impossibility of limiting our interventions to “ultimate tests”. Many explanations for the same problem can be found, and the problems themselves should be recognized in their dynamic and context-dependent nature. A definition that includes some of these perspectives is SLOC (Manzini, 2010) for which design interventions for sustainability should be Small, Local, Open and Connected.

In this paper, it is the authors’ intention to describe Open-ended Design (Ostuzzi, De Couvreur, Detand, & Saldien, 2017), as an approach that can possibly inform designers in their Design for Sustainability practices specifically by framing the creation of unfinished and ever-evolving outcomes (imperfect by intention). The Open-ended Designed outcomes are in fact intentionally balancing openness and over-design, Design for All and Design for One, in order to facilitate both global diffusion and local re-appropriations of the design outcomes. In the text, existing connections between OeD and DfS are highlighted and underpinned both by theoretical considerations and practice-based pieces of evidence. The main value of the proposed paper lays in the act of questioning the very nature of the design process and outcomes, suggesting a change in perspective and roles both in the use-context and in the design-context.

## 2. STATE OF THE ART

To frame the topic, it is necessary to outline the state of the art of research in this field. The two basic points are: 1) the dominant design paradigms and (2) change in design as spontaneous process.

### 2.1. Design paradigms

Consumption patterns across the industrialized world, such as the tendency towards accumulation, hyper-consumerism and throwaway dynamics became dominant, causing drastic environmental repercussions (Cooper, 2010) (“Annual Report on Sustainable Development Work in the OECD”, 2008).Also, it has been recognized that most of these impacts are defined since the design phase (Thackara,2005), putting the role of the designer in strong connection with the need for a more sustainable development, defined as a development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland 1987, p. 13). It is essential to focus on two main aspects of this definition: the future perspective and the diversity of needs (their own needs). In this Section, two diametrically opposed approaches to design and Design for Sustainability are introduced: the general (or universal, ideal, standard, for all)approach and the local (or contextual, idiosyncratic, unique, for one) approach, both represented in Figure 1. Design goes then beyond the creation and modification of the arti-

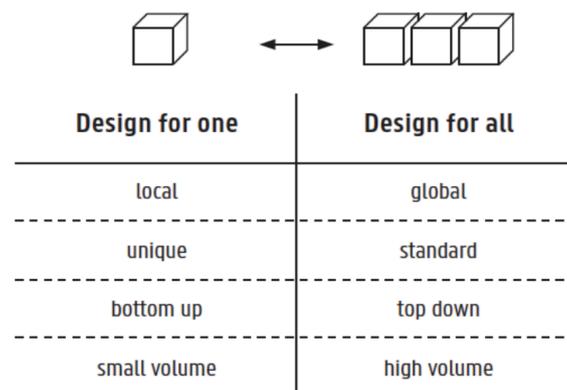


Figure 1 Design outcomes: Design for one as opposed to Design for All

<sup>1</sup> <https://www.un.org/sustainabledevelopment/sustainable-development-goals/>

ficial aspects of the world since it ultimately deals with social organizations and patterns of human interactions (Nelson, 1994). This transition can be supported by engaging with participatory design in combination with an open process where small local activities operate while keeping in mind a more global vision (Manzini & Rizzo, 2011; Manzini, 2010). This transition can be supported by the current digital revolution, that builds upon networked society with increased trust in sharing dynamics, diffusion of creativity and production capabilities. In other words, radical social and technological innovations where resources (creativity, knowledge, etc.) are shared.

Nevertheless, spreading relevant design solutions is not easy since this process strongly relies on the kind of design outcome we are facing. For example, in the case of more universal solutions (Design for All), also definable as top-down solutions, difficulties might be encountered during adoption and use phases. In fact, the product may face non-acceptance in the real environment because of loss of the “intentional” (from the designers’ point of view) initial value: or it may happen that users’ behaviors escalate, generating the phenomenon of the rebound effect. Examples could be One Laptop Per Child(wiki.olpc.org), and Nonfuture (designthatmatters.org/nonfuture). In the case of specific solutions (Design for One), also definable as bottom-up solutions, difficulties can be found while up-scaling them to solve globally diffused problems. Examples could be provided by very context-dependent and local projects, as Design for Every(one) (designforeveryone.howest.be), and the Eye Writer (eyewriter.org). In this study, we recognized as one of the core issues in this process of diffusion the hard conversations between global and local spheres. In synthesis, it is difficult for the context of use to change the designed outcomes in accordance to specific and contextual needs.

### 2.2. Change in design as spontaneous process

Being part of reality, products (also artificial ones) are dynamic entities, as well as dynamic is our perception of them. Specifically, when products move from the “design space”, where they are thought to be and enter in contact with the “real environment”, they spontaneously start changing (Nelson & Stolterman, 2012; Wakkary & Maestri, 2008). In fact, in the design space, they are strongly subjected to the abstract conceptualization of the designers -they are under-control and ideal, while in the real environment they are strongly interwoven with the coordinates of space and time becoming subject to the messiness of life, out-of-control and real. Products’ attributes often emerge (both implying material changes and change in meanings), becoming the local and “ultimate particular” expressions of the initial abstract intention of the designer (Rognoli & Karana, 2014; Bridgens & Lilley, 2017; Lilley et al., 2019). The changes occurring in the designed outcomes are not always predicted, or even predictable, by the designer. Therefore, design space and real environment, appear as distant and profoundly different. This perception is well spread among the scientific community (Hermans, 2014; Risdiyono & Koomsap, 2011; van der Bijl-Brouwer & van der Voort, 2014;

G. Fischer, Giaccardi, Ye, et al., 2004). A simplified list of possible dichotomies used to distinguish the design space from the real environment has been provided in Figure 2.

Design space	Real environment
abstract	concrete
standard	unique
stable	dynamic
true	real
proximal	distant
under control	out of control
simple	complex
use through design	use through use

Figure 2 Possible dichotomies used to distinguish the design space from the real environment

The design space is proximal and under control, while the real environment is distant and out-of-control. The design space aims at simplifying and recognizing problems as tame, while the real environment is complex and characterized by wicked problems (Rittel, 1972; Buchanan, 1992). The design space defines use in the “design time”, through design (designing for use before use), and the real environment defines use through use, in the “use time”, better defined as “design after design time” – since it doesn’t only refer to the use stage, but also production, distribution, end of life, etc. (Ehn, 2008; Bjorgvinsson, 2008; Redstrom, 2008). But, if we identify change as a spontaneous process, why, then, do we tend as designers to think of our products as stable entities? Why do we often design gathering information from abstract constructions of a specific situation, or controlled environments, more similar to laboratories than reality?

### 3. OPEN-ENDED DESIGN AND DESIGN FOR SUSTAINABILITY

Open-ended Design has been seen as a possible method to intentionally suggest out-of-control conversations (Ostuzzi, 2018). It starts from the recognition that participatory design works with identifiable users (Ehn, 2008), or stakeholders, at a precise moment, while the final products will be addressing – of course – to more users, stakeholders, ecologies, at different moments in time (Bjorgvinsson, 2008). This way, the unexpected part of the desiderata, a more honest conversation intime, and potential subversion of non-intentional appropriations might be lost (Dix, 2007). Different methods are then needed to engage with reality in its messy dynamic, in which design becomes “not a matter of getting rid of the emergent, but rather of including it and making it an opportunity for more creative and more adequate solutions to problems” (Gerhard Fischer & Giaccardi, 2006). It can be done only by observing reality and anticipating, or foregrounding, it. The term anticipation is different from prediction, and it is used to highlight the conscious not knowing of the designer (Nelson, 1987).

Open-ended Design has been defined as “An Open-ended Design (OeD) is seen as a project able to change, according to the dynamic and changing context. Open-ended Design, can also be defined as suboptimal, error-friendly (Manzini, 2010), unfinished, Wabi Sabi (Juniper, 2011) contextual, context-dependent and is characterized by its inherent flexibility due to the incomplete voluntary definition of its features, also defined as its Imperfection.” In other words, it suggests a paradigm shift where products become themselves becomes learning objects and, in this perspective, they share characteristics with prototypes (Bjorgvinsson, 2008)(Ehn, 2008), definable as prototypes-in-context. In this way, the design outcome is intentionally done to be changed and re-appropriated, becoming a suggestion for action and call for participation.

#### 3.1. Description of cases studies

In this paper, we decided to report on two cases that meaningfully show intentional engagements with Open-ended Design outcomes, meaning outcomes that are made to be changed through outof-control conversations. The cases are (1) the collaborative development of Mycelium-based Materials, specifically by the Belgian cooperative GLIMPS (glimps.bio, biofabforum.org) and (2) the project Incremental House by the Chilean Architecture studio Elemental (elementalchile.cl).

Mycelium-based materials are the result of the convergence of both experimental and applicative research in combining living biological systems with materials science in order to produce new circular and sustainable materials from biological resources. Mycelium-materials are characterized by a low tech and slow process, which is respectful of the natural rhythm of growing. One uncommon feature of the material is that it can be grown in a mound, which allows designers to grow the mycelium directly into the shape of the final object (Parisi et al., 2016; Parisi & Rognoli, 2017). Thanks to its unique structure and composition it is expected a significant diffusion of materials based on mycelium (Karana et al., 2018). Furthermore, the process -as it is for now, in the DIY scale-takes advantage of out-of-control process instances, generating every time products that are unique and beautifully imperfect.

What is of great interest of this family of materials and the way they have been addresses by some research streams is the clear challenge they pose to traditional industrial paradigms. In the Bio Fab Forum, we can read “The research approach is community-based and uses an online forum (www.biofabforum.org) for knowledge sharing with the commons. It includes action-oriented and material-based research which is probabilistic, explorative and shaped by its local context. While most experiments on the open-platform are not always scientifically reproducible, they embody a valuable set of psychogeography possibilities for the re-appropriation of matter. (...) Furthermore, the collaborative and non-competitive engagements regularly form new ‘out-of-control’ information, which creates fertile and fluctuating spaces between disciplines, the people, and their relationships. As such, the approach is based on two main concepts: non-competitive dynamics and closed-loop dynamics.”

Incremental Houses is a project for people who lost their own house during an earthquake in Chile. This house is not finished, while the entire structure is visible, and half of the volume is completely built, the second half is still empty. To finish the house, the occupant has to take an action, to reappropriate the void. In this way every house becomes personal and different from the other surrounding ones. The house, that started as identical to many others, becomes personal and addresses the aesthetic and functional needs of the occupant. The local re-appropriations of this house can be seen in Figure 3.



[Figure 3] The same house becomes many houses: Open-ended Design through unfinished products

#### 4. DISCUSSION

Throughout the research around Open-ended Design, several examples have been collected<sup>1</sup> (Ostuzzi, 2018). These examples share the capability of being able to change meaningfully according to the contextual needs and wishes. Furthermore, their ability to change is the result of an intentional act from the designers' side, who decides to engage with out-of-control instances that might merge thought out the whole life cycle, as well being activated by human and non-human stakeholders. It has been claimed that these characteristics are typical also of design solutions meant for sustainability, being fundamental for these solutions to keep their local and dynamic nature. It has been decided to report on only two cases, selected based on their different characters and reach, hoping to trigger a quick glimpse inside the whole broad framework for OeD. On the one hand, mycelium-based materials show the possibilities of out-of-control production processes, where each product results as unique. They also vanish at the end-of-life, meaning that they can be fully integrated back in the eco-system, and even they can be grown locally and in a small volume, and to assure that a broad community of designers and researchers is providing easy-to-use and re-appropriate knowledge. On the other hand, we have the example of Incremental House which is a project made to be changed by the user (defining use through use, Redstrom, 2008), to achieve a unique outcome and triggering higher emotional bonds. Finally, this paper is essentially explorative, and it aims including the accepted complexity of Sustainability for All challenges into our designed outcomes, through imperfection. Therefore, by sketching the link between Sustainability for All and Open-ended Design, an approach firstly emerged within the assistive technology field, the authors intend to stimulate the reflection around the necessity of engaging in out-of-control and imperfect outcomes to improve re-appropriation, that is understanding, copying and modifications on the original, core project (Ostuzzi et al., 2016).

#### 5. CONCLUSION

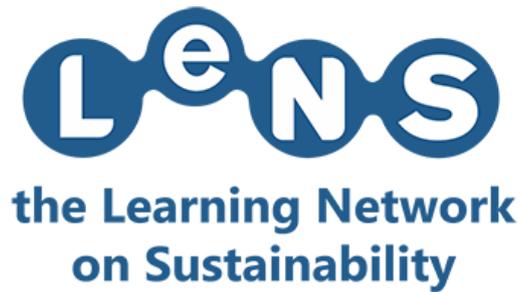
Sustainability for All is one of the most crucial global goals. It challenges very complex problems that are diverse and strongly interconnected, globally diffused and differentiate in time, depending on the specific context from where they emerge. In this paper an attempt has been done in order to connect the Open-ended Design approach with a broader Design for Sustainability one. In fact, Open-ended Design intentionally seeks for a better balance between unfinished and over-design, opening-up space for local (in space and time) re-appropriations of the designed outcomes. In this way, a mutual conversation is suggested. On the one hand, designers lose control on their designed outcome and suggest participative actions needed to "finish" the design process itself, while on the other hand, the use-context can participate to the creation of the emergent qualities of the design outcome. In this shift of perspective, Open-ended Design does not aim at solving the problem, but rather becomes a prototype-in-context aiming at lowering the barriers for re-appropriation and facilitating the steps towards action from all stakeholders' sides. Finally, it suggests a shift from a Design Sustainability for All to a Design Sustainability for Every(one) goal (cfr De Couvreur, 2011) where each stakeholder (human and non-human) is asked to take part of a common conversation for more sustainable futures.

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#### **IBIS PROJECT: THE INNOVATIVE, SUSTAINABLE AND INTEGRATED BUS**

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#### **ABSTRACT**

The paper presents the results of studies on sustainable mobility, conducted by a multidisciplinary research group. The aim of the activity is to design and assemble a totally modular and innovative bus. This vehicle, designed for sustainable mobility in Italian cities and sites of monumental artistic interest, is equipped with the latest generation of electric motors and batteries. It will therefore be made with environmentally friendly materials. The project aligns with the most recent European research lines on the theme “Building an integrated intelligent transport system”. The methodological approach used is oriented towards the creation of a “collaborative ecosystem” between researchers and companies for the definition of a working prototype. The work is in line with the European guide on eco-sustainability of products, the reduction of pollution in urban centers and the so-called “circular economy” that minimizes the risk of non-recyclable waste. The project includes the main specialized multidisciplinary sectors.

Key Words: modularity, sustainability, recyclability, versatility.

## 1. INTRODUCTION

In recent years there have been numerous specialized contributions offered by research related to the sustainable mobility sector that have proposed new models oriented towards the environment, aimed at experimenting with solutions and operational methods with the aim of “rethinking sustainable mobility”. This orientation is always impregnated by an innovative perspective, which tends to “contextualize” the approach, adapting it to the state of the art of urban infrastructures and to the requirements indicated by current environmental policies.

At the same time, inexorably, the harmful effects caused to the indiscriminate use of resources to the environment have shown the limits of the previous model of industrial development linked to the logic of the exploitation of non-renewable energy sources. Consequently, this approach has had a negative impact on the socio-economic development of the industry and, in particular, on the automotive sector. In this scenario, it is crucial for the automotive industry to identify a new and more coherent motivation that combines new mobility needs with sustainable design and production practices (Vezzoli, 2014).

This orientation, unfortunately, is not completely exhaustive for the definitive implementation of sustainable mobility models, as it would require a fundamental revision of the approach that has been maintained until now, integrating the different “actors” participating in the new sustainable approach, with the current urban infrastructure system that is not yet adequate. In fact, it is evident that the seniority of urban infrastructures (roads, parking lots, pedestrian zones) does not allow the ecological “mobility manager” to benefit from all the sustainable options defined in the design, production and use of means of transport. Therefore, when approaching sustainable mobility, it will be essential not only to pay the utmost attention to the “green” characteristics of power trains and energy accumulators, but, above all, to operate with the greatest consistency of strategic and planning options in a more complex and integrated mobility system which also includes the various alternative modes of transport. In the last two years, a great driving force has been given by the promulgation of a decree that has significantly opened the legislative horizon on ecological prospects at the same level as those of other European countries and in particular: the legislative decree of 16 December 2016, n° 257, specialized in the creation of an alternative fuels infrastructure, with entry into force of the law starting from 14/01/2017.

## 2. ITALIAN SCENARIO OF SUSTAINABLE MOBILITY

With reference to the mobility scenario (road transport) of our country, of particular interest is the statistical data emerged on the report prepared by the “Centro Studi Isfort” (Higher Institute of Training and Research for Transport). The results emerged from the analysis of data with reference to passenger transport, describe how the movements of Italians are decreasing in percentage, despite the increase in the use of private cars to the detriment of public transport and therefore as a result of the environment. In the biennium 2017/18 Italians have spent over 40 million hours traveling for their travels. According to the Isfort report, in the last 15 years, overall mobility demand in Italy contracted by 15.2% and even the total number of passenger-kilometers decreased by 23.9% (from 1,561 to 1,188 million passengers at km 2016). Mobility has also been reduced due to the effects of the crisis, but the share of transport on private vehicles has increased. Regarding the modal split, the data of the first survey 2018 indicate a further increase in the weight of active mobility of about one and a half points compared to 2017 (about 23% by bike, 6% by bike). The share of the motorcycle also increased (from 3% to 4%), while public transport remained stable at around 11%. The expectation is therefore that the modal split of 2018 will be in line with that of 2017, with a possible further consolidation of the modal share of low impact vehicles.

To this not encouraging scenario we must add the lack of structural interventions in terms of construction of adequate infrastructure and production of new ecological vehicles, in order to contribute to making the park bus less and less old and inefficient from an environmental and travel comfort point of view of sight. The option for public transport is clearly confirmed as the preferred choice of citizens: 94% of respondents consider it useful to “improve and improve public transport services” and of these over half (57% of the total) evaluate this action “absolutely priority”. Only 6% of respondents are considered a data considered not useful. For the next decade, new implementation methods will be envisaged for the renewal of the bus fleet; in fact, the government has announced new government offers with the latest stability law for the supply of vehicles for passenger transport. The data previously described highlight the need to operate on the aging of the circulating “vehicle fleet”; according to the ANFIA (National Association of Automotive Industry Factories) elaborations on the data of the Transport Archive of the Ministry of Transport, the bus market by type is as follows: 1.547 buses (+ 14.3% on 2014), 124 minibuses (+ 9, 7%) 487 minibuses (+ 39.5%) and finally the 262 school buses (-21%). Another significant figure is represented by the ecological share represented by “green” vehicles; out of 2,420 new registrations, the electric traction buses sold were only 35 and those with natural gas 92, representing therefore only 5.2% of the total. As already highlighted, it is not easy to find a more effective and efficient model of sustainable mobility that characterizes the carriers for the public/private passenger transport service, since the innovative solutions for the infrastructures and services connected to them are not always integrated with each other. A research report provided by the E-Mobility Report of the Milan Polytechnic<sup>1</sup> underlined that in 2017 in Italy there are only 2750 public places used to recharge electric vehicles, on

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<sup>1</sup>Digital Energy Report: Smart Cities and Digital Energy in Italy: an overview of light and shadow Presentation Digital Energy Report February 14th 2019

the national territory and just fewer than 10 thousand private columns used for the same purpose.

Comparing the previous numerical values with the data collected with reference to the upgrading of the Italian infrastructural network, it should be noted that these numbers are totally inadequate compared to the quantity of electric car charging stations present on average in the European territory; in particular in Europe, they would be 80% more than in Italy. However, these values, albeit small, showed a significant growth trend as the installations of “green” infrastructures, such as public recharging points, increased in total by about one thousand units in the course of 2018. The data collected express the nature of infrastructural deficiency, highlighting that the number of electric car columns in Italy compared to that of other European countries is 1/5 and 1/10.

As reported in the work of Köhler et al., in addition to the implementation of integrated systems and infrastructure for sustainable vehicles, the impact of transport on the environment, to implement a transition to sustainable mobility requires their change of “lifestyle”, “the model shows that technological transitions are more likely: the transitions of lifestyle change require sustained environmental pressure on society and behavioral changes by consumers” (Köhler et al., 2009). Awareness that the individual levels are able to work in synergy between the different strategic levels of action: legislative, production and use of carriers the dissemination of intangible transport services shows that the communities are willing to experiment with new models of public transport shared in the active participation in the choice of vehicles for mobility (Vergragt, Brown, 2007). The data collected in the last two years 2017/2018 in which the reports on climate analysis refer to the 28 EU Member States show that around 31% of greenhouse gases and a similar percentage of carbon dioxide emissions, as well as a significant rate attributable to urban air and noise pollution, they are linked to transport and mobility. These European values demonstrate how the European transport system has not been able to operate independently the reduction of its “environmental weight” on the global economy, in terms of environmental protection and protection of the health of the inhabitants of urban and extra-urban areas.

The statistical trend shows an exponential increase in emissions, and more significantly in the last period due to surveys conducted in 1990 and 2018, in which the record values of greenhouse gas emissions were recorded due to public transport and private. Wanting to segment the distribution of pollutants, it emerges that 73% of the greenhouse gas emissions produced by transport are referred to road transport, with this distribution in the distribution between carriers: private transport is with 65% of total emissions of harmful gases the main “pollutants”, heavy vehicles for the transport of goods and buses are “responsible” for 20% of harmful emissions and finally the commercial vehicles used in urban distribution the remaining 15%.

On the basis of data provided by the European Environment Agency (EEA), the 1990-2018 figures for the European Union are worrying, in which the polluting weight caused by the road transport sector increases emissions from around 125 millions of tons of carbon dioxide CO<sub>2</sub>. Even in the road transport sector, the large car manufacturers have invested on average a part of their turnover in research and development at the European level with a value of around 5%. In addition, the European Environment Agency highlighted important signs towards clean and intelligent mobility with 26% of total investments in research and innovation in Europe, based on the European Commission data estimates of 2018. It will therefore be necessary to apply new strategies for the transport sector, and in particular it would be appropriate to pursue those linked to the “modal shift”, that means an inversion of the route that leads to the transfer of the demand for mobility, from means of transport, more polluting to those less polluting. The modal distribution in transport, the “green” technologies will demonstrate a virtuous path able to combine the ever-increasing need for travel with a diversified type of transport in the perspective of sustainable mobility (Vezzoli et al., 2009).

The new urban vectors configured as “service platforms”, may be characterized by greater specific typological diversification in the optimization of uses such as electric, hybrid and low-emission buses, characterized by a technological renewal of the engines, with a view to energy efficiency, passenger safety and environmental sustainability (Vezzoli et al., 2014).

### 3. A MODEL OF SUSTAINABLE MOBILITY: THE IBIS CASE

In this scenario we insert our research and experimentation contribution focused on the objective of designing and building an “eco-oriented” bus as a product/system for urban passenger mobility to be carried out in the historic centers of our cities. The project proposal of the vehicle “IBIS”, Innovative Bus, Integrated and Sustainable<sup>2</sup> is based on the concept of an innovative urban bus design and production platform. The goal is to provide a means of transport for sustainable, collective and competitive urban mobility. The approach used in the research has made possible a design and production process, which had the objective of maximizing the benefits, environmental and economic linked to the industrial development of the carrier (Verganti, R., (2009). The research and experimentation project focuses on the following areas of research and experimentation:

- Definition of functional and morphological aspects of the main vehicle components;

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<sup>1</sup> Polytechnic University of Milan.

<sup>2</sup> Project “Innovative Bus Integrated and Sustainable” - IBIS-PON I & C 2014-2020 “, (03/04 / 2017-31 / 12/2018), funded by the Ministry of Economic Development - (project budget: 3 million euro, budget Local: 317 k €) Scientific Coordination P. Ranzo, R. Veneziano, F. Fittipaldi postdoc reaserch.

- Study of the frame module, body panels, interior coverings and furnishings;
- Study of eco-oriented materials to be selected for vehicle components;
- Analysis of the assembly and disassembly methods of the components;
- Study of propulsion and power supply solutions (engines, batteries, on-board electronics);
- Definition of production technologies for the optimization of the production cycle.

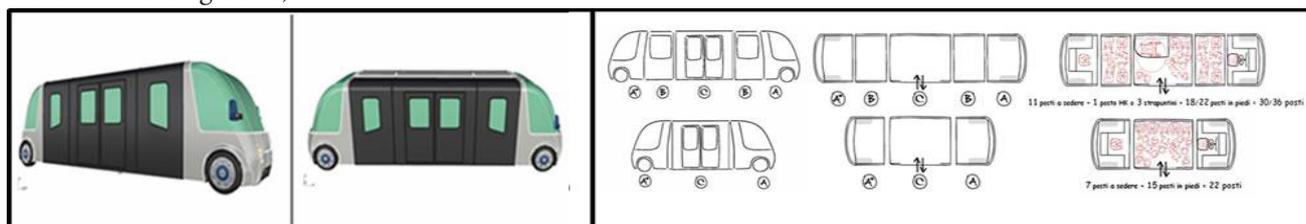
Particular attention was paid to the definition of an abacus of eco-oriented materials for the realization of the components and the internal and external finish of the vehicle. The design of particular devices (body panels) and their functional parts (interior panels, roof pavilions and finishing elements) has been integrated into the experimentation of a polymer matrix material with appropriate structural reinforcements, oriented in the directions of maximum mechanical stress, which confer strength and rigidity / rigidity in specific points. This part of the research, conducted by the Institute of Polymers, Composites and Biomaterials (IPCB) of the National Research Council (CNR) of Naples, concerned the engineering of polymeric and cellulose materials and thermoplastic polymers based, treated with traditional methods (manual lamination/stacking, molding, compression molding) and Nano composites with specific mechanical characteristics and eco-oriented properties.

### 3.1. THE MODULAR STRUCTURE AND THE PRODUCTION PLATFORM

The IBIS project is structured around the concept of an evolved modular platform and consists of sub-modules that aggregate, making possible different functional configurations of the bus, optimization of production processes and materials used. The approach to this operating model is not unpublished in the automotive panorama as it was developed following the economic crisis of the eighties by US and European car manufacturers. In particular, this methodological/operational approach was tested and implemented, following the adoption of practices of the “lean product development”, particularly in Japan, where they have increased the use of outsourcing, transferring to the development of suppliers an increasing number of components.

This trend has increased interest in modularity as a tool to facilitate the integration of external sources of innovation; Specifically, a series of advantages is evident in the development of a standard platform that can be used for various vehicle models such as: benefits of economies of scale, instead of the development and production of different platforms; acceleration of the production process and development of new models and finally a better use of production capacity and flexibility to respond to changing market dynamics. In the automotive sector, the standardization of the “module” concept is intended as a re-proposition in the compositional schemes of common elements, with the definition of a “product platform” that allows the creation of a family of products characterized by a structural and facility. A “platform” can therefore be defined as the basic mechanical structure of the car on which to build more diversified typological models (Berlina”, Station wagon, SUV “Sport Utility Vehicle”). The effectiveness of this approach lies in the ability to share subsystems during the development of differentiated solutions for the bodywork and for all other elements that must be harmonized with the needs of different markets, segments and individual preferences.

In relation to the configuration of the platform designed for the IBIS it was possible to define the various customizable configurations with the aggregation of three main modules; “module A” (front and rear cabin), “module B” (element corresponding to the passenger compartment) and finally “module C” (element characterized by double doors with folding doors).



[Figure 1] IBIS bus style sketches (conceptual proposal) Modularity scheme

The vehicle can therefore be configured in a long wheelbase version, that means the wheelbase, also called wheelbase (distance between two vehicle axles), indicates the distance between the axle of a front wheel and the axis of the rear wheel placed on it side. In this way it will be possible to set up the vehicle with the ACA modules for the vehicle “short wheelbase” and with the ABCBA configuration for the “long wheelbase” declination (figure 2). The IBIS vehicle module is based on the mirroring of the front and rear of the vehicle for the elements (A), the mirroring of the passenger module (B) and the uniqueness and reversibility of the central module (C). This compositional scheme, unpublished in a means of road transport, but very used in the railway sector, has allowed to reduce by 30% the costs of design and construction of structural components and bodywork (chassis, body panels, mudguards and wheel arches) that those of interior finishes, with related to sustainability for the project from the environmental point of view. Also for the vehicle chassis the modular solution allows a productive and therefore ecological saving using a “space-frame” type, that means frames characterized by reticular structures consisting mainly of a network of standard elements or metal segments with circular or square section for the tie rods and struts, connected to the ends to form triangular base geometries, with permanent connections that can be traced back to the type of rigid joints. The geometrical / functional scheme thus defined, allows the overall structure to be optimally stressed all the

structural elements involved by the forces both at bending and torsional loads and at the same time allows a characterization of the modular frame with high rigidity. The advantages of this solution can be summarized as follows:

- decrease in the number of common parts with a consequent reduction in costs of 20%;
- reduced investment on machinery reduced by 20% and reduced production costs by 30%;
- 20% Time-to-Market reduction with maximum flexibility for changes in the bodywork;
- improvement of dynamic performance and better crash behavior + 15%;
- reduced overall dimensions in production plants as most of the sub-components are prepared before assembly of the bodywork.

The vehicle is designed to accommodate 22 users with a single lowered platform, with no “step-up” in the rear area, typical of competing electric buses. This is possible thanks to a battery compartment located between the axles that guarantee an excellent balance of the vehicle. The low belt line emphasizes the permeability of light and space in the “interior / exterior” ratio, such as the large glazed surfaces, the transparent roof, the large front panel also free of cumbersome pillars characterizes the vehicle setting with destination housing for passengers of the “open space” type. The rationalization of the components of the frame and of the body, involves concretely the reduction of the weights to manage in the movement of the vehicle optimizing the performances and the consumptions. The possibility of reducing the use of the material component of the materials for production, has the purpose of simplifying the “bill of materials” of the elements making up the vehicle in the production phase, and consequently can reduce the costs of assembly, maintenance and not from less the final price of the vehicle on the road.

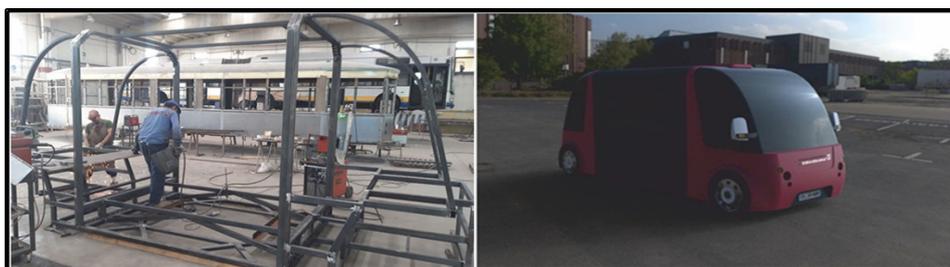
### 3.2. Battery

In today's reference market, battery-powered electric vehicles are significantly favoring significant sales volumes. To date, there are many types of batteries for the automotive industry and the choice of the right choice is always the result of a careful analysis in terms of costs / benefits with reference to performance. The most important features are essentially the efficiency of energy storage, construction features, cost price, safety and useful life. In this activity the research is oriented towards a family of main products: lithium ion (Li-Ion), molten salt (Na-NiCl<sub>2</sub>), nickel metal hydride (Ni-MH) and lithium sulfur (Li-S), all with the same ability to accumulate electricity. Some important studies in the scientific literature have highlighted the possibility of comparing four different types of electric vehicle batteries on the same model to evaluate the vehicle's autonomy and the efficiency of these types of batteries on a real-time, digitized driving cycle, by computer simulation. (Zhang, 2015).

In reference to the energy accumulators to be allocated to the project vehicle, a specialized consultancy offered by the Department of Industrial Engineering / University of Salerno advised to implement in the vehicle the type of “ultra-capacitors”, which presents a higher energy density and actions to devices plus area for holding a charge. Specifically, the use of lithium ions allowed the accumulation of energy on the market. In particular, the choice of telling the accumulation of energy was even more effective considering also the most important scientific experiments in the literature that have validated as a priority the use of “super-capacitors” in rubber traction systems have the advantage of accumulating the energy on board, unlike traditional electrochemical batteries, with the same mass and at the same time can deliver and receive energy from almost two orders of magnitude higher. Next was faster and more efficient. Not least must consider the useful life that is at least a million cycles written; specifically on an automatic recharge of electricity lasting 5-10 seconds the bus will travel 2-3 km.

Charging takes place at each stop during the time of ascent and descent of the users through an automatic connection between a “catch” under the vehicle and a “conductive carpet” positioned on the road. It will be possible to use a “photovoltaic shelter” for the single stops where there will be, for example, charging columns for batteries with pedal assisted bikes. With a view to an effective system, the bus is obviously equipped to accommodate disabled people. Energy support story will serve an integration of the vehicle's electrical consumption in parallel, compared to that provided by the alternators. As described in the latest EUROBAT report, the significant advantage of lithium ion electrochemistry is its ability to allow and control very high charge rates (including regenerative braking energy recovery) and the associated discharge. Full charging is achieved in less than an hour with the appropriate equipment. The benefits include less downtime, resulting in greater availability for the return to the bus passenger services. The lithium-ion battery also offers better long-term performance.

Therefore, while the high initial costs of acquiring a lithium-ion battery seem high, the reduced need for maintenance and the life of the same battery will present an added value in the cost / benefit analysis typical of TCO (Total Cost of Ownership).



[Figure 2] IBIS bus design: construction and visualization of prototypes in full scale

#### 4. CONCLUSION

The research carried out in the IBIS project made it possible to realize a vehicle with electric power and alternative propulsion with a modular compositional scheme and to evaluate its benefits both in terms of sustainable design and in relation to the economic balance of design / construction costs. The expected result was validated by the performance of the real-scale and functioning project vehicle simulator as a further “demonstrator” of the effectiveness of the design approach. The project aims to achieve the following results:

- support a dialogue between different scientific disciplines, in which to share experiences of integrated research;
- supporting the competitiveness of companies through design methodologies oriented to the overall sustainability of the design and production process;
- experiment with new production models to optimize production in the automotive sector.<sup>3</sup>

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<sup>3</sup>The paper, realized in the full collaboration of the authors, has a paragraph attribution: 1, 4, edited by P. Ranzo, section 2 and 3 edited by R. Veneziano; section 3.1, 3.2, edited by F. Fittipaldi.



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## **ANALYSIS OF THE POTENTIAL APPLICATION OF RECYCLED THERMOFIX INDUSTRIAL POLYURETHANE RESIDUE IN SCHOOL DESKS**

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### **ABSTRACT**

The objective of this work is to compare the composite developed by Baldan (2015) with materials such as MDF (Medium Density Particleboard) and MDP (Medium Density Particleboard) for its application in the production of school furniture. In order to do so, we present the stages of preparation of the material developed by Baldan (2015) and the comparative tests developed (physical, mechanical and durability properties). The results showed that the recycled thermoset polyurethane composite presents satisfactory results when compared to MDF and MDP, and can be applied in the construction of school furniture. Also, the possibility of the developed material being recycled at the end of its useful life, guarantees the reverse logistics of the developed product and safeguards the sustainability of the process.

Key words: composite, recycled thermofix polyurethane, school furniture

## 1. INTRODUCTION

According to NBR 14006 (ABNT, 2008), which deals with school portfolios, school furniture is a seat and table for a group of students from educational institutions, and recommends the use of solid or plywood for their manufacture. of agglomerate panels. Among its advantages, according to Oliveira (2010), are its homogeneous structure, elimination of reducing factors of resistance and possibility of raw material with smaller restrictions on form and dimensions.

Regarding to its composition, the Technical Information Book (FNDE, 2017) establishes that school furniture should be composed of a table topped with MDP (formed by three layers of wood particles, one thicker in the middle and two thin on surfaces) or MDF (made from wood fiber bonding with synthetic resin), coated on the upper face of high pressure melamine laminate and on the underside with a balancing sheet, mounted on a steel tubular frame, containing book-holders in injected plastic and a stackable chair with seat and back in injected polypropylene or molded anatomical plywood, mounted on steel tubular structure.

Oliveira (2010) also points out disadvantages about the material, such as surface and rough edges, poor machining quality, unsuitability to nail fixing, crumbling with inadequate use of hinges and screws, and poor resistance to moisture.

Also, it is possible to point out that today the serious problems in the school portfolios, mainly in public institutions, caused by vandalism, the inadequate use or even the wear of the materials, besides the lack of ergonomic studies capable of adapting the equipment to the user. The danger to students exposed as rivets of the show and rusted nails and tips of chipped laminate, as exemplified in Figures 1 and 2, is therefore clearly noted. In such cases, high costs to the government or private institutions.



[Figure 01,02] Deteriorated laminated material used in school portfolio (Source: <http://lecoeducar.com.br>)

Therefore, one of the alternatives to minimize this type of problem is the replacement of the MDF or MDP with another component that has as main characteristics, strength and durability.

The substitution of MDF and MDP for composites - materials formed from the joining of other materials of different natures, which in turn generate complementary properties and that can be obtained from the incorporation of residues in their composition - becomes a feasible alternative in view of its possibilities of application, which range from the aeronautical to the civil construction sectors.

On the other hand, companies from Vale do Rio Sinos, in the state of Rio Grande do Sul, Brazil, a major national leather-footwear producer, generates, on average, one million tons of thermo-fixed polyurethane industrial waste from its post- production, which has as final destination the landfill of solid waste (BALDAN, 2015).

Polyurethane deserves special attention because it presents several technical characteristics, such as lightness and resistance to abrasion and flexion, and can be widely used in the manufacture of soles for footwear and furniture, which allows its application on a high industrial scale (SILVA, 2003).

However due it is a thermoset polymer - material that, from the first molding, can not be melted or molded again - the polyurethane used in the leather-footwear production of Vale do Rio Sinos presents difficulties in its reuse and / or recycling .

However, Baldan (2015) promoted the recycling of thermofixed polyurethane industrial waste and the development of a composite from the incorporation of the recycled residue to the polyurethane resin and glass fiber mats and, therefore, can analyze its application potential by the civil construction sector in the substitution of materials such as cement board and gypsum board. The results obtained demonstrated that the thermofixed polyurethane industrial waste can be 100% incorporated into the composite development process. In addition, the composite when analyzed as a component of civil construction, demonstrated applicability by the sector.

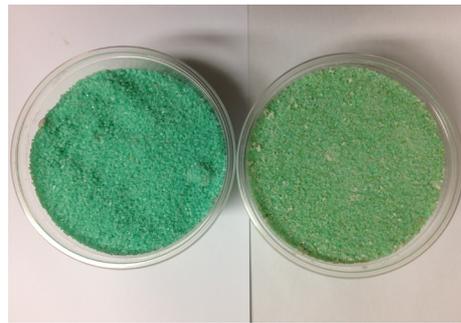
The objective of this work is to present the feasibility of replacing materials such as MDF and MDP by the composite developed from recycled thermofix polyurethane industrial waste in the production of school furniture.

## 2. DEVELOPMENT AND CHARACTERIZATION OF POLYURETHANE COMPOUND RECYCLED THERMOFIX

Aiming to recycle the thermofixed polyurethane industrial waste from the post-production processes of the Vale do Rio Sinos, Baldan (2015) developed a methodology in which the thermo-fixed polyurethane industrial waste (Figure 03) is transformed into a recycled aggregate (Figure 04), from cutting and milling processes.



[Figure 03] Post-production thermo-fixed polyurethane industrial waste (Source: Baldan, 2015)



[Figure 04] Recycled aggregate (Source: Baldan, 2015)



[Figure 05] Recycled aggregate + polyurethane vegetable resin (Source: Baldan, 2015)



[Figure 06] Recycled aggregate blend + polyurethane vegetable resin + glass fibers (Source: Baldan, 2015)

Then, the recycled aggregate of thermoset polyurethane was added to the polyurethane resin in the ratio 4: 1 (Figure 05). In order to reinforce the composite, two 90 ° oriented fiberglass blankets were also added to the blend (Figure 06).

With the aid of a thermal press (Figure 07) and a metallic shape in the dimensions of 250 x 300 x 9 mm (Figure 08), the blend was compacted for 15 minutes at a constant temperature of 50 ° C and pressing of 5 tons , which generated the material called by Baldan (2015) as polymeric plates (Figure 9).



[Figure 07] Metal press (Source: Baldan, 2015) [Figure 08] Metal press (Source: Baldan, 2015) [Figure 9] Polymer plate (Source: Baldan, 2015)

In turn, the developed polymer plates were characterized for their physical properties (density, water absorption, swelling, hardness and impact) and mechanical (tensile strength and parallel and perpendicular screw start) and for the durability potential (abrasion surface and fire resistance). Thus, it was possible to compare the results obtained with the same properties presented by MDF and MDP.

### 3.ANALYSIS AND DISCUSSION OF RESULTS

To perform the tests, MDF and MDP polymer plates of the same dimensions (25 x 30 x 9 cm) and the same density were used. Table 1 presents the results obtained from the comparison of the physical and mechanical properties of the polymer plate with respect to MDF and MDP.

[Table 1] Comparison of the physical and mechanical properties of the polymer board with respect to materials commonly applied in the manufacture of school furniture

Parameters analyzed	polymer plates	MDF	MDP
Density	760,0 kg/m <sup>3</sup>	760,0 kg/m <sup>3</sup>	760,0 kg/m <sup>3</sup>
Absorption in water	Up to 0,5%	Up to 13,0%	Up to 13,0%
Swelling	Up to 0,5%	Up to 3,5%	Up to 3,5%

Hardness	50,0	45,0	45,0
Impact	4,0 J	2,6 J	3,0 J
Tensile strength	1,6 N/mm <sup>2</sup>	1,0 N/mm <sup>2</sup>	1,2 N/mm <sup>2</sup>
Parallel screw start	1380,0 N	1000,0 N	1200,0 N
Perpendicular Screw Start	1100,0 N	800,0 N	950,0 N

The water absorption and swelling analyzes presented lower results when compared with MDF and MDP, causing the material to not overload, present good structural performance and be light. Further, the polymer plates tested were classified as a ductile material and of elution resistance to impact.

With respect to parallel and perpendicular screw start tests, the results obtained demonstrate that the polymer plates obtained the best results, which guarantees stability to the material.

Table 2 shows the results obtained from the comparison of the physical and mechanical properties of the polymer plate with respect to MDF and MDP.

[Table 2] Comparison of the durability potential of the polymer board with respect to the materials commonly applied in the manufacture of school furniture

Parameters analyzed	polymer plates	MDF	MDP
Surface abrasion	PEI-3	PEI-1	PEI-1
Fire resistance	Self-extinguishing	Flammable	Flammable

When subjected to the surface abrasion test, the polymer plates presented characteristics of PEI - 3, which guarantees high resistance to the risk according to NBR 13817 (ABNT, 1997). On the other hand, MDF and MDP, which presented PEI-1, can be classified as low resistance to risk according to the same standard.

With respect to fire resistance, the material presented as extinguishing self, in addition to not releasing smoke during the test. This means that the polymer plates, when subjected to the fire conditions, lose their flames when they are removed from the fire, unlike the MDF and MDP, in which the flames remain constant even when they are far from the fire.

These results are important considering that the polymer plaques present superior results when compared to MDF and MDP, which allows their application in the construction of school furniture.

#### 4.CONCLUSIONS

The data obtained through the tests showed that the plates made by Baldan (2015) presented superior results when compared with the MDF and MDP, which allows the use of the material also developed in the production of school furniture.

In addition, it is important to highlight that, according to Baldan (2015), the boards developed by their research can be recycled again, with the potential to make new boards with the same characteristics and results, guaranteeing the reverse logistics of the product, safeguarding sustainability of the entire production chain.

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## RE-DESIGNING RECOVERED MATERIALS. CASE STUDY: FIBERGLASS IN THE NAUTICAL SECTOR

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### ABSTRACT

In the last decades, the relationship between designers and materials changed radically, bringing designers to relate to materials manipulation and production processes. At the end of the twentieth century, the growing attention to environmental issues reduced the choice of materials to those considered sustainable and risking to mortify, together with the materiality, the expressive-sensorial richness of the objects. Therefore, recycled materials have become part of the choices available to designers, foreshadowing new challenges for redesigning their aesthetic aspect and identity. Recently, the dissemination of the maker culture through the Fablabs and the promulgation of the DIY phenomenon, have favored a rapprochement between designers and materials and their transformation, leading them to enter the interspace between research on materials and their applications. The paper focuses on the experimental research aimed to design new materials experiences and identities which allowed the exploration of new forms of recycling matter recovered from the decommissioning of GFRP boats.

Key Words: upcycling, recovered materials, circular materials, GFRP

## 1. INTRODUCTION

After the Second World War, the economic boom and technological development gave rise to the belief that the availability of products and materials was unlimited. The “consumer society” has created this illusion of infinite resources. The plastic was the absolute protagonist of this period, being a material with infinite applications and deriving from a material with infinite applications (Fiell & Fiell, 2010). Nowadays, it is clear that the frenetic and irresponsible use of resources available, combined with the accelerated demographic pressure, is no longer sustainable. The linear economy, which characterized the past years following the approach of “producing, using and throw away”, is an economic model no longer convenient, since it could lead to the exhaustion of resources, the increase in prices of raw materials and of waste management in economic and environmental terms.

The transition toward a more sustainable economic, consumption and development model for our society needs a radical transformation in how human society operates and this desirable radical change requires not only technological interventions but also social, cultural/behavioural, institutional and organisational change (Ceschin & Gaziulusoy, 2016; Ryan, 2013; Loorbach, 2010). The long-awaited cultural and behavioural change that can allow the adoption of more sustainable solutions also involves the materials of which the artifacts that surround us are made.

In the field of design for sustainability, we can easily find relevant information and guidelines to use for reducing the impact of materials and materials transformations in the design process (Vezzoli, 2018). What we consider here as useful for our discussion, are the different forms of recycling that, as demonstrated widely, always lead to a net environmental profit. Recycling is defined as the process for converting waste materials into new materials and things. It avoids the landfill, and no virgin resources are used to create new artefacts, generating an indirect environmental advantage (Vezzoli, 2014). In the context of materials for design, it is possible to find easily many successful examples for a specific recycling practice which is more precisely called upcycling. In fact, there are clear distinctions between the various ways we can reuse waste and with the upcycling, we mean the process for adding value to the waste materials and takes less energy to process.

As defined by Sung (2015): “Upcycling is a process in which used materials are converted into something of higher value and/or quality in their second life. It has been increasingly recognised as one promising means to reduce material and energy use and to engender sustainable production and consumption.”

We are aware that waste occurs at every stage of the artefact’s life, during the design process, both pre-consumer and post-consumer and there is an abundance of wastes and they are usually easily available and cheap. Through creativity, the use of these waste materials as raw materials can be favored. Such has the benefit of assisting material circulation and reduction of waste in the environment. In our vision, the upcycling design process begins from reassessing waste and follow with adding functionality and aesthetic to the recycled materials (Ahn & Lee, 2018). In the recycling concept in general, the circular approach is implicit, even only at the semantic level and even in the current debate on design the need to move from a linear economic model to a circular model is becoming increasingly evident. Circular economy, as clearly indicated by its name, is an economic model capable of regenerating itself and, as indicated by McArthur (2015), is aimed to redefine growth, focusing on positive society-wide benefits. It is based on three main principles: a) design out waste and pollution; b) keep products and materials in use; c) regenerate natural systems.

Within this framework, materials have acquired great importance and become protagonists in the design of a product in all the phases, requiring particular attention to their origin, their processing and their sizes. In circular economy, the flows of materials are of two types: the biological ones, able to be reintegrated in the biosphere, and the technical ones, destined to be revalorized without entering the biosphere.

The aim of this paper is to present a research and design experience focused on the upcycling of a specific waste and to demonstrate how designers are more and more interested in applying their skills to the development of material from waste, looking at these as resources to generate new raw materials. Today recycled materials have become part of the choices available to designers, foreshadowing new challenges for redesigning the products aesthetic. Recently, the dissemination of the maker culture through the Fablabs and the promulgation of the DIY phenomenon, have favored a rapprochement between designers and materials and their transformation, leading them to enter the interspace between research on materials and their applications (Rognoli et al., 2015).

This new approach gave rise to a material culture of design in which designers choose to “manipulate” the material through tinkering processes and experiments based on personal experience, collaborating with other experts, leading to the acquisition of new technical-scientific knowledge and creating an opportunity to continue to investigate the relationship between nature and artifice according to the sustainability issue.

In the unlimited number of post-consumer materials or industrial leftovers, fiberglass was very interesting as a case study, because of its difficulty to be recycled for its composition, the environmental impact deriving from the huge amount of material and the high cost of disposal. As it is well-known, fiberglass, GFRP (Glass-Fiber Reinforced Plastic), is made from glass fibers in fabrics or TNT and thermosetting liquid resin which can be polyester- or vinyl ester-based as well as epoxy-based. It is adequately mixed with chemical products (catalysts) allowing its polymerization at ambient temperature. Thanks to its excellent lightness and mechanical properties, as well as its resistance to corrosion and weather conditions, it is used to produce pipes, wind turbines, silos, swimming pools, tanks and especially boats, for which it has been the main material in use since the sixties.

According to a UCINA research in the world, already in 2011 about 75,000 vessels were no longer in circulation, and 54% of these were abandoned, with a presence of about 53,460 tons of waste fiberglass. Also, the amount of fiberglass deriving from old hulls is not without importance: in fact, on the date of this investigation, it was about 148,500 tons (UCINA, 2013).

The nautical industry has not been concerned over time to dispose or recycle used vessels or hulls no longer in use, and only now it is dealing with environmental problems connected with the disposal of the end-of-life products. Current regulations for the disposal of fiberglass are inappropriate and, at the same time, the definition of eco-sustainable integrated production systems is complex from an industrial point of view. At present, disused vessels are delivered to landfills as complex waste with a high cost for those who dispose of them and for the environment. The possible traditional forms of fiberglass re-use are energy recovery through incineration and chemical recycling (pyrolysis), although neither of the two operations is advantageous (Corvino et al., 2016) since material is not 100% utilized: in fact, incineration allows to produce energy only from 27% of waste material and its remaining part is combustion dross; pyrolysis produces about 12% of gaseous substances and 12% of oil substances, and the remaining part is made from solid substances difficult to be disposed.

## 2. BASIS OF THE RESEARCH

This research has taken inspiration from tests carried out at IPBC – CNR center of Naples, giving birth to Cold Plast patents which allow creating thermoplastic products starting from recycling composite thermosetting materials and expanded polystyrene packaging (EPS).

In particular, ETE (Emulsified Thermoplastic Engineering) process includes the jellification of expanded polystyrene with suitable solvents, followed by the mixing with charges deriving from the grinding of thermosetting composites. This material is obtained in calendered slabs or in pellets so that it can be used in the following processes of thermoforming and injection molding, generally used for thermoplastic materials. The resulting material is a high charge thermoplastic “technopolymer” (up to 85% of charge), which in turn can be recycled, with excellent mechanical and thermic properties. It does not require any virgin material; it is made only from recycled fiberglass and polystyrene which is still, although thermoplastic and therefore recyclable, a relevant part of plastic waste because its recycle is uneconomic. In addition, it is a cold working process through machining, in full compliance with environmental and economic sustainability. Mechanical and physical characteristics of the material deriving from this process can be compared with the properties of fiberglass, both DMC and SMC fiberglass. In particular, in some cases, this material has a resistance lower than the classic fiberglass resistance, whereas its Young’s modulus is generally higher and its thermal expansion coefficient is lower. If compared with Corian Dupont, mechanical properties appear to be on average increasingly higher. The resistance of this material is obviously influenced by the percentages of charge (ground fiberglass) and of the matrix (jellied polystyrene).

## 3. MATERIALS AND METHODS

The procedure described in this issue was aimed at analyzing the perceptive and sensorial aspect of this material, by critically evaluating its effects and re-designing it (Sauerwien et al., 2017). This investigation particularly focused on the perceptive performance of the material surface in terms of Re|Surface with the purpose of identifying the experimentation, in accordance with an immediate reference to the re-design of the material surface and at the same time with the meaning of bringing back to surface, thus evoking both the aim and the object of this study and therefore the recovery of fiberglass from old hulls which re-emerge, through this process, returning in the production cycle. As an alternative to materials included in ETE process (fiberglass, polystyrene, and solvent), other materials were used (ABS, PLA, limonene, carbon resin), by adding marine fillers (seaweeds or mussels), by working in layers or by differently placing basic materials. This experimentation was carried out in IPCB – CNR laboratories of Naples in cooperation with Milan Polytechnic and the University of Campania Luigi Vanvitelli, according to the approach of the Designer in lab, typical of DIY Materials, because, apart from basic material (ground fiberglass), matrices and fillers were recovered and processed in a direct way. Moreover, this procedure can be easily industrialized, with the possibility to create objects of various forms and dimensions in short times, with low costs and different techniques of molding (injection molding, thermoforming, etc.). In addition, this study followed the Material Tinkering approach (Parisi & Rognoli, 2017), based on a Design based critical analysis of tests and the observation of samples.

The design experience for each sample was useful to understand how to manage the process, by addressing modifications to create the following samples. In particular, starting from the basic sample, precise scales of interventions were taken into consideration, that is the selection of ingredients, the management of the process and the expressive applications, through the variation of basic composition, two-color composition, and the addition of marine elements.

This experimentation was carried out by using: a grinder, a planetary mixer, a Carver hydraulic press able to apply an axial load up to 100 kN (having heating plates measuring 15 cm x 15 cm with temperature up to 400°C), a hydraulic press used as an extruder, a vacuum oven. Rectangular steel molds were also used, with internal dimensions of 60 mm x 70 mm, formed by three parts (a frame and two pistons), as well as the equipment commonly used in a laboratory. The experimental procedure for the preparation of samples included two macro-stages: prepara-

tion of basic material in the form of pellets and shaping of the sample. In particular, the first stage, that is the preparation of material in the form of a pellet, included: a) grinding of fiberglass to obtain a ground product whose fragments have a maximum dimension varying from 3 mm and 7 mm; b) cutting of the polystyrene to obtain fragments with a maximum dimension of 5/6 cm; c) jellification of polystyrene through the addition of a solvent (methyl ethyl ketone), by using the planetary mixer to uniformly spread treatment; c) mixing of the ground fiberglass and the gel obtained with the polystyrene; d) application of the mix on a smooth surface; e) immersion of the mixture in water to remove the solvent (soluble in water) until the mixture is hardened; f) grinding of the plate in pellet.

The second stage, the shaping of the sample, included: h) setting the temperature of the press plates at 220°C; i) placement of the material in pellets inside the mold; l) introduction of the mold inside the press; m) fusion of material (fusion time about 5 min); n) application of vertical tension by means of a force of 20 kN corresponding to a vertical tension of 4,8 MPa (for about 5 min); o) cooling of the mold through the circulation of cold water in the heating plates (waiting time: about 10 min); p) mold dismantling with extrusion of the sample from the mold. The resulting samples measure 60 mm x 70 mm and their thicknesses are 4 mm or 1 mm.

#### 4. RESULTS AND ANALYSIS

This procedure led to create the first sample with a thickness of 4 mm (basic sample 00), made from 50% of ground fiberglass whose pieces measure 4 mm and 50% of jellified white polystyrene

For assessing the potential of ETE process and of the materials deriving from it, first of all, it was decided to carry out some tests by changing basic composition, without adding other elements. In particular, a first phase involved the modification of the matrix, formed by jellified polystyrene in the basic procedure, using ABS in different colors (white, yellow and blue ABS, derived from disused grinders). A test was also performed with PLA, which is less toxic than ABS, but requires a more polluting solvent for its fluidization. Thereafter, the focus was on charge material, by using carbon resin in place of fiberglass. This material has an intense black color, due to carbon fibers replacing colorless glass fibers typical of fiberglass. Finally, an experiment was carried out on the effect of the solvent modification, by using limonene, which is a natural solvent, and by investigating the olfactory aspect, also to make the process more sustainable. The sample obtained has a color lighter than the sample 00, some transparency of fiberglass fragments and more brightness, probably because during the process, some sheets of Teflon were placed on pistons. The sample is smoother to the touch and gives a sensation of moisture, maybe due to not completely evaporated limonene. The sample has a strong smell of lemon. The use of mixtures with carbon resin and fiberglass charge, both with white ABS matrix, was aimed at obtaining two-color samples with strong chromatic contrast. Two procedures were performed producing different effects. The same procedures could have been carried out using mixtures with different basic colors. The sample of the material showed that the procedure in use does not produce a blending of the two mixtures and there is a definite transition from one to another. But the process does not allow to define geometries of the contact line a priori. In fact, this line is strongly irregular. The difference between the two mixtures is not significant to the touch. This test was repeated with a different percentage of the two materials. A third two-color white-black sample was obtained with an alternative technique. In fact, the pellets of the two mixtures separately produced two thin sheets of 1 mm of monochromatic material. These were then cut in strips with a width of 5 mm and a length of 60 mm. The strips were again placed in the press by alternating a black strip with a white one corresponding to 15 g of the mixture with carbon resin charge and 15 g of the mixture with fiberglass charge. The result was a zebra-stripes material, with a prevalence of the black color.

In order to modify the expressive-sensorial characterization of the material, it was decided to try to introduce additives in the mixture through different procedures, whether the mixture is with ABS or with PS. To keep a reference to sea, some fillers having marine origin were used, in particular fragments of mussel shells or dried *Posidonia* seaweeds. The presence of "narrative ingredients" coming from other contexts gives the material an impression of depth and diachronic value so that it acquires meaning through the recognition of the element qualifying it.

The first experiment was carried out by using fragments of mussel shells. This choice was basically due to environmental reasons and to two different considerations: the intense black color with violet tints that can enrich visual perception of the material and the abundance of this kind of waste both in catering and in the food industry. It should be also noted that, since mussel shells are formed by calcium carbonate, they should not be disposed of in biodegradable waste because not compostable. It must be underlined that in this procedure, after pressing, the fragments of mussel shells are irregularly placed in the thickness of the sample, since the finest pieces are in the lower part. For greater control of the surface texture, it was decided to adopt a different procedure including a double phase of sample molding. The first of these steps is absolutely equal to the procedure of sample 01, made from roughly ground fiberglass and white ABS in percentages of 50% and 50%. In the second step a thin layer of mussel shells fragments (1,5 g corresponding to a surface density of 3,6 g/dm<sup>2</sup>) was placed on one of the surfaces of the sample, followed by a hot pressing in the same way, although at a slightly lower temperature (180°C).

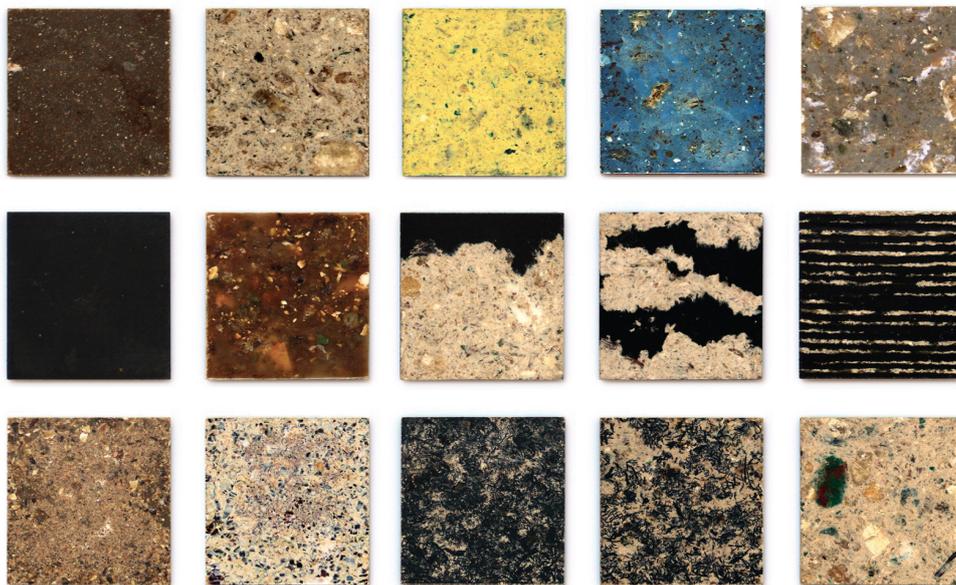
This procedure (sample 12) was adopted to create a new sample (sample 13), replacing the fragments of mussel shells with pieces of *Posidonia* seaweeds collected on the seafloor of Naples, always on a sample with the matrix in white ABS. These seaweeds were previously sun-dried and shattered so as to obtain threadlike particles with a maximum length of 1 cm and placed (0,7 g) on the sample with a surface density equal to 1,7 g/dm<sup>2</sup>. The resulting

sample has a dark irregular design, in contrast with the light color of its bottom. The surface treated with seaweeds is slightly wrinkly to the touch than the surface not treated. This test was repeated by using a lesser amount of seaweeds (0,4 g corresponding to a surface density of about 0,95 g/dm<sup>2</sup>) to show the possibility to obtain a different surface treatment according to the fillers. Subsequently, it was necessary to carry out forming trials to investigate the possible working techniques of the material, in order to best understand its potential applications. Some pressure molding tests were performed with different molds, a thermoforming with hemispherical molds of different size and milling through a numerical control machine. Some of these procedures were suitable for working the material since they give satisfactory results. Other tests were carried out to verify the possibility to give the material even complex shapes with very reduced thicknesses (2 mm).

## 5. IMPACT AND SUSTAINABILITY

These tests showed the versatility of the material which, in the first instance, was ascribed to the marine context, since the resulting samples revealed images recalling visual associations with seascapes, a wave which covers and strongly breaks, or the calm surface of the sea in the sunshine. In addition, it was clear that the material can further be developed, by decreasing colors and textures starting from samples already made. During experimentation, the materials to be used and combined were sometimes chosen according to their availability, in order to work on the visual contrast, directly using samples. The application of marine elements was aimed at “narrating” the connection between the material and a specific context: this does not exclude that also elements of different origins can be added, such as straw, pine cones or any natural fragment or waste, in line with other fields of application. It was found that this material has infinite expressive potential and its combinations can produce many visual and perceptual effects, as well as further tests could explore the olfactory and tactile dimension. It would be surely appropriate to carry out further mechanical resistance tests – particularly bending resistance – and to verify the other properties of the material, such as scratch and grip resistance. It would be also necessary to analyze costs, the observation of regulations, as well as problems concerning marketing and trends, and their possible applications.

In conclusion, this research was aimed at metaphorically revitalize a material which would otherwise “sink” in landfills because non-recyclable, giving it a new life and re-inventing its surface, in order to give it an added value. Nevertheless, it is only the top of an iceberg because there are still many aspects to be analyzed and to be “brought back to surface”.



[Figure 1] Samples in chronological order of realization

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## UNFINISHEDISM

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### ABSTRACT

This thesis boldly proposes the concept of sustainable “unfinishedism” (leaving development space and room for future generations). The author discovers the “unfinishedism” in the art fields through correlation research and focuses on the “unfinishedism” concept in fashion design according to her professional direction, and systematically classifies and develops the possibility of “unfinishedism” in all stages of fashion creation.

Through research and practice, a variety of clothes have been designed under the concept of “unfinishedism” such as zero-waste clothes, multi-purpose dresses, variable colour patterns shirts, and corn Eco-fur coats... The design and implementation of this concept are expected to awaken people’s sustainable slow fashion design concepts, taste interesting interaction, and picking up a moderate frugal lifestyle.

In the end, the author extends “unfinishedism” to non-artistic disciplines such as philosophy, psychology, ecology, and human development to analyze the significance of its existence.

Key Words: unfinishedism, unfinished fashion , interaction, moderate frugal lifestyle

## 1. INTRODUCTION

In the current foppish money oriented fashion industry, the author sees not only the high energy consumption and high waste of the traditional textile and garment industry, but also the large-scale low-cost purchase and rapid discarding that the fast fashion culture highly admires, and very much distressed that people who pursue a healthy life have been misled into the wrong way of money worship material enjoyment numbness, and emptiness in today's pan-entertainment era. This thesis boldly proposes the concept of sustainable "unfinishedism" (leaving development space and room for future generations).

## 2. UNFINISHED ART

The skeleton of a theory of unfinished concept - unfinishedism. "Unfinished" in art can be explained as incomplete, half-done, partial, fragmentary, uncompleted and ongoing, or rough, bare, crude, natural, raw and unrefined. So "unfinished art" includes several kinds of unfinished processes or possibilities. I divide it into "deliberate unfinishedism" and "unplanned unfinishedism".

Two case of "unplanned unfinishedism", one is the archetypal unfinished symphony - Schubert's 8th (written in 1822, but not performed until 1865, several decades after the composer's death). It featured two fully orchestrated movements; while from some of the sketches which were left, it is clear that Schubert originally intended to create a four-movement symphony<sup>1</sup>. But just because the unfinished sketches of the 3rd and 4th movements contrast with his most cherished compositions, it becomes more well-known than other finished symphonies. Another is the Venus de Milo, more precious than some intact artworks which belong to the same period of time. Actually, there are many versions of Venus statues all over the world, but only the Venus de Milo, who stands gracefully without her arms has become the one which is most well-known.

From Modernism to Postmodernism, focus on searching for the case of "deliberate unfinishedism". Many people may think that the 'unfinished concept' comes from postmodernism. But actually it exists in modernism. "Aesthetic self-reflexivity, in which artifacts explore their own constitution, construction and shape (e.g. novels in which narrators comment on narrative forms, or paintings in which an image is left unfinished, with 'roughed-in' or blank sections on the canvas)"<sup>2</sup>.

A good example comes from the exhibition in Washington, D.C. (2001), with The National Gallery of Art's exhibition, *The Unfinished Print*, which investigates the question of aesthetic resolution in European printmaking from the 15th to the early 20th century. Approximately 100 works in various stages of completion by such artists as Andrea Mantegna, Michelangelo, Albrecht Durer, Rembrandt, Hendrik Goltzius, Anthony van Dyck, Edgar Degas, Edouard Manet, Paul Gauguin and Edvard Munch reveal the importance of the artistic process in the history of printmaking. By the turn of the twentieth century the problem of the unfinished print had been taken to its furthest reaches: the matter of the unfinished is transformed from a practical and philosophical problem to a precondition of modernity. The nature of the unfinished "state", presupposing some final version, had by this time been well authorized as a work of art worthy of exhibiting and collecting in its own right. Hence, the dictum attributed to Rembrandt that a work of art is finished whenever its maker determines it to be<sup>3</sup>. Rembrandt made etchings as sketch sheets to interest patrons in his work. Often the images were unfinished, such as "Old Man Shading His Eyes with His Hand," (Figure 1) which focuses on a closely observed face, hand and arm, leaving the rest of the figure thinly outlined, a lovely web-like tracery imposed on gleaming etching paper.



[Figure 1] Rembrandt: "Old Man Shading His Eyes with His Hand" reference from <http://www.nga.gov/exhibitions/2001/unfinished/modernity.shtm>



[Figure 2] window-display, Harvey Nichols, London

1 [http://en.wikipedia.org/wiki/Unfinished\\_symphony](http://en.wikipedia.org/wiki/Unfinished_symphony).

2 Tim Woods, 1999, *Beginning Postmodernism*, Manchester University Press.

3 <http://www.nga.gov/exhibitions/2001/unfinished/modernity.shtm>

Compared to Modernism, Postmodernism explores more aesthetical possibilities, embraces broader hybrid cultures and publicizes self-consciousness and individuality. Its indeterminacy and extent mature and grow the ‘unfinished concept’ towards more freedom and latitude. There are several postmodernist characteristics such as fragmentation, deconstruction, improvisation, adhocism, process, and participation often inducing the “unfinished concept”.

Fragmentation is a term that occurs in several fields and describes a process of something breaking up or being divided into pieces<sup>4</sup>. Unfinishedists often pick up discontinuous and even contradictory fragments in different contexts and mix them together in an uncompleted way. In other words, just because of the creation from incomplete fragments, the artworks always exist in the unfinished state and express the process of fragmentary development. A good example is coming from the window-display of Harvey Nichols in London. All fragmentary pieces of old reliefs and the latest short-coat accessories were mixed together, twisted the time and the space. (Figure 2)

The term ‘deconstruction’ was coined by the French philosopher Jacques Derrida in the 1960s and is used in contemporary humanities and social sciences to denote a philosophy of meaning that deals with the ways that meaning is constructed and understood by writers, texts, and readers. I will explain ‘deconstruction’ in fashion, and discuss the relationship with unfinishedism in the next chapter.

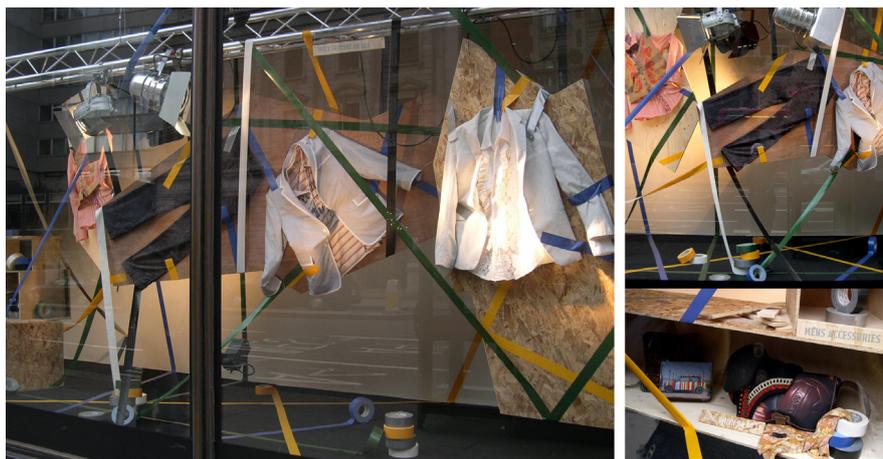
Improvisation is the making or doing of something using whatever you have, or without having planned it in advance. Improvisation in art is the inventing or designing of artworks while, or in the process of, drawing, singing, performing, and designing.

“Adhocism is a term coined by Charles Jencks and first used by him in architectural criticism in 1968. It is the art of living and doing things ad hoc—tackling problems at once, using the materials at hand, rather than waiting for the perfect moment or ‘proper’ approach. As a principle of design, it begins with everyday improvisations, such as bottles for candle holders and tractor seats on wheels for dining chairs<sup>5</sup>.

Unfinishedism borrows improvisation as exploring the open-unfinished results and embraces spontaneity and diversity.

“As the influence of postmodernism, people nowadays usually have an increasing interest in process and procedure or like to enjoy themselves in the process as opposed to the finished artefact.” (Reference from Tim Woods, 1999 *Beginning Postmodernism*, P.151, Manchester University Press) Unfinishedism applauds “life as a process, art as a process, fashion as a process”. It exposes the process of creation. Exposing process is crucial in the notion of unfinishedism. Sometimes the process may be more interesting and inspirational than the outcome, sometimes the process may be difficult, and not as pleasurable to see, but it endures the creativity and hard works towards hope and future. Unfinishedist opens the processes of art and wants to share them with more people. The other window-display from Harvey Nichols is a case of showing the laying process. It attracts attention of exposing the Colourful wide tapes with different lengths and irregular edges, which used to fix the shirts, trousers and accessories on the display board so that they don’t fall off. Deliberately exposing tape and fixing tools gives people a sense of the scene being decorated. (Figure 3)

In addition, Unfinishedist provokes the interaction of active participation. It is encouraging the notion of ‘participation’ in order to promote a new relationship among artist, audience and the art-works; or designer, consumer and the design-works. It is hoped that through the participatory process, open-ended results and an unconventional approach to co-create, will provide interest, curiosity and stimulation to audience/consumers.



[Figure 3] window-display, Harvey Nichols, London

### 3. UNFINISHED FASHION

From the analysis of art theories to the examples of ‘unfinished Art’ in the former chapter, I hope a solid theoretical backup can be established to help the foundation of ‘unfinished fashion’. Now I would like to focus on fashion design and see how to apply the unfinished concept in fashionable garments.

<sup>4</sup> <http://en.wikipedia.org/wiki/fragmentation>

<sup>5</sup> Charles Jencks & Nathan Silver, 1972, *Adhocism-the case for Improvisation*, Auricula Press

As far as my research has uncovered, I cannot find any particular founder of unfinished fashion. But there are some styles in fashion which have a close relation with unfinished style. I suggest two main relatives: one is Punk fashion, the other is Deconstruction fashion.

Punk first emerged in the mid 1970s in London as an anarchic and aggressive movement. About 200 young people defined themselves as an anti-fashion urban youth street culture. Closely aligned was a music movement that took the name punk. They cut up old clothes from charity and thrift shops, destroyed the fabric and refashioned outfits in a manner then thought a crude construction technique, making garments designed to attract attention. It deconstructed garments into new forms. Safety pins and chains held bits of fabric together. Whilst torn fabrics, frayed edges and defaced prints are now considered normal in the 21st century, in the 1970s it shocked many people, because it had never been seen before<sup>6</sup>. Punk fashion has come to be associated with clothing that has been destroyed, has been put back together, is inside out, is unfinished, or is deteriorating.

Deconstruction usually breaks the intact, harmonious and classic forms, the central content, the meaning, and as well as the function, and values. It advocates disarrangement rather than order; difference rather than similarity; process rather than result; unfinished rather than complete; variation rather than unification; fragmentary rather than continuous; odd, queer, unusual rather than normal, conventional and orthodox. "Deconstruction in fashion is something like an auto-critique of the fashion system: it displays an almost X-ray capability to reveal the enabling conditions of fashion's bewitching charms and the principles of its practice (i.e., form, material, construction, fabrication, pattern, stitching, and finish). At one level, the word 'deconstruction' suggests a simple reversal of construction and therefore, at this common-sense level, a reading of clothes that look unfinished, undone, destroyed as 'deconstructed' fits. It involved the exploration of clothing structure, featuring, for example, visible seams on the outside of clothing and zippers as ornamentation." (Reference from Alison Gill, 1998 article-Deconstruction fashion)

In fact, the "unfinished fashion" not only contains some characteristics of "punk fashion" and "deconstruction fashion", but also has more characteristics to be summarized, for example, "Unfinished Fashion" intentionally retains some untreated materials or incompleting parts on the garments as a display of the design process, or leaves the follow-up creative space for the garment to have a variety of open-style wearing methods or multi-function. It leaves the re-creative or co-creative potentiality on the unfinished parts for the customers. In other words, creators open the design or making process to customers through keeping the unfinished stage visible, or encouraging people to participate in the creative process.

There are some representative unfinished looks already in existence in contemporary fashion. I will exemplify designers' works to outline the applications and development of unfinished fashion. In this section, I classify three kinds of unfinished fashion, each kind has its own emphasis.

The first category is the very straightforward unfinished fashion. Designers directly leave the unfinished details on the garments. A good case is John Galliano. His ready-to-wear collection for Dior (S/S 2006) showed some unfinished looks. The most outstanding detail was the incomplete trimmings on delicate dresses. Some structural lines of the trimmings were suddenly missing or lost in their right places to make an unbalanced visual effect. (Figure 4) His couture shows for Dior (S/S 2005) presented a more dramatic unfinished style. Some dresses were roughly tacked by hand with bright coloured threads; some were still marked with black adhesive tapes which are normally used to mark the guide-lines of draping and cutting; and some still kept the sponge padding and the customer's name on a little piece of white fabric; some dresses were only half decorated with elaborate embroidery and the other half deliberately unfinished. (Figure 5) This straightforward unfinished fashion brought the sense of strangeness and space by the deliberately incomplete part; extended imagination and pluralistic structure due to partial absence; showed the original details of the production process brings the authenticity of the story.

The second group takes the unfinished process to the stage, and then it will be finished during the performance. The first example comes from Hamish Morrow (S/S 2002). He presented all-white outfits, including shirt, jackets, pants, skirts and dresses. During the catwalk performance, models walked through a shallow tank with violet ink, tingeing the base of the garments and the white sports shoes and leaving violet footprints on the white T-stage.



[Figure 4] John Galliano ready-to-wear collection for Dior (S/S 2006) reference from <http://www.style.com>

<sup>6</sup> [http://www.fashion-era.com/punks\\_fashion\\_history1.htm](http://www.fashion-era.com/punks_fashion_history1.htm)

(Figure 6) Another example is comes from Martin Margiela's (S/S 2006) collection. A couple of dresses came with one side finished and the other melting off into fabric bolts waiting for cutting. Models wore some extraordinary jewellery—necklaces and bracelets made of coloured ice cubes, which, in the process of melting, marked the clothes with streaks of blue or magenta. During the whole performance, the ice jewellery dyed the garments gradually with the movements of the models' performance. Sometimes while the model was standing with arms akimbo, the melting ice bracelets marked the waist of the dress. (Figure 7) These two examples let the audience witness various interesting process of dyeing clothes, think about the relationship between the fashion dyeing with unfinished concept and the wearer's movement.



[Figure 5] John Galliano couture collection for Dior (S/S 2005) reference from <http://www.style.com>



[Figure 6] Hamish Morrow (S/S 2002) reference from <http://www.style.com>



[Figure 7] Martin Margiela's (S/S 2006) reference from <http://www.style.com>

The last kind of unfinished fashion goes into the stage of consumers' lives. Consumers can co-design the garments rather than accepting the finished garments passively. From designers, they not only fulfil their own design concept, but also leaving space to satisfy people's participation desires. A Chinese young designer, Liu Lei, graduated from KIAD, developed a range of stylish, loose, cotton T-shirts, the design point is that many press-button buckle strips are sewn in different places on the T-shirts. So there are lots of possibilities and combinative ways to press the buttons with different numbers and different places. It is an easy and effective way that customers can change the various shapes as they wish and the particular length or size of the garments as well. (Figure 8)

From these examples, designers with different backgrounds can be connected together in using the same 'unfinished concept' in their fashion design. Therefore, a lot of characteristics of unfinishedism in fashion need to sort out and portray systematically. This is presented at the next chapter. In doing so, a comprehensive and clear framework, which will benefit both deep exploration and wide development of unfinished fashion will be built up.



[Figure 8] Liu Lei T-shirts' design (S/S 2005)

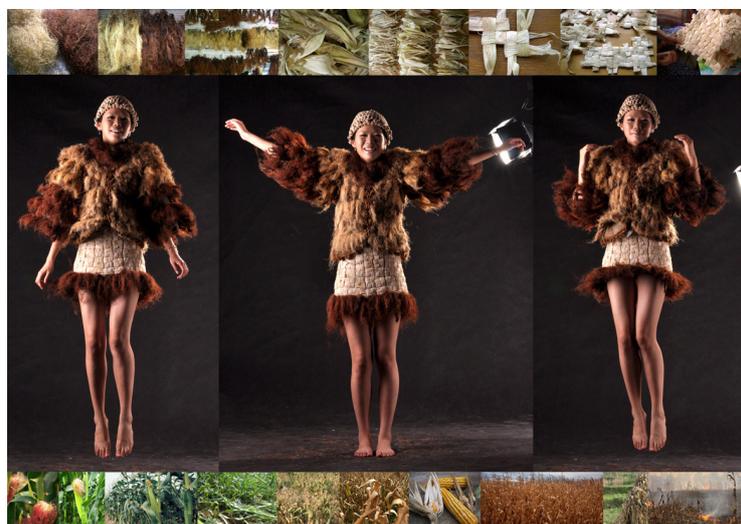
#### 4. MY OWN DESIGNS TOWARDS UNFINISHED FASHION

During the research process and my design practice, I have explored and developed the diversity of unfinished possibilities in all feasible stage of design and making garments. Designers have to know every process of how to make a garment. Each step of making helps the design concept realization. On the steps of sketches and design drawings, designers deliberately miss the lines, some parts of the details and maybe only finish the focus. It usually has stronger aesthetic value than finishing all design details. As in freehand Chinese painting, there are often deliberate omissions of white space. I have drawn some unfinished illustrations to uncover the aesthetical contrast points. (Figure 9)



[Figure 9] Huanhuan Peng Unfinished fashion illustrations 2005

From the initial stage of selecting fabrics, unfinished features can emerge with fragmented materials (old and new), waste materials (recycling), improvisation materials at hand (not deliberately selected and matched), reverse use of materials, original germ cloth or yarn juxtaposing with the final material, mismatching or dislocating fabrics and so on. In this stage, I have an experimental study on the use of waste materials and eco-environmental protection materials. I use discarded corn silk made of natural air-dried corn silk fur coat, like animal fur, warm and healthy, hypoallergenic, with a light corn fragrance. (Figure 10)



[Figure 10] Huanhuan Peng Unfinished fashion design "corn Eco-fur coats" 2009

Then in the pattern cutting design stage, unfinished characteristics usually attach to dislocation and deconstruction of

Conventional Structures, multi-functional and Variable Common Structural Design, and misappropriating some pieces of patterns. My exploration in this part is to design a multi-functional dress with a cape. Its hemline structure is a changeable double-deck design, which combines different styles and dual functions of flower bud dress and shawl dress. (Figure 11)

[Figure 11] Huanhuan Peng Unfinished fashion design "multi-functional dress with a cape" 2011



Thirdly, the sewing stage is the most straightforward way to display unfinished facets. For example, expose rough stitches, raw edges; patch the pockets upside down or distort the inner pockets outside; leave the close seam open, partly overlocking, edging, piping; partly attaching collar, sleeves, and facing...and etc. I did some experiments on garment parts and details to show the unfinished sewing process, as shown below. (Figure 12)

[Figure 12] Huanhuan Peng Unfinished fashion design "close-seam-open, upside-down" 2010

Fourthly, the decorating stage mostly presents unfinished looks as incomplete decorations. There are various kinds



of ways of decorating on the clothes. The unfinished decoration has the same spirit. Either embroidery, patchwork, beading, trimming, burning-out or hand-painting, wax-dyeing, embossing, cutting-out...all partly finish the patterns, or miss parts intentionally. This not only saves the working procedure, but also makes it more interesting and lively than the full decoration. I experimented some samples in this stage, such as dislocated pockets, changeable flounces, fragmentary collars. (Figure 13)

[Figure 13] Huanhuan Peng Unfinished fashion design "dislocated pockets, changeable flounces, fragmentary collars" 2007

Fifthly, the finishing processes, which includes thread-cutting, buttonholing, buttoning, washing, ironing, and pack-



ing, often uses unconventional methods or reversing ways according to the unfinished spirit. The attributes are usu-

ally regarded as keeping thread ends, partly ironing and partly Wrinkling, mis-ironing(Figure 14), loose buttoning, partially buttonholing...

[Figure 14] Huanbuan Peng Unfinished fashion design “mis-ironing” 2011

Finally, the unfinished concept comes to the consumption stage. They are often demonstrated as variability of



the silhouette, flux of the patterns and colours, and multi-functionality. I have a new idea regarding plant-dyed fashion with variable colour patterns. I am just developing one kind of shirt, which secretly contains some dye colour powder in their seams, darts and piping.

Whenever a customer washes the shirt, the colour will mark a little around the seams and darts. The process will continue ten to twelve times, little by little, whenever people wash it. Every time it will dye the clothes wider and darker while the customers can appreciate the changes gradually. And if customers want to shorten this process, they can wash the clothes in hot water, or keep it longer in the water. The interesting thing about this shirt is that the random change of the dyeing pattern is related to the way the user washes, twists and dries, and hangs in the air.

In addition, recently, I have an experiment to link the unfinished concept in several aspects of clothing design and production. I try to use the whole fabric as far as possible without cutting the waste material to complete a garment, and can make it change a variety of styles and Multi-function. Every piece of clothing in this experiment can be restored to the original square fabric after being laid flat. This magical and interesting feature also enables the group of clothing images to show the dynamic change process of fashion design from plane structure to three-dimensional wear, so that fashion design does not end because of wear, but because of wear and truly open the design journey. I named this series of clothes as “zero-wastes” & “multi-purpose” dress (Figure 15).

[Figure 15] Huanbuan Peng Unfinished fashion design “zero-wastes & multi-purpose dress” 2017



After this comprehensive narration and detailed tangible examples, there is a clear formulation of the spirit of unfinished fashion, as well as the various already-existing or newly-developing features of this style in fashion. However, my project is still on-going. I am just pattern cutting and making more sample garments towards unfinished fashion. This is both an inherited and invented process.

## 5. CONCLUSIONS

Any city, any culture, any genre of art is built up by the past civilizations including theories and practices. Likewise the conception of unfinishedism is formed by extracting many ideas, concepts and theories from modernism, post-modernism, and their subsystems; and at the same time using the abundant practices of a wide variety of people.

During my interdisciplinary research, I found unfinishedism exists not only in art and fashion, but also in many other subjects such as philosophy, psychology, ecology and human development. “finished and unfinished” exist relatively, according to the time and space. The unfinished stage is the process of finish, while the finished stage is the process of another unfinished stage. From an ecological and human development view, unfinishedism encourages the conception of sustainable development which is very necessary for our environment and human development. If there is more chance of changing and developing garments (just like the multi-function dress in unfinishedism), then there will be less need for endlessly throwing garments away, which is so wasteful in resources and environment. In this respect, unfinishedism can be interpreted as a healthy and inspired lifestyle which is not only producing fashionable garments, but also taking care of nature and human development. “Unfinishedism “ remind people today not to consume natural resources uncontrollably, not to occupy land resources indefinitely, and not to destroy ecological resources fearlessly.

Don't be deceived by the presentations of money right, material desire, high efficiency, speediness and instant success. Teachers and designers should return to their conscience, think about the design for the benefit of the environment and future generations, make appropriate use and development, leave space for tomorrow for nature for our next generation, and deliberated on the future and human development from multiple perspectives.

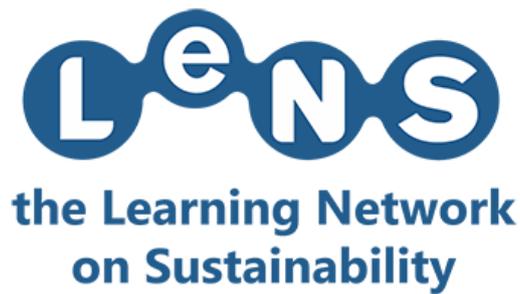
Just as research is on-going, the more the unfinished concept can be found in every aspect of our life. This essay is just a stage of my research process. I have an enthusiasm for this topic. I hope this is an unfinished topic, which not only records my own research, but also has the capacity for more people to add their wisdom and passion onto it. We can enrich it continuously, endlessly.

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## **CRITICAL FUTURES TODAY: BACK-CASTING SPECULATIVE PRODUCT DESIGN TOWARDS LONG-TERM SUSTAINABILITY**

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### **ABSTRACT**

The age of climate breakdown brings with it an uncertain future, even within our collective imagination we are presented with increasingly dystopian visions of the future. This tendency towards dystopian futures can also be seen in Speculative and Critical Design (SCD) process which emerged as a disciplinary response to challenge commercial design by envisioning radical futures scenarios and artefacts that so far has been limited to museum exhibits. This paper suggests a solution-driven SCD method exploring a ‘designerly’ reimagining of existing solar technology as a “back-casted” design solution into the present—a 3D printed optical solar cell. The solar cell is proposed as a possible, speculative alternative for existing solar cells exploring the “what if” possibilities of technological forecasting in a futures-oriented practise, ways in which product design can contribute to climate action today while still looking towards visions of better, more thriving paradigms of futures beyond ‘business as usual’.

Key Words: Future, Speculative Design, Climate Change, Sustainability

## 1. INTRODUCTION

With the onset of cataclysmic climate breakdown and the sixth mass extinction, organised human life is presented with a bleak future. Anthropocentric climate change brings with it an existential threat—an unquantifiable hyper-object (Morton, 2016) that has sent ecological systems into a tailspin. There is enough compelling evidence<sup>1</sup> that much of this pervasiveness is an unleashing of the primal forces of nature only responding to the violent systems of extraction sustaining modern human civilisation<sup>2</sup>, triggering the sixth mass extinction<sup>3</sup>, melting the arctic ice cover<sup>4</sup> and degrading soil fertility<sup>5</sup> due to industrial activity on a global scale. According to the latest IPCC reports<sup>6</sup>, we have 12 years to act in order to limit the global average temperatures to 1.5°C—if we want to avoid triggering irreversible feedback loops. Even if we manage to reduce our carbon emissions, we will end up failing to meet the targets of the Paris agreement which is projected to result in a 2.7°C increase<sup>7</sup>.

While clean energy for a clean civilisation means a shift to ‘clean’ renewables from ‘dirty’ fossil fuels, it is important to understand that technology alone will not create the change we hope to see. Even when alternatives are introduced it is found that it is bound in a paradox—increasing the capacity for further growth and even more consumption (York, 2017). The shift to renewables such as solar is inherently dependent on depleting global reserves of several crucial minerals<sup>8</sup> such as copper and lithium (García-Olivares & Solé, 2015). Further, even when it comes to our cultural imagination of the future in science fiction, climate change creates echoes of dreadful dystopias, as a comfortable “warning of things to come” (Slaughter, 1998). If we are to avoid these self-fulfilling “mythical path dependencies of dystopias” (O’Brien, 2018)—we need alternatives to avoid a “defuturing” (Fry, 1999) of human civilisation itself. Insofar as the future is not yet determined, better visions of the future are not just required, they are essential. How we humans envision futures, is very much in the domain of design (Margolin, 2007)—a form of “designerly way of knowing” (Cross, 1999) the future.

Designers could possibly be trained to conceive a wicked subject of climate change, and in the attempt at concreteness take the “wickedness” out of the problem (Buchanan, 1992). This paper looks at how speculative product design can make concrete the alternative design solutions of long-term sustainability today through “designerly ways of futuring”. Speculative and Critical Design (SCD) as a practise attempts to “dream up alternative futures” by posing “what if” questions, in order to open up alternative future visions—not how things are but how they could be (Dunne & Raby, 2013). However, SCD as design research is under-articulated as a methodology (Bardzell et al, 2012) and offers little to no insight about how to make things<sup>9</sup>.

The claim that SCD engages in “problem finding” as opposed to “problem solving” inadvertently leads to the provocations depending heavily on dystopian narratives, leaving the audience helpless and without a vision for action. This paper proposes an SCD method for a solution-driven, ‘rigorous’ imagining for long-term sustainability in the case of a 3D printed, optical solar cell as a speculative concept vision for climate action.

## 2. SPECULATIVE METHOD FOR ‘DESIGNERLY’ FUTURING

Foreseeing radically different futures beyond ‘business as usual’ depends on being able to visualize a future that doesn’t yet exist. Designing for such a future context depends on garnering valuable foresight that through certain design tools can help create a vision both desirable and feasible. The premise of this SCD process explores an iterative method that combines future studies, design fiction and product design to create speculative future artefacts that are focussed on creating a design solution; in this paper this solution is focused on creating a solar cell. Design fiction is explored here for a focused and creative way to think about possible future scenarios that broaden the solution space through designed artefacts. In this case, it is used to deliberate on the “real” possibilities of near and far future technologies of solar cells through narrative fiction. These fictional accounts create the “what-if” scenarios

<sup>1</sup> Terms like “biological annihilation” and “insect apocalypse” have often been used. In essence, it is the collapse of whole ecosystems as a result of variations large or small in climate patterns that organisms cannot adapt to and perish.

<sup>2</sup> The extractive forces that create our cities, infrastructure, industrial systems of agriculture, manufacture, etc. are all dependent on scouring the natural world of “resources. Resources that are in fact being shifted on continental scales. “Earth’s ‘technosphere’ Now Weighs 30 Trillion Tons, Research Finds.” n.d. Accessed April 22, 2018. <https://phys.org/news/2016-11-earth-technosphere-trillion-tons.html>.

<sup>3</sup> “Plummeting Insect Numbers ‘threaten Collapse of Nature’ | Environment | The Guardian.” n.d. Accessed February 13, 2019. <https://www.theguardian.com/environment/2019/feb/10/plummeting-insect-numbers-threaten-collapse-of-nature>.

<sup>4</sup> Resnick, Brian. 2017. “We’re Witnessing the Fastest Decline in Arctic Sea Ice in at Least 1,500 Years.” Vox. December 12, 2017. <https://www.vox.com/energy-and-environment/2017/12/12/16767152/arctic-sea-ice-extent-chart>.

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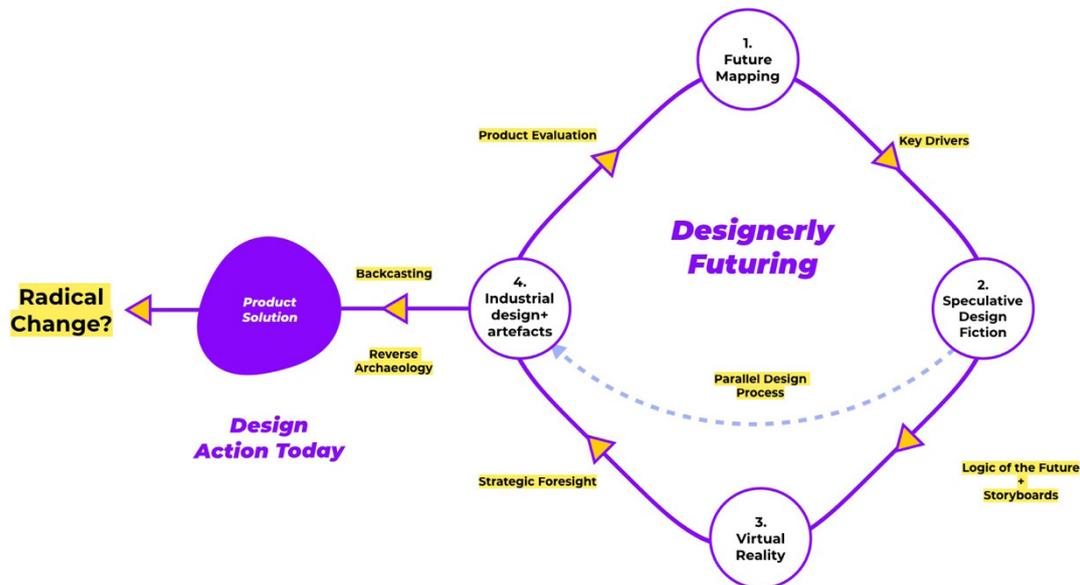
<sup>6</sup> Irfan, Umair. 2018. “Report: We Have Just 12 Years to Limit Devastating Global Warming.” Vox. October 8, 2018. <https://www.vox.com/2018/10/8/17948832/climate-change-global-warming-un-ippc-report>.

<sup>7</sup> Schwartz, John. 2018. “Paris Climate Deal Is Too Weak to Meet Goals, Report Finds.” The New York Times, January 20, 2018, sec. Science. <https://www.nytimes.com/2016/11/17/science/paris-agreement-global-warming-ia.html>.

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<sup>9</sup> Bardzell et al. observe that SCD uses Critical Theory for the provocations and thus has a general anti-method stance, which emphasizes meanings and effects of the artefact and not that of its creation. It ignores the individual agent of creation that is the author, ignoring his/her intention, the authors find out that this is a limitation to its application to design. This perhaps could be why critical design becomes an ‘elitist mystery’ like art itself.

and frameworks similar to film production, that make fictional worlds possible in cinema (Wille, 2015). The possibilities of these artefacts follows a certain narrative logic or diegesis that allows for the suspension of disbelief whereby the audience can believe the performative role of the artefact<sup>10</sup>, even if it cannot be proven to be real (Raven & Elahi, 2015). These so called “diegetic prototypes” create desirable technological possibilities as a “performative artefact” made real by contextualizing technologies through a narrative within the frame of speculation (Kirby, 2010). Designers thus enter these future narrative as archaeologists of the future, learning from and producing the artefacts from this imagined future (Candy, 2013). The future scenarios are chosen to envision better solutions to what exists today by garnering foresight from these speculative far future scenarios that are brought back and manifested in the here and the now, in this case, a solar cell. So long as the aim of the fiction is to discover an artefact from the broad solution space, apologetics can be used as a creative tool<sup>11</sup> to strategically justify or apologize for anomalous inconsistencies in the future scenarios without discarding possibilities (Shedroff & Noessel, 2012). Thus, in telling a compelling narrative of radically different futures, an encounter with a conflicting artefact may lead to a creative speculation of its own.



[Figure 1] A iterative, back-casting Speculative Design Method proposed for creating alternative product solutions today (credit: Author)

### 3. CASE STUDY: 3D PRINTED OPTICAL SOLAR CELLS

#### 3.1. Imagining Better Futures: Three Horizons, Design Fiction and VR

A speculative design fiction titled “Blockchain Radioactive” was created by projecting the “symptoms” of a radically hopeful future over sweeping horizons in the Three Horizons framework (Curry & Hodgson, 2008). The technological and socio-economic drivers projected here are research areas being pursued today while allowing possibilities for speculation. Using these future horizons as the backdrop, a futures poker game<sup>12</sup> was created for building radical future scenarios by forcing combinations of these symptoms of the future that would undercut, amplify or interplay with each other. Apart from written fiction, “Blockchain Radioactive” addresses the question of solar energy in a speculative future as been solved in the form of an “energy harvest”, visualized in virtual reality and film<sup>13</sup>. Each of them an exploration of the future scenario that is set in the post nuclear wasteland of Chernobyl. The narrative goes on to explore how an “energy staff” and a sentient “energy drone” together create the ritualistic “energy harvest” from sunlight, wind and radioactive soil. Being the designer here, the fiction provoked me to apologize (Shedroff & Noessel, 2012) and solve the design of the “energy staff”, by projecting existing technology from today. Thus, the solution was speculated to use a transparent solar ink canister with graphene electrodes<sup>14</sup> at the top, a carbon nanotube muscle<sup>15</sup> ‘hinge’ that bends in the wind in the middle and a mycelium (fungal) electrode that feeds on radioac-

<sup>10</sup> Taken from film theory, a diegetic artefact embeds within it the narrative diegesis/narrative logic. So, a lightsaber in Star Wars may not real in the real world but it is real in the narrative world. A lot of this depends on suspension of disbelief and narrative strengths of the world-building that the film plays with.

<sup>11</sup> In the book Make it So, the authors found themselves using the method in the cases where they looked at an interface that couldn’t work the way it was shown and “apologised” for it by thinking of ways that the interface could work the way it was depicted. Thus, in telling a compelling narrative of a radically different future, an experiential encounter might not need to provide a heavy burden of proof to begin with and sometimes conflict may lead to a speculation of its own.

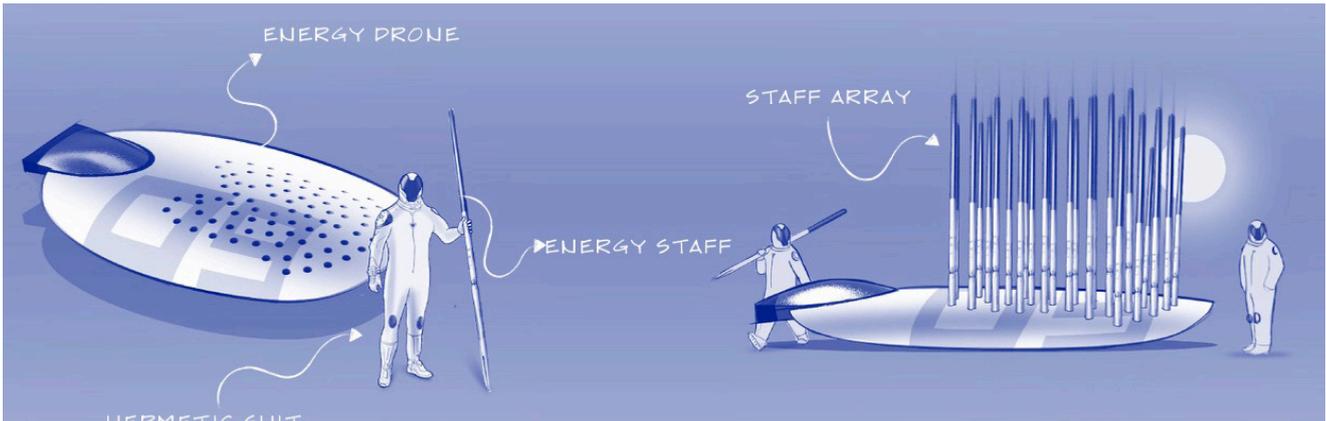
<sup>12</sup> The card game was inspired by Futures Poker, a game created by Strange Telemetry, a London based studio. “Projects.” n.d. Strange Telemetry. Accessed January 19, 2018. <http://www.strangetelemetry.com/projects/>.

<sup>13</sup> Link For Blockchain Radioactive: A VR Experience concept Film: <https://youtu.be/6ZQrbOBcWxk>

<sup>14</sup> “Electrons Flowing like Liquid in Graphene Start a New Wave of Physics.” n.d. Accessed March 11, 2018. <https://phys.org/news/2017-08-electrons-liquid-graphene-physics.html>.

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tive soil<sup>16</sup> at the bottom. The arrangement of these energy staffs would be inspired by the properties of a polar bear's hair that allows for absorption and internal scattering of light (Stegmaier, Linke, & Planck, 2009).



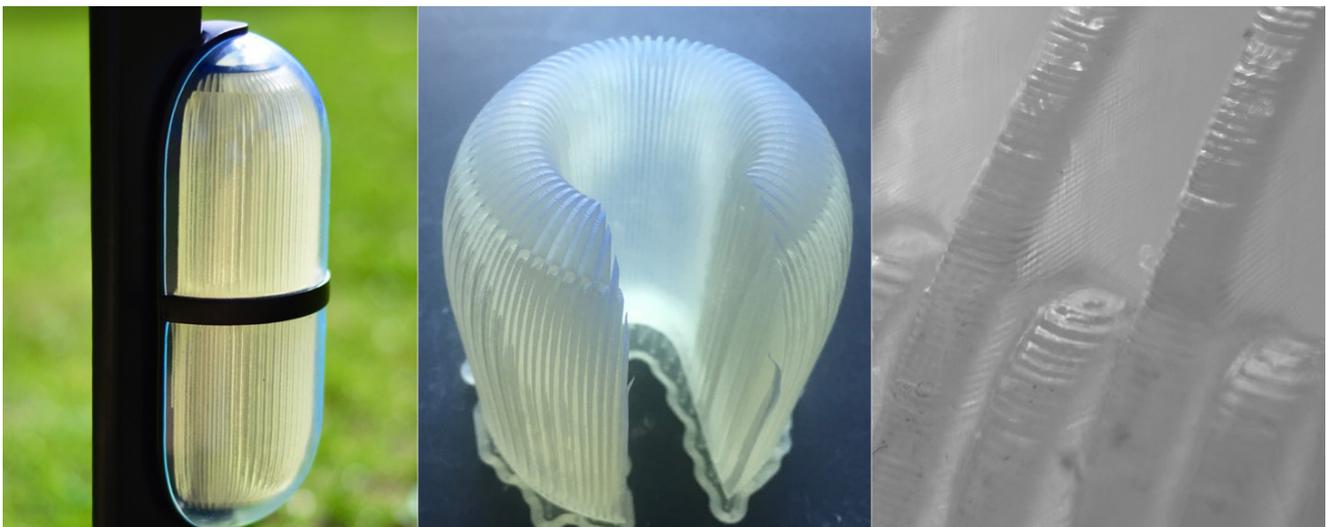
[Figure 2] Energy Harvest Ritual from the Design Fiction “Blockchain Radioactive” (Sketch credit: Author)

[Figure 3] Left: Experiential future VR scenario produced using the design fiction. Right: Concept Film shot in VR (Design and Image credit: Author)



### 3.2. Back-casted Solar Cells

Having explored a speculative future of solar energy, the challenge was to create a solar cell that could contribute to a solution and still point to a vision of long-term sustainability. This is where this project diverges from a traditional SCD project. In this case, the intention was to pursue a “pragmatic” back-casting that would point to a radical solution for solar energy today. The back-casting was done in order to manifest a solar cell that could allow for internal reflection and refraction of light within a 3D printed optical structure and that could be coated with graphene and produce energy from heat and sunlight. In keeping with existing technology, the concept here proposes making solar cells out of fibre optics<sup>17</sup> by coating the optic surfaces with solar inks such as dye-sensitized solar



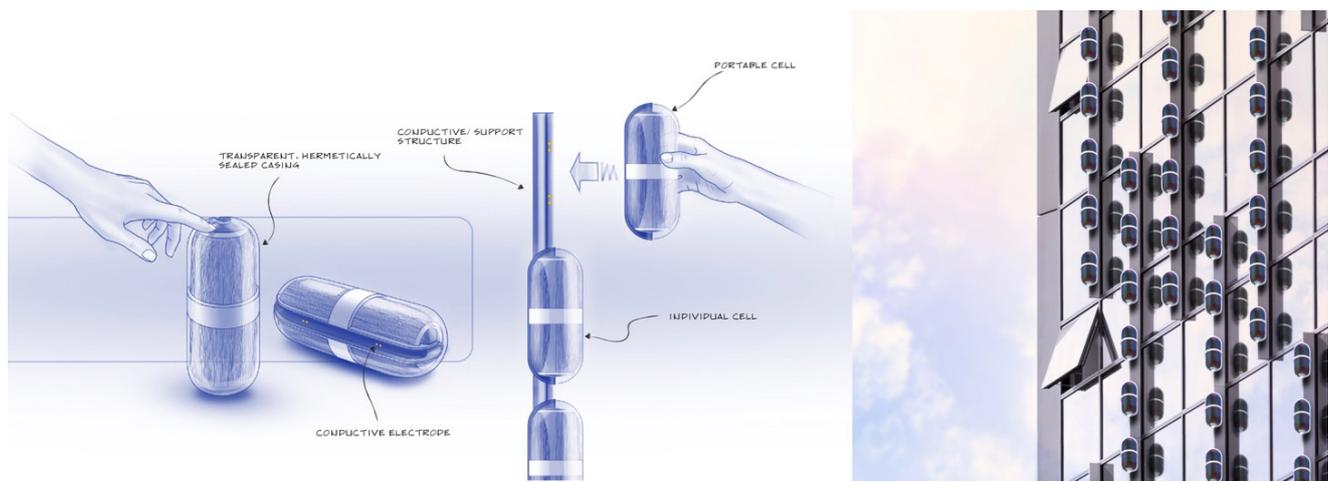
[Figure 4] 3D Printed Optical Solar Cell Concept showing optical structures with layers resolution 100 microns and made using existing LA printers with clear resin, without any surface treatment.

<sup>16</sup> Biello, D., & Biello, D. (n.d.). Do Fungi Feast on Radiation? Retrieved January 22, 2018, from <https://www.scientificamerican.com/article/radiation-helps-fungi-grow/>

<sup>17</sup> Bourzac, Katherine. n.d. “Wrapping Solar Cells around an Optical Fiber.” MIT Technology Review. Accessed March 14, 2018. <https://www.technologyreview.com/s/416052/wrapping-solar-cells-around-an-optical-fiber/>.

inks or perovskite solar solutions<sup>18</sup>. These optical structures are then etched with graphene nanotubes<sup>19</sup> that capture a large spectrum of visible and infrared solar energy vastly increasing efficiency. The modularity of the solar cells is inspired by glass sponges in the sea that grow scalable and resilient hierarchical optical structures called ‘spicules’ in different scales. The concept also incorporates digital fabrication for these cells that allow for 3D optical structures to be printed with precision and in a decentralized manner. As a manifestation of the radical future solution in the present, a 3D printed optical solar cell was produced by the author using existing resin based 3-D printers that can print at a resolution of 100 microns, structures that possess the ‘speculative’ optical properties.

On the question of climate action today, the solar cell can contribute to transforming our existing cities into solar power plants, without the need for massive infrastructure overhaul. When mounted vertically on dense urban skyscrapers, the cells could also additionally capture the reflections and scattered incident sunlight off of other buildings in addition to direct sunlight. At night, the ‘urban heating effect’ becomes a possible source of infrared radiation that the ‘graphene ink’ could capture thereby greatly enhancing the efficiency of these cells. If we challenge the notion of the ‘rooftop approach’ to solar, a possibility opens up where the vertical facades of existing buildings can be transformed into solar panels and cities thus become net generators of energy instead of net consumers.



[Figure 5] When mounted on vertical facades of buildings, these 3D solar modules capture reflections and scattered incident sunlight from other buildings as well. These cells could thereby transform cities into net generators of renewable energy. (Design and Image credit: Author)

#### 4. REFLECTIONS

Weaving different future scenarios around the position of “what if”, the future of solar cells questioned here was to engage not with how things are but how they “could be” and thus create a design intervention that facilitates long-term sustainability today. When dealing with the uncertain future, it makes sense to put forth speculations that may otherwise seem absurd from a ‘business as usual’ perspective since the proposed SCD method uses a far future scenario to construct a fragment from a world yet to be. In that respect the designed artefact allows for a form of in-ter-dimensional time travel that can probe, sense and respond to the fictional world as a normative everyday object that projects the designer’s values into a context of the future; a complex unknown. The point of this speculative method is to open up space for new possibilities for such ‘designerly’ visions and as such does not attempt to “prove” the solutions. The possible solution suggested here, a 3D printed optical solar cell, points to an infinitely scalable, modular solar cell that can be deployed in complex and varied combinations to create resilience for renewable energy transitions.

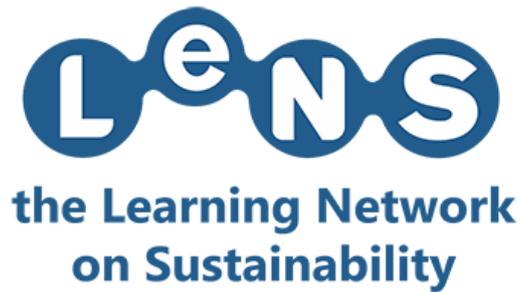
While it is important to dispel the myth that merely shifting to renewables from fossil fuels will be enough to transition to a sustainable future, the rigorous imaginings of the future of solar cells presented here suggests that speculative narratives built around technological artefacts can create a point of departure for technologies to over-come the framing within ‘business as usual’. Industrial Design praxis thus creates discursive spaces that strive to-wards, better long-term sustainable visions of the future not just by speculative “problem finding” but also by “prob-lem solving”. In such an SCD process, posing the question “what if” provides for possibilities that today’s research might take in creating the technological futures we want and still imagine possible alternatives to our existing solu-tions. In the absence of a perfect world with perfect solutions, this paper looks towards opening an alternative space in acting towards long term futures and sustainability decoupled from the dystopian visions of ‘business as usual’.

<sup>18</sup> “Printable Solar Cells Just Got a Little Closer: Research Removes a Key Barrier to Large-Scale Manufacture of Low-Cost, Printable Perovskite Solar Cells.” n.d. ScienceDaily. Accessed January 2, 2018. <https://www.sciencedaily.com/releases/2017/02/170216142800.htm>.

<sup>19</sup> “Proof: Graphene Can Convert Sunlight to Electricity.” n.d. Scienordic.Com. Accessed March 6, 2018. <http://scienordic.com/proof-graphene-can-convert-sunlight-electricity>.

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## **HOME TEXTILE: AN ANALYSIS OF ENVIRONMENTAL AND ECONOMICAL IMPACTS IN BRAZIL**

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### **ABSTRACT**

The goal of this paper is to analyze the environmental impact of the home textile sector in Brazil since 2010, in the production of raw materials and textile waste affecting the environment. The textile and garment sector is very relevant to the Brazilian economy as it is the second major job provider. The methods for this research will utilize information from systematic literature review and field investigation with technical visits and semi-structured interviews to companies linked to the home textile sector. With growing consumer awareness, the eco-friendly concept has become a trend in the home textile industry, which is considered the most environmentally damaging industry currently. The impacts of greater consequences of the home textile industry to the environment are: increase of solid waste, contamination of rivers and seas, contamination of the soil with sequels, it became infertile among others. This paper presents solutions to reduce them.

## 1. INTRODUCTION

The trousseau is popular from its antiquity to the present day, undergoing several modifications. These changes are reflected in the type of fabric, in the way it is made and in its market share. The most commonly used material is 100% cotton. The polyester / cotton blend is used to a lesser extent, although its advantages are shrink resistance and durability (Das Subatra, 2010). This study is to analyze the environmental impact of the home textile sector in Brazil since 2010, in the process of producing raw material and textile waste affecting the environment. The textile and garment sector is very relevant to the Brazilian economy as it is the second major job provider. The textile industry has generated 1,5 millions job opportunities in 2016 confirming its relevancy to economic and social impacts. (Iemi, 2018). The home textile production originally started with hand-made spinning and weaving by women who had this family responsibility. The introduction of design as a conceptual factor to improve the products creation, transformed the old trousseau into the modern concept of Homewear or Home Fashion, following fashion trends by improving shapes, colors, textures and patterns, so that home textiles became fashion. (Pinto, 2009). In the textile industry, cotton fiber is the most important natural material, especially considering eco-efficiency as it requires neither mechanical nor costly chemical treatment. It is washable and more resistant than wool, from its core it extracts the edible oil and the milling of its residues in bran is used for feeding the cattle or as fertilizer in planting. The methods for this research will utilize information from systematic literature review and field investigation with technical visits and semi-structured interviews to companies linked to the home textile sector. With growing consumer awareness, the eco-friendly concept has become a trend in the home textile industry, which is considered the most environmentally damaging industry currently (Das Subatra, 2010). The impacts of greater consequences of the home textile industry to the environment are: increase of solid waste, contamination of rivers, seas and soil. This paper presents solutions to reduce them.

## 2. RESEARCH PROBLEM / GOALS

Analysis of the environmental impact of the home textile sector in Brazil, in recent years, in the production of raw materials and solid waste in the environment.

## 3. THEORETICAL BACKGROUND

The present study carried out an analysis of four important points to give foundation to this article: the Textile Industry in Brazil; the bedding, table and bath linen sector; the productive process of cotton and its environmental and economic impact; and finally the Impacts of textile waste.

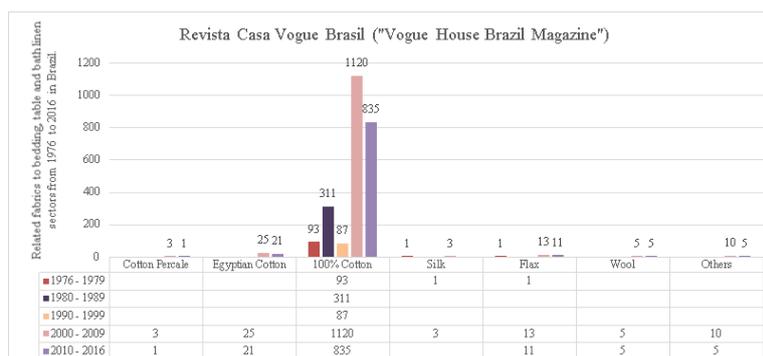
### 3.1. The Textile Industry in Brazil

The textile and confection sector is the second largest sector in Brazil in job creation. According to the “Ministry of Development, Industry and Foreign Trade”, in 2010, 1.7 million employees were registered, of which 75% of this amount is made up of female labor. It represents 3.5% of PIB and has a large volume of production, making a total of 9.8 billion pieces per year. The IEMI (2017) highlights the Brazilian textile and apparel production chain, both because of the importance of its production and because of its ability to generate jobs.

### 3.2. The Bedding, Table and Bath Linen Sector (Home Textile)

The composition of home textile (trousseau) including basic items like towels and sheets continue to be part of the wedding lists, varying in technical attributes such as the finish. According to Pinto et al. (2010), many trousseau companies have begun investing in design as a distinguishing factor, turning the old trousseau into the modern Homewear or Home Fashion concept, following fashion trends by improving shapes, colors, textures and patterns. This process transformed the marriage trousseau into a fashion product.

The author Laktim et al (2017) presents a study of forty years of publicity in a magazine of national and international impact to Vogue Living Brazil (Casa Vogue Brasil). Figure 01 shows the consumption of the most used materials in Brazil in bedding, table and bath linen products highlighting cotton fabrics due to their properties.



[Figure 1] Related fabrics to bedding, table and bath linen sectors from 1976 to 2016 in Brazil. (Font: Laktim, 2017)

The largest growing markets in all categories of home textile products are in Brazil, Russia, India and China. The World Trade Organization's World Report on the Textile Market (2005) showed that the United States was the largest importer of domestic textile products (34.3%), followed by Germany (11.6%), Japan (10% 9%), the United Kingdom (8.3%), France (6.5%) and Canada (4.2%). On the other hand, the largest exporter of domestic textile products was China with 33.4% of the world market, followed by Pakistan (12.1%), India (9.7%), Turkey (6.6%), Portugal (4.8%) and Mexico (4.5%). It is believed that China will remain the world leader in exports, while it is uncertain that the US will be the largest importer of home textile products (Das Subatra, 2010).

### **3.3. Cotton: Its productive process and the environmental and economic impact**

Cotton is among the most respectable fiber crops in the world. According to the Brazilian Association of Cotton Producers - ABRAPA (2018), around 35 million hectares of cotton are planted all over the world, with about 1.13 million hectares in Brazil. In the international market there is the ideological belief that it should be possible to make more sustainable textiles. Das Subrata (2010) states that industries recognize that the environmental impact of textiles lies in the supply chain, from chemical fertilizers and insecticides to chemical treatments used in refining, spinning, dyeing and weaving. Novotex has been instrumental in mapping this impact and helping suppliers use more sustainable methods. The company worked a "log book" for textiles to map the chemicals used in the production process.

Global cotton industry includes more than 100 million farm families across 75 countries (ICAC and FAO, 2015). Cotton is one of the most widespread crops in the world in terms of land area and its supply chain actors range from small farmers, intermediates, traders and ginners, to sophisticated mills, textile processors, brands, exporters, retailers and final consumers (Glin et al., 2012). However, conventional cotton production greatly overuses and misuses agrochemicals that have an adverse serious impact on the environment and agricultural workers (Chaudhry and Wakelyn, 2006; Rieple and Singh, 2010; Pal, 2014; Pal and Gander, 2018). Excessive use of insecticides and pesticides can significantly affect the natural biological control system, pollute soil and water resources (Chaudhry and Wakelyn, 2006; Yang et al, 2017).

At the same time, the interest in the use of sustainable raw materials has increased (Geissdoerfer, 2017), due to market demands on sustainable initiatives, the growth of awareness campaigns by some of the world's major retailers and clients engagement (Rieple and Singh, 2010; Diabat et al., 2014). Sustainability has become one of the key factors for long-term business success (Macchion et al., 2015). Sustainable development has become, one of the strategic focal points of organizations (França et al., 2017). A sustainable business model aims at improving the economic, environmental, and social effectiveness integrated (Geissdoerfer et al., 2016), requiring a holistic approach to resource consideration and addressing the needs of partners and customers (Amit and Han, 2017). Organic cotton is considered more sustainable than conventional one, an environmentally preferable product, of added benefit to the environment, farms and consumers (Chaudhry and Wakelyn, 2006). Cotton is a strategic crop that it is grown in many countries (Chaudhry and Wakelyn, 2006; Adanacioglu and Akin Olgun, 2010). It is a hugely important crop in countries, such as India, China, United States, Brazil, Turkey, Australia (Rieple and Singh, 2010). It is the main natural fiber used in the textile industry (Fletcher, 2010). However, cotton is a leading agricultural non-food commodity associated with soil degradation, water pollution and pesticide poisoning due to high levels of agrochemical inputs (Chaudhry and Wakelyn, 2006; Caniato et al., 2012).

### **3.4. Impacts of Textile Waste**

The Institute of Industrial Studies and Marketing – IEMI (2014), in its analysis of the textile and clothing sector, identified that in 2013 the textile and clothing chain generated around US \$ 58.2 billion, which consists of 5.7% of the total value of the production of the Brazilian processing industry, eliminating the mineral extraction and civil construction trades, which fulfill the secondary sector of the Brazilian economy. However, there are a large amount of unused and discarded textile waste in landfills in Brazil, in 2012, 9,829,928 kg Liq of textile flaps and fabrics composed of silk, wool, cotton, artificial and synthetic fibers were imported, which is equivalent to US \$ 11,421,644.00 (FOB - Free on Board). This reveals the enormous demand for textile flaps for recycling and various purposes, as well as the production of blankets (for industrial and geotextile purposes), coatings, composites for industrial and civil construction purposes, fillers, yarn and string production, among others (Sinditêxtil-SP, 2013). Wang (2006) points out that recycled fibers are produced in a secondary processing cycle. To obtain them, the mechanical processes of waste defibration occur. Conventionally, the wastes are pre-treated by cutting or separating and then transported to undergo proper recycling, converting the consolidated material into individual fibers.

According to the study by Zonatti (2015), the Brazilian market involved in textile reuse and recycling opts to import instead of taking advantage of the national textile waste, in abundance, due to a series of problems related to the poor management of this material. There are various types of excrement mixed with waste, mixing of different raw materials and difficult separation, lack of fiscal and tax incentives relevant to textile recycling, few skilled and specialized labors. It emphasizes that in addition to disdaining national textile waste from industries and clothing, the Brazilian market for textile reuse and recycling, disregards the potential for inclusion of garments discarded by people after consumption, lack of reverse logistics.

#### **4. RESEARCH METHOD**

As for the objective this research is applied. Regarding the approach is qualitative-quantitative. The objectives are descriptive exploratory. The procedures used to collect information were bibliographic and documentary research, field research with technical visits and semi-structured interviews with companies related to the home textile sector in Brazil and Portugal.

#### **5. RESULTS AND ANALYSIS**

With growing consumer awareness, the concept of eco-friendly has become a trend in the home textile industry. Brazil is among the top ten world markets for the textile industry, it is the second largest supplier of indigo and the third largest producer of knitwear. Brazil is self-sufficient in cotton production and a world reference in beachwear, jeans and homemaking, producing 9.8 billion pieces of clothing per year, of which approximately 5.5 billion pieces of clothing (ABIT, 2017). In Brazil, the home line was the one that had the greatest growth from 2010 to 2014, with a high rate of 14% (IEMI, 2015). Therefore, the innovation models corroborate the indicator of the systematization of the procedure of the evolution of the design and the home fashion industry, and the increase of participation in the market economy is its main goal. As a consequence, this study addresses an analysis of the consciousness of the industries in adopting and making their customers aware of consumption of eco-friendly products. According Das Subrata (2010, p.215):

...India launched the eco-labelling scheme known as 'Ecomark' in 1991 for easy identification of environment-friendly products. Any product, which is made, used or disposed of in a way that significantly reduces the harm it would otherwise cause the environment, could be considered as environment-friendly product.

Two companies were interviewed, one national and one international, in Brazil the largest textile company, the Coteminas Group, and in Europe the Portuguese company More Textile, both with historical context of achievements in the bed, table and bathroom market.

The Coteminas Group in an interview of CEO Mário Sette highlights the new technological facilities to improve production and product quality and reduce environmental impacts such as the implementation of circular economy. He also underscores the new retail culture and how they have had to adapt market changes to product diversification from a 3,000 SKU (Stock Keeping Unit) in minimal batches, which was unthinkable in the past. There has been a profound change to meet this consumer who is increasingly fragmented, within each economic class and with completely different profiles. Consequently, its intention is to reduce the quantity of pieces in the same model, to reach all types of taste, and to produce its products from the demand, thus avoiding the discard of old collections and the excess of stocks.

In the company More Textile was interviewed Mrs. Isa Rodrigues, she talks about the appearance of the More Textile Group and its achievements in recent years, highlighting the awareness of reuse of textile waste in the production of fabrics, and leftovers in the cutting process. She also underscores the awareness of acquiring organic cotton in its collections that has the least environmental impact and as a process to make the consumer aware of acquiring a sustainable product, even if its consumption is low, due to the few suppliers of this raw material in the world, high cost, production does not meet demand.

The future of the home textile industry nowadays depends a lot on the eco-friendly as: fibers, natural dyes and chemicals of less impact to the environment, for example organic natural fiber fabrics and biodegradable fabrics, which decomposes rapidly after land disposal. Consumers and producers today with designers also have to get a look at the home textile. The society demands home textiles that satisfy the conscious or "green" consumer.

#### **6. IMPACTS ON SUSTAINABILITY**

The impact of the greater consequences of the home textile industry on the environment are: increase of solid waste, contamination of rivers and seas, contamination of the soil with sequels, like it becoming infertile among others. This study presents topics that can diminish these impacts, presenting two industries that already have this awareness and adopt sustainable forms and of less environmental impact.

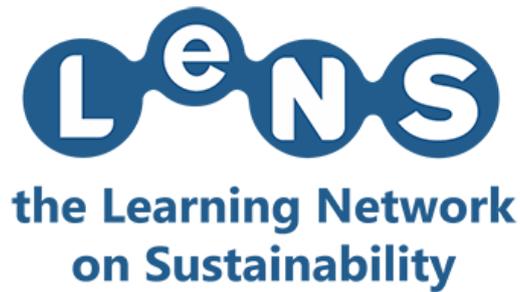
#### **7. CONCLUSION**

To minimize environmental impacts, we can use tools for recycling, education and knowledge to reduce impacts. The awareness of companies and consumers in discarding textile waste, knowledge of the raw material, the origin of the product and the impact on the environment of its production are essential. We can conclude that all environmental impacts in relation to textile consumption can be reduced from the disclosure and incentives passed on to manufacturers and final consumers and with political incentives implanted. Large amount of wastewater is generated in textile industry due to the intensive water consumption and chemical usage (Fletcher and Grose, 2012; Pal and Gander, 2018). Researchers and practitioners are devoting increased attention to environmental sustainability, as they face the challenge of achieving a balance between environmental and business needs (Caniato et al., 2012). As sustainability labelling is gaining momentum in the global textile industry, opportunities for market expansion

are increasing. Market innovation in its production procedures and clients engagement, can contribute to communicate to stakeholders the companies practices regarding cultural, social and environmental aspects (Magnusom et al., 2017; Matthews and Rothenberg, 2017).

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## **PRODUCT DESIGN FOR SUSTAINABILITY – GUIDELINES FOR THE LIFE CYCLE DESIGN OF OFFICE FURNITURE**

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### **ABSTRACT**

Competitiveness of the office furniture industry on the global market is strongly affected by an ever-increasing focus on environmental performance of products. Hence, verifiable information of the environmental compliance of products throughout their whole life cycle is demanded from stakeholders of the furniture industry, which needs to be based on scientific proposition. This paper investigates how to support companies in designing environmentally sustainable office furniture, considering all phases of the life cycle. It deals with the identification of the environmental profile and main environmental impact potential of the office furniture product group aiming to develop an instrument which orients towards sustainable design.

A Life Cycle Assessment (LCA) has been conducted to evaluate the environmental profile of five different office furniture product categories. Data drawn from publicly available Environmental Product Declarations have been evaluated with the software programme SimaPro. Furthermore, a system to prioritise Life Cycle Design (LCD) strategies for environmental sustainability has been adopted and a workshop for generating ideas for an LCD tool related to the design of office furniture has been carried out.

An important factor is that the majority of environmental burdens is significantly linked to the pre-production stage which implies that environmental impacts related to the furniture derive mostly from raw materials extraction and its processing. The final outcome of the research is a handbook and a tool with product type specific guidelines which assists in the product design process and addresses companies, i.e. engineers and designers.

Keywords: Life Cycle Design; Design guidelines; Office furniture; Environmentally sustainable design

## 1. INTRODUCTION

The debate on the environmental concern has reached high strength nowadays. Regarding the office furniture market, which is focused in this research, growing environmental consciousness increases influence on the furniture industry. Accordingly, many market participants demand verifiable documentation of the environmental performance of products throughout their entire life cycle, which needs to be found on scientific methods (The Norwegian EPD Foundation, 2018).

Today, the office furniture product group confront new and competing claims and significant challenges are faced by manufacturers in the marketplace (Luccitti, 2005; Smieja & Babcock, 2017). Regarding this issue, supporting methods referring to design for environmental sustainability has been evolved. Even though, developed methodologies and tools for design for eco-efficiency are limited due to critical issues related to difficulties of examine complex systems, some sustainability research centres provide consultancy for companies and manufacturers by developing specific tools for furniture industries in order to foster and support the environmental compliance of products. The objective is to offer organisations a tool for the development of a culture and design practice by guiding them towards new technical and strategic knowledge which promotes the emerging generation of products with high eco-efficiency combined with economic and competitive value (Vezzoli, 2018).

According to Vezzoli (2018) there is an explicit need to establish a more consistent approach to design methods for the implementation of low environmental impacting design in real company practices and culture. This can be achieved not only through a wider diffusion of supporting instruments and methods and operative expertise but also through practice of a *functional* and *life cycle thinking* approach.

This research investigated how to support companies, i.e. engineers and designers, in developing environmentally sustainable office furniture, considering all phases of the life cycle which are: pre-production, production, distribution, use and disposal. The aim was to develop an assisting instrument which orients towards environmental sustainability in the office furniture sector and specifically support designers in the development of low impacting furniture products.

## 1. GUIDELINES FOR LIFE CYCLE DESIGN

The development of product type specific guidelines can further the aims of sustainable development by supporting the design process in reducing environmental impacts (as e.g. global warming, ozone layer depletion, acidification, eutrophication and abiotic depletion potentials), taking into account all phases of the life cycle (Vezzoli & Sciama, 2006). Specific objectives of such kind of consultancy for companies is to identify environmental impacts as well as assessing design priorities which are necessary to improve product's environmental quality. In addition, it aims to promote diffusion of a new design culture as well as to develop a tool including a set of environmentally sustainable guidelines, strategies and design advisements for organisation's internal use which addresses designers and engineers who deal with product development (Vezzoli, 2018).

## 2. METHODS

For the identification of the environmental impacts of office furniture which is the objective of this study, different research methods have been conducted. The first research carried out was a desk research. Environmental Product declarations (EPD) of current existing office furniture have been investigated in order to identify the life cycle stages with the highest environmental impact. All EPD's which are involved are type III environmental declarations which provide quantified environmental data and accord to ISO 14025. The parameters are based on ISO 14040 and ISO 14044. Data of office furniture of five different product categories as task chairs, visitor chairs, office desks, (conference) tables and storage furniture has been examined. These EPD data which provided necessary information about the product's life cycle impacts has been drawn from documents which are publicly available on the internet. Data examined were drawn from *The Norwegian EPD Foundation*, as well as from the company and office furniture manufacturer *Wiesner-Hager Möbel GmbH*.

After the definition of the main impacting life cycle stages, a Life Cycle Assessment (LCA) has been carried out in order to provide specific information about those stages and to define the environmental impact of each single life cycle stage in a more detailed manner. Data drawn from publicly available EPD studies have been evaluated with the LCA software programme SimaPro which contains the latest databases.

In a further step, a tool for Environmental Design Priority Indicators (IPSA) has been applied in order to define the priorities of general Life Cycle Design (LCD) strategies<sup>1</sup> for the furniture products. The application of IPSA encompasses calculation tables with algorithms that use the results of the LCA's for the determination of potentials for reducing the environmental impact for each strategy, as well as for comparison between each other. The objective was to evaluate which LCD strategies are more relevant for a certain type of furniture. Additionally, a workshop about Life Cycle Design specification for office furniture has been conducted in order to define product type specific guidelines for office furniture. The participants of the workshop were composed by professors (Prof. Vezzoli and

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<sup>1</sup>General guidelines for environmentally sustainable design are available in 'Design for Environmental Sustainability', (Vezzoli, 2018).

Prof. Scullica) and two design students from the Department of Design of the Politecnico di Milano. General LCD strategies for environmental sustainability have been considered as a basis for the development of specific guidelines for the different office furniture products. The Brainstorming technique has been used to generate a draft of those guidelines which thereupon has been further elaborated.

### 3. RESULTS

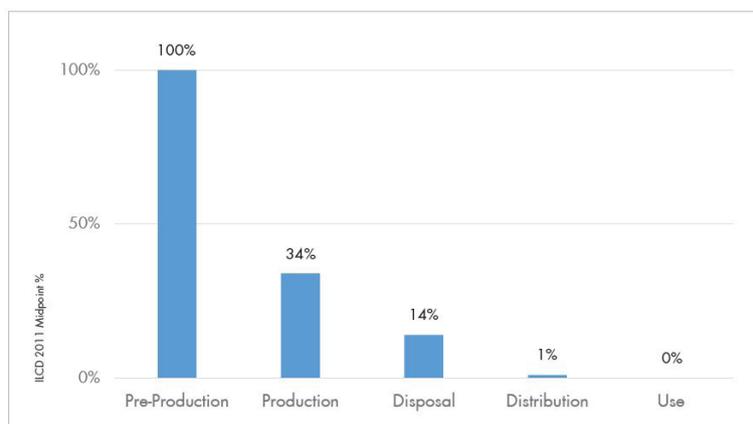
The final result of the research are product type specific guidelines and a digital tool for the sustainable development of office furniture that assists in the product design process and addresses companies, i.e. engineers and designer. The guidelines refer to a handbook which has been developed in the framework of the research and is available as free open source at [www.lens-international.org](http://www.lens-international.org) (see Fig.1).

Guidelines presented in the handbook provide a set of procedures and tools to orient the decision-making process (i.e. the design process) towards the objective of reducing environmental burdens. The developed digital tool includes the compiled guidelines and provides an idea board which can be used from designers to generate specific and explicit ideas that aim to achieve the development of low environmental impacting office furniture products. For this purpose, easily upgradable idea boards as shown in Fig. 2 can be used in workshops or meetings where a team of experts practise brainstorming. Both, the handbook with office furniture specific guidelines and the related tool are available under copyleft for everyone who is interested in the development of environmentally sustainable office furniture.



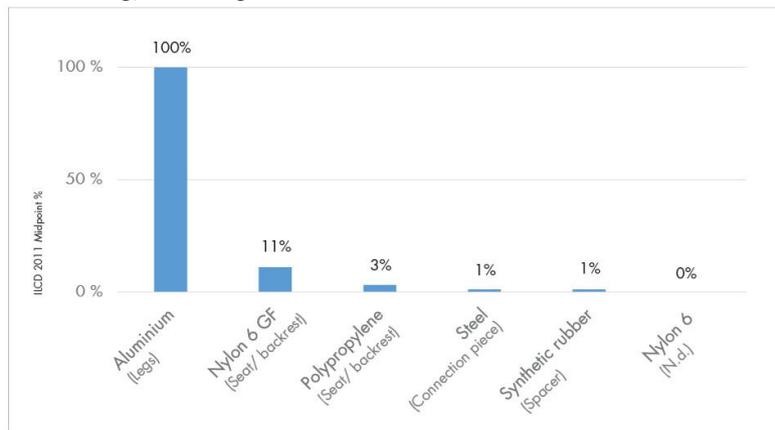
[Figure 1] Handbook with product type specific guidelines, 2019 (Personal collection).

Results of the Life Cycle Assessment which has been carried out on different office furniture products has been a very crucial part of the process of the development of office furniture specific guidelines. They reveal the most impacting life cycle stages, materials and production processes as well as impact potentials of the distribution, use and disposal stage referring to different office furniture products. Key findings of the performed LCA support that the majority of environmental burdens of all assessed office furniture products is significantly linked to the pre-production stage which implies that environmental impacts related to the furniture derive mostly from raw materials extraction and its processing. The second main impacting stage is the production stage, which refers to the production of components, assembly and final making of the product. Another fact is that the source with the lowest environmental impact potential is the use stage. Environmental impacts of the life cycle of a task chair are presented in Fig. 2 (The Norwegian EPD Foundation, 2016) as a representative example. All assessed products of the five office furniture categories provided very similar results as those illustrated below.



[Figure 2] Environmental impact of life cycle stages of a visitor chair, LCA results, (The Norwegian EPD Foundation, 2016).

Figure 3 (The Norwegian EPD Foundation, 2016; European Commission, Joint Research Centre, 2012) illustrates the environmental impact potentials of the task chair's pre-production stage. Each material has a different contribution to environmental burdens. The materials have been assessed with respect to their weight that appears in the assessed product. It is to point out that primary aluminium shows very high impact potentials compared to other common materials used in office furniture. Overall, metals revealed generally more impact potentials than materials as plastics and wood. In addition, results of the Environmental Design Priority Indicators (IPSA), which have been applied to determine the priorities of LCD strategies, showed that the LCD strategy of *Product use extension* has the highest priority regarding office furniture production. This is followed by the strategy of *Material reduction*, which has been defined as a strategy with high relevance.



[Figure 3] Environmental impact of the pre-production stage of a visitor chair, LCA results, (The Norwegian EPD Foundation, 2016; European Commission, Joint Research Centre, 2012).

#### 4. DISCUSSION

The conducted study investigated the environmental profile of office furniture in order to develop an assisting instrument which orients towards environmental sustainability in the office furniture sector and support companies, i.e. engineers and designers, in developing environmentally sustainable office furniture, considering all phases of the life cycle. The Desk research as well as the Life Cycle Assessment revealed valuable insights that have been thoroughly considered for the development of specific guidelines for the design of office furniture. The LCD guidelines are designated to be incorporated into the design process, where they foster the integration of environmental requirements in product development. They offer an assisting instrument for designing low environmentally impacting office furniture and support the designer in orientating design decisions towards an effective implementation of sustainability. However, due to the fact that technologies evolve over time, some limitations can appear and certain issues might be unpredictable during the design process. Considering that an office furniture product has a lifetime of several years<sup>2</sup>, it could be the case that, e.g. technologies of recycling or other disposal processes are different than meant to be when the product has initially been designed. That means that design guidelines run the risk to become partly obsolete over time. Not only technological and economical changes, but also changes in office and workplace needs to be considered as an important factor. Our working environment is changing constantly and increasingly faster. Tech-



[Figure 4] Digital tool with specific LCD guidelines, 2019 (Personal collection).

<sup>2</sup> EPD's of office furniture products which has been assessed considered a product lifetime of 15 years.

nological progress, globalisation, flexibilisation and demographic change, are drivers and indicators of the evolving working environment.

Those changes in office environment and new ways of working can strongly relate to the sustainability and requirements of designing office furniture. Thus, guidelines for the development of environmentally sustainable office furniture need to adapt to new circumstances and new situations in which office furniture will be used in the future. For instance, office furniture has to meet new requirements in terms of utility value, stability, maintenance and longevity regarding emerging hot desking approaches and prevalent coworking spaces where one desk is assigned to many different employees i.e. users. Another example is that furniture consistently has to adapt to new needs of the future of work which is driven by effective communication, collaboration, employee experience and flexibility. In the case of fast-changing office structures, it should be avoided that furniture become obsolete prematurely regarding its function. Consequently, it is important to emphasize that the developed guidelines are no rigid rules and need to be understood as indications and advises which can be updated and extend over time. To enable adaptation of guidelines to those previous described changes, it is necessary to design flexible solutions. The issue of upgradability of the design guidelines has been considered in the research project by providing a modifiable digital tool which enables their constant update.

On the other hand, referring to the overall concept of sustainable office furniture including its real application, it is important to indicate and advise that measures aiming at sustainability should not only be taken regarding the production of office furniture but also regarding its use and maintenance. Insight of the research revealed that high attention should be paid to the strategy and the related design guidelines that deals with the office furniture product's use extension. Consequently, it is very crucial as well to pay attention to the use phase and the relation between the office furniture products and those who use and maintain them.

According to Vezzoli and Manzini (2008), 'the impact during the stage of usage is more of a socio-cultural phenomenon, since this request, to a different extend, changes in the way products ... are utilised' (p. 65). In other words, in order to aim entirely and with a widespread approach at life time extension of office furniture, not only instructions should be provided aiming at sustainable office furniture production but also to those who use, buy and maintain the furniture.

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## **ON THE COLLABORATIVE MODELS FOR DESIGN SCHOOLS ENGAGING IN THE SUSTAINABLE DEVELOPMENT OF TRADITIONAL BAMBOO CRAFTS**

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### **ABSTRACT**

The traditional bamboo crafts as China's valuable cultural heritage is faced with recessions. Design schools can integrate resources to provides solutions to the sustainable development of the bamboo crafts. Characteristics of stakeholders in the rural craft collaboration should be fully taken care of so as to achieve win-win outcomes with equality, which is conducive to long-term collaboration. With bamboo weaving craft of Xiangxi and Xiaoyu raw bamboo craft of Yiyang in Hunan Province as the study objects and based on fieldwork, workshops, design courses and practices, this study analyzes the advantages and limitations of local collaboration, on-campus collaboration and production collaboration and validates the positive impact of collaboration on stakeholders. In addition, collaborative models driven by culture, teaching, activity and service design are identified as four models that facilitate the development of the traditional bamboo industry based on the cases of other design schools in China.

key words: Collaborative model, Stakeholders, Traditional bamboo crafts, Sustainable development.

## 1. INTRODUCTION

Extensive design efforts have been made over the past few years to reinvigorate traditional crafts, particularly the traditional bamboo crafts in China. Design schools as well as organizations are looking for collaboration in this emerging design sector. Bamboo is the material with excellent ecological nature that best represents the culture and tradition of the East and China in particular. However, traditional bamboo crafts are experiencing recessions, which makes the engagement of design schools significant for the sustainable development of both the environment and the society. As noted by Manzini (2011), “In the emerging scenario, therefore, design schools, with their tremendous potential of students’ enthusiasm and teachers’ experience, represent a social resource: a potentially powerful and useful player in the transition towards sustainability” (p. 1).

The mainland China, Taiwan and Japan in Southeast Asia as the major regions where bamboos grow have become key areas for collaboration practices between the traditional bamboo industry and design schools. This paper takes China as the study area. Design schools are non-profit entities with strong innovation capabilities and initiative. Design schools can be specialized academy of fine arts or design schools in comprehensive universities in China. With the purpose to enrich teaching and research activities, scholars and teachers carry out a wide range of practices and experiments by pooling on-campus resources and bridging bamboo craftsmen and schools.

The Academy of Arts & Design of the Tsinghua University worked with Yong’an Municipal Government of Fujian Province on Bamboo 20+ Program (2018); Shanghai Academy of Fine Arts organized Workshop on International Creative Bamboo Design and Study Program for Inheritors of Bamboo Crafts (2016); the School of Urban Planning of the Central Academy of Fine Arts took Dongyang of Zhejiang Province (2017) and Daoming Town of Sichuan Province (2018) as the base for students’ creation practices; and China Academy of Art, Guangzhou Academy of Fine Arts, Jiangnan University, Taiwan University of Kaohsiung, Taiwan Yunlin University of Science and Technology, etc. have held several design workshops on bamboo crafts or published graduation works themed on bamboo crafts. Governments strongly support academic research and development of bamboo crafts initiated by design schools by granting art foundations or social science foundations.

From these collaboration practices, it can be found that design schools are taken as an essential factor that facilitates inheritance and innovation of the traditional bamboo industry because they are with vision, innovation and social impact. For us, the collaborative process is of social significance. As non-profit organizations, design schools aim to address social problems faced by the traditional bamboo industry through social innovation. In other words, the solutions should be more productive, efficient and sustainable, with the value created belong to the whole society instead of any individual (Phills, Deiglmeier & Miller, 2008).

Collaborative models vary in practices. This paper firstly summarizes the research approaches adopted by design schools for their involvement and the challenges. Different collaborative types are then compared based on our 3-year practices and research on the bamboo weaving craft in Xiangxi and Xiaoyu raw bamboo craft in Yiyang of Hunan Province. Strengths and shortcomings of different collaborative types are compared based on our case study. The goal has changed from enriching teaching activities to achieving win-win outcomes among stakeholders via cross-disciplinary approaches. This paper also studies the collaborations of other design schools, summarizes the collaborative models and their characteristics based on different drives. Impact of such practices and methods on different stakeholders as well as limitations with this study are analyzed.

## 2. RESEARCH METHOD

Before discussions, the definitions of two pairs of terms should be distinguished. The first pair is cooperation and collaboration. Cooperative work is a task that is accomplished by dividing it among participants, where “each person is responsible for a portion of the problem solving”, and collaborative work is “the mutual engagement of participants in a coordinated effort to solve the problem together” (Roschelle and Teasley, 1995). Cooperation is more focused on working together to create an end product, while successful collaboration requires participants to share in the process of knowledge creation (Dillenbourg, Baker, Blaye & O’Malley, 1996; Roschelle and Teasley 1995). Joint efforts and knowledge transfer among all participants are valued, which decides the collaborative models to be the research content.

The second pair is co-design and participatory design. Neither of them has formed convincing systematic knowledge for promotion and replication (Zhong Fang, Liu Xin, 2018). Nonetheless, co-design focuses on design while participatory design values democracy (Shi Di, 2017). There have been no authoritative definitions for participatory design and co-design. Since the 1970s, collective creative practices have been taken as participatory design in Europe (Sanders & Pieter, 2008). Generally accepted definition of co-design is brought about by Sanders & Pieter to “refer to the creativity of designers and people not trained in design working together in the design development process” (2008, p.2). Collaboration discussed in this work reflects democracy. Schools are the dominant power and lead the collaboration process with the identity of experts, focusing on the equal participation and contribution of all stakeholders rather than the design results. Participatory design would therefore be mentioned in the context later.

Rural craft collaboration is formed when design schools are engaged in the development of traditional bamboo industry. Stakeholders involved in this collaboration can be anyone who might be the influencing factor or the influenced factor of the project. However, the power of design schools is limited; so is the power of design in social

design. As stated by Chen, Cheng, Koskinen and Hummels, “Social design in its current stage may do well at the scale of a village or an informal organization, but its prospects of success are far smaller when it has to deal with the abstract structures of governance typical to late modernism” (2015, p.3). Three key stakeholders, namely the organizers (scholars or teachers), design students and bamboo craftsmen, are identified based on our case study. Different stakeholders of the project vary in interests, goals, career ethics and contributions. Table 1 lists the correlation and impact of stakeholders in collaboration.

[Table 1] Correlation of Stakeholders in Collaboration

Stakeholders	Interests	Goals	Career Ethics	Contributions
Organizers (teachers or scholars)	Individual teaching and research interests	Teaching and academic obligations	Teaching responsibilities and sense of social responsibilities	Academic and design integration, organizing skills and abilities to pool on-campus resources
Design Students	Individual interests and leaning passion	Enhancement in designing experience	Self-growth and sense of social responsibilities	Innovative and new perspectives and aesthetics
Bamboo craftsmen	Contact with the outside world	Increase in incomes and vision	Passion for, dedication to and pride in bamboo crafts	Knowledge in bamboo crafts and traditional culture, plus aesthetics

China’s traditional bamboo crafts are well preserved in rural areas. Thanks to the popularization of the Internet in China, middle-aged bamboo craftsmen involved in this project are able to access the Internet with mobile phones. They can stay “on-line” though daily communication is not timely. Nonetheless, they live far from cities and manufacture bamboo products at home where facilities are not in place. Ideally, teachers and scholars as the organizers, as required by sociology and anthropology, are expected to lead the students to get immersed in rural communities so as to understand local culture and residents. Students would be separated from local culture and produce superficial designs if failing to understand the environment where the crafts are rooted and their symbolic significance. However, limited by many factors, it is impractical for the organizers to lead students to do long-term fieldwork. Moreover, bamboo craftsmen are willing to learn about urban life and reflect on their culture and crafts. Participatory approach is adopted, with bamboo crafts learning being the core of the collaboration process. We attempt to abstract theories on processes, actions and interactions from the perspective of participants. Win-win outcomes with equality are the key to maintaining sustainable collaboration. But it’s not easy to achieve an equal contribution or collaboration, as Murray (2010) wrote in the following comment about the inequality of rural craft collaboration: “The wide difference in education between designer and (local) artisan constitutes a difficult barrier” (p. 19) .

### 3. CASE STUDY: PRACTICES OF GDUT

#### 3.1 Background

In order to explore effective models for the engagement of design schools, traditional bamboo crafts from two areas of Hunan Province are selected: one is the Xiaoyu bamboo craft in Yiyang, which is one of non-tangible cultural heritage of China; and the other is the bamboo weaving craft in Xiangxi, which has been rated as the non-tangible cultural heritage of Hunan. The Xiaoyu bamboo craft have lasted for over 600 years. Bamboo with a diameter of less than 5 cm are used to create various appliances after over 30 processes. In the dialect of Yiyang, “yu” as the core craft refers to bend to shape the bamboos after heating so as to get beautiful curve shapes and stable hoop structures. With a history of over 1000 years, Xiangxi bamboo weaving can be used to manufacture products for both daily life and farming purposes. Fine weaving to manufacture craftwork such as botanic dyeing and pattern weaving has been developed.

Unlike bamboo carving or bamboo marquetry crafts that value art, these two crafts are both folk arts by the mass, with the products being widely applied in daily life. Most of the products are affordable daily necessities that can be massively manufactured (Yanagi, 1955). The functionality of them makes engagement and participation of modern design possible. However, just like other traditional crafts, the bamboo crafts are faced with social, economic and cultural challenges during social transformation. Traditional bamboo products have been replaced by massive industrial products. The difficulty in mastering the techniques, the intensive labor involved and the low prices of bamboo products drive people away from this industry. In addition, collaboration does not last although many schools as well as organizations have been engaged in traditional bamboo crafts.

School of Arts & Design of Guangdong University of Technology (GDUT) first started collaboration with Xiangxi and Yiyang in 2015. Guided by Fang Hai’s program of Arts in Chinese National Social Science Funds “Study on Re-design of the Traditional Bamboo Products in an Environmentally Friendly Way”, a series of design practices have been carried out with the engagement of several teachers, over a hundred of students and over a dozen of bamboo craftsmen. Based on a series of workshops, design courses, fieldwork and design practices and guided by the idea of innovative and sustainable design, GDUT explores the engagement models of design schools so as to facilitate sustainable development of the traditional bamboo crafts in Xiangxi and Yiyang.

In hope of finding effective, innovative and sustainable collaborative models from the perspectives of sociology and social innovation, we tried to discuss this topic from a multidisciplinary perspective. Collaborations with bamboo craftsmen over the past three years can be classified into three types.

### 3.2 Types of collaboration in GDUT

*Local collaboration:* The first collaboration began with fieldwork. No more than 10 students went to Yiyang and Xiangxi with teachers to interview bamboo craftsmen, visit the Museum, and join local studios to learn crafts as apprentices so as to acquire local bamboo culture rapidly. In this collaboration, participants contributed acquired knowledge other than innovation, with teachers and students from schools being the beneficiaries because they've acquired rich knowledge on the traditional bamboo crafts and broadened their cultural perspectives. However, benefits and long-term impact on craftsmen and local bamboo industry are limited. Nothing would come out from such collaboration if no further contact and collaboration is made between the two parties. But local collaboration is a must because this is an important way for us to truly understand the tradition and culture of bamboo crafts.

*On-campus collaboration:* Bamboo craftsmen are invited to the regular workshops on crafts learning provided by the schools. Two sessions have been organized, each lasting 20 days with 3 to 4 teachers and 25 to 30 students involved. The organizers would exchange ideas on teaching contents and teaching plan with bamboo craftsmen in hope of imparting as complete knowledge on bamboo crafts as possible in a limited period. These craftsmen were able to decide proper teaching contents in accordance with the teaching objectives and personal judgement though they might fail to express the knowledge with accurate language.

The primary goal of the organizers was to inspire creativity in students after the workshops. Surprisingly, students and craftsmen took the initiative to carry out small-scale co-creation. Master Xie assisted students with the re-design of traditional bamboo stools and the bamboo lanterns. Master Xu guided students with their bamboo brooches creations and even made one by himself. Empathy was achieved among participants in the 20-day immersive workshop, each contributing their acquired knowledge and creativity, with direct knowledge transfer being accomplished. More students would be benefited from on-campus collaboration while the limitation lies in that students have no access to learning more about the bamboo culture represented by craftsmen. Craftsmen would broaden visions during the short stay in the city and obtain inspirations when getting along with teachers and young students. Master Xu who has a family studio manages to expand the product lines after being inspired by the jewellery works by students at the workshop. More bamboo re-design models are generated in the subsequent design courses, reflecting significant facilitating impact of workshops on teaching and the role of design innovation in the advance of bamboo crafts.

*Production collaboration:* Out of needs from graduation designs, design exhibitions, competitions and other design events, there are always semi-products, product models or products to be manufactured now and then, which makes sub-contract the common form of collaboration, which involves 5 bamboo craftsmen and a raw bamboo furniture factory. There are two forms of collaboration: one is remote sub-contract and the other is local co-production. In the first form of collaboration, design sketches and engineering drawings are sent to the craftsmen and communications during phones. In the second form, designers go to the region to collaborate with local craftsmen. Both forms have strengths and shortcomings. Remote sub-contract saves money and time but the outcomes would be unsatisfactory co-design due to untimely and unclear communication.

Co-production would cost time and travel costs but it enables designers to communicate with the craftsmen on site timely. The final outcomes are mostly acceptable. In production collaboration, designers and craftsmen contribute their own expertise and facilitate direct or indirect knowledge transfer, thus giving birth to participatory design. For instance, student Cai Xiaoxue designed a set of bamboo furniture based on Xiaoyu bamboo crafts after finishing the workshop. According to Master Wang Shenglian, he had never seen such structure before and decided to produce another set with improvements. Craftsmen began to realize the importance of design. Master Wang is planning to found an independent studio and engage young designers to do the design. Master Xu and his son voluntarily joined the training program by Academy of Arts & Design of the Tsinghua University and Shanghai Academy of Fine Arts.

### 3.3 Reflection

These three collaboration types are applied at different stages, all bringing benefits for stakeholders though with limitations. We are not able to organize long-term influential co-creation activities of large scale with extensive social engagement like the New Channel Program organized by Hunan University (Wang, Bryan-Kinns & Ji, 2016). Instead, we attempt to think the social role of most common design schools when they are engaged in similar propositions by making concrete efforts with limited resources and conditions.

## 4. COLLABORATIVE MODELS ANALYSIS

Based on our three collaboration practices and activities organized by other design schools, collaborative models for the engagement of design schools in the sustainable development of traditional bamboo crafts can be classified into four types, namely Collaboration Driven by Culture(CDC), Collaboration Driven by Teaching(CDT), Collaboration Driven by Activities(CDA) and Collaboration Driven by Service Design(CDSD).

#### 4.1 COLLABORATION DRIVEN BY CULTURE (CDC)

CDC that focuses on traditional bamboo craft culture and adopts anthropological or sociological research methods, such as fieldwork, participatory observation, interviews, questionnaires and statistical research. Local collaboration is driven by culture. We gladly found that bamboo craftsmen are proud of their career and highly collaborative in local collaboration. This model is basically based on the research interests of teachers and scholars.

#### 4.2 Collaboration Driven by Teaching (CDT)

CDT that centres on teaching objectives, which is the key task and responsibility of engagement of design schools in the traditional bamboo industry. CDT takes place in the form of workshops, courses and other conventional teaching activities. The regular courses of bamboo product design are provided for students in GDUT. Stable and conventional teaching is the guarantee for lasting collaboration between the traditional bamboo industry and the design schools. The schools mentioned in the beginning of this paper have offered similar courses and organized workshops. In the CDT model, students are the best beneficiaries with learning effect and output as key indicators.

#### 4.3 Collaboration Driven by Activities (CDA)

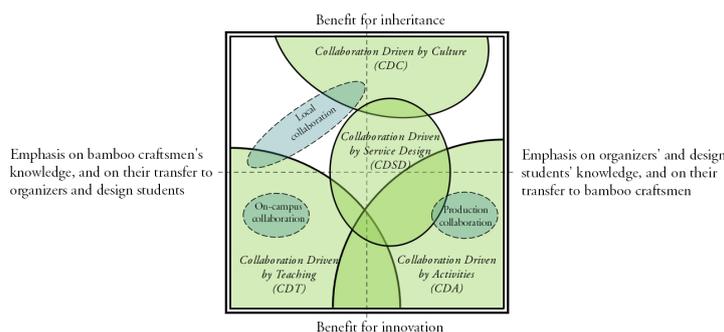
The diversity of collaboration contents turns various activities, including competitions, exhibitions, productions and programs supported by governments and enterprises, the carriers of short-term collaboration. The production collaboration of GDUT is based on this model driven by various on-campus activities. The influential Bamboo 20+ Program launched in 2018 by the Academy of Arts & Design of the Tsinghua University engaged 20 famous contemporary designers worldwide and will produce 40 bamboo works in about half a year from the collaboration with local enterprises and craftsmen in Yong'an. The CDA model is led by designers as well as design schools while bamboo craftsmen provide craft knowledge or do the manufacturing tasks. CDA provides craftsmen with job opportunities and access to the external world.

#### 4.4 Collaboration Driven by Service Design (CDSD)

Design schools integrate their resources to resume social responsibilities and take the initiative to accelerate the sustainable development of the traditional bamboo industry with service design. The key of this model lies in the shift in the awareness of design schools. Universities and colleges take charge of the Training Program for the Inheritors of Non-tangible Cultural Heritage promoted by the government of China, helping inheritors to enrich the knowledge base, broaden visions and enhance cultural confidence and abilities for sustainable development. There are also public projects supported by government and enterprise. In this most complicated and efficient CDSD model, craftsmen as the service objects benefit the most. Governments, private organizations and enterprises are stakeholders as well, with the benefits of stakeholders increasing significantly.

#### 4.5 Analysis of collaborative models

Figure 1 analyzes the four collaborative models, partly referring to the landscape tool of Sanders & Stappers (2006) and the space diagram of Steen, Kuijt-evers & Klok (2007). The horizontal dimension is the sharing and transfer of knowledge, and it is the key to deciding the benefits of each stakeholder. The vertical dimension is the two directions of the sustainable development of traditional bamboo crafts, i.e. the influence of models on inheritance or innovation.



[Figure 1] The Landscape of Different Collaborative Models for Design Schools Engaging in the Sustainable Development of Traditional Bamboo Crafts

## 5. CONCLUSION

Results of this work suggest that engagement of design schools in the traditional bamboo industry promotes the sustainable development of the industry. The challenge that design schools are faced with is to bring benefits for all stakeholders with an effective collaborative model so as to establish equal, lasting, steady and progressive collaborative relationship. The collaborative models discussed in this work can be applied into other traditional crafts with similar features. The CDSD model is recommended because the industry are the focus of the collaboration. It is also agreed that all collaborative models would be integrated with the purpose of social innovation based on "the trend of distributed economic network and the individualization of labor in future" (Xia, Liu, Zhong, 2018). Driven by global economy, more creative models would be brought about to facilitate the sustainable development of the traditional bamboo crafts by making full use of the organizational network.

## 6. ACKNOWLEDGMENTS

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## **EXPERIMENTAL MATERIAL DEVELOPMENT LEADING TO SUSTAINABLE PRODUCT DESIGN**

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### **ABSTRACT**

Industrial Designers need to understand the implications of the materials they specify in products intended for manufacture. In order to equip students to be more conscious about the materials utilised and the environmental impacts of these materials, the department of Industrial Design at the University of Johannesburg has incorporated experimental material development into its Design Practice curriculum. This paper present a current annual project undertaken where final year students are tasked with developing their own material composites which are used in the signing and making of a product which they develop. This has been undertaken for two years, where the outcomes of the projects have proved to be extremely valuable for the students. An overview of the project composition and examples of student projects are presented, with recommendations for other design schools to attempt a similar approach.

## 1. INTRODUCTION: INDUSTRIAL DESIGNERS AS PRODUCT DEVELOPERS

Industrial designers are trained to be able to develop products intended for manufacture using available manufacturing processes and materials. These manufacturing processes are often large industry applications which negatively impact the environment, for example injection moulding using plastic, where the plastic manufacture; tooling and production all have extremely high energy demands and large negative environmental impact. Although the industrial design process is a creative and inventive process concerned with the synthesis of such instrumental factors as engineering, technology, materials and aesthetics into manufacturable solutions (Fiell & Fiell 2006, p.6), there is an increasing need for Environmental Sustainability to become an integral part of this process. For students learning about the processes of creating new products, there is a sense of urgency for them to understand the entire life cycle of the material used in the products, from where it is mined or processed from initial raw materials. It is one thing being able to purchase raw materials from a hardware store, another being able to understand the energy and work that has been undertaken for the material to have been generated.

The incorporation of experimental research within the field of industrial design education allows for students to better understand and appreciate the environmental sustainability of the products which they design. Examples of appropriate theories include Cradle To Cradle, Life Cycle Assessment, Design for Sustainability, Design for Recycling, and Design for the Environment are all methodologies that students interrogate and learn about through the practical undertaking of these projects. A conventional approach to Industrial Design would be a designer would use available material, and for students this would be material purchased from a hardware or material supply store. The students may not have an understanding of the processes which were used to produce that material, nor the environmental impact linked to the generation thereof. This is a problem as the negative environmental impact from industry in the processing of goods is very high. For the undertaking of these projects, a sustainability approach following that of Cradle To Cradle, Life Cycle Assessment and Design for Sustainability. Cradle to Cradle design principles provide a positive agenda for continuous innovation around the economic, environmental, and social issues of human design and use of products and services (C2C, 2016 p.2). Life Cycle Assessment looks at all of the stages and processes that go into the production and entire life cycle of products (and systems), which includes raw material, product processing, manufacture, use as well as death/disposal. Although there are 32 different sustainability tools available to assess sustainability, the most appropriate to the undertaking of this project are Life Cycle Assessment, and Environmental Impact Assessment as they are suited to material processing as well as product manufacture (Ness et al, 2007 p.500).

## 2. STUDENT PROJECT COMPOSITION

In order to integrate this sustainable approach to design thinking we have an annual project currently running within the final year of the BA Industrial Design<sup>1</sup> course, within the primary Design Practice module. Generally a design process starts with an initial project briefing: providing scope for the project and what is required throughout the entire project. This includes deliverables and specific timelines. This entire process in a typical 3rd year level would last about 4 –5 weeks, with 25 hours of timetabled class-time per week. The projects are developed to align with specific module learning units for example design for manufacture / design for the environment, community engagement or designing for brand identity. The student body consist of approximately 23 students each year (2017 and 2018). The design process is illustrated in figure 1, which starts with research, where students undertake thorough research to provide a solid footing for the following steps: brainstorming/ideation, concept development & refinement, and design finalisation.



[Figure 1] 3rd Year BA Industrial Design Process

Throughout the projects, at key points there is lecturer and class contact sessions where students receive input and advice. The peer related feedback is extremely beneficial where students can break into smaller discussion groups and explain their work, and discuss / negotiate / defend their design decisions for the process. It is expected that by the time students graduate, they are able to be independent decision makers and guide their own design process.

### 2.1 MATERIAL RESEARCH FOLLOWED BY THE DESIGN PROCESS

The first session at the start of the project was that of the Material Experimentation and Research & Development part of the project. It was my thought that the goal of this project section was for students to experiment as much as possible, and not be wholly concerned with 'the product', because at this stage they had no idea what they would be developing. The second briefing takes place once material experimentation was well under way (after 2 weeks of research) and students have a considerable amount of testing and documented findings. Only then are they able to finally find out what they will be developing, and the material research then leads into the design process. As the

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experiment outcomes are not resulting in a project success or failure, the students are more likely to take chances without the worry of an unsuccessful test. This allows for students to push their boundaries and learn as much from experiments that failed as those that were successful.

The aim of the project was threefold: firstly to teach students that experimentation and trial and error are a suitable approach to product design where they are able to learn from failures, secondly that the development of new sustainable materials is possible and able to be done on a small scale, and thirdly: as industrial designers they are able to be environmentally aware of the entire life cycle of a product, from material processing, through to end of product life. Industrial design students (in our department at least) often decide on an idea/concept early on in a project, and hold onto this idea for dear life, even though there are opportunities for it to develop into something much more novel and innovative. It seems as though the assumption is that a good idea automatically will result in a good product outcome, however this is not that case. For these project I intended to remove the students from their comfort zones by separating the project briefing into two different briefing sessions.



Figure 2: Project sequence and process.

The intention of not providing the students with the final product development requirements was deliberate, as the students were then able to experiment freely without a pre-defined output imposed on the expectations created by their undertaking of product precedent research. Although there were many different student projects, all of which were very interesting and different, four will be presented below, illustrating different project processes that the students followed. Two students from 2017 are presented, and two from 2018. The presented projects include a side table, coat rack, range of watches, and a skateboard, however, there were many different types of projects between homeware, interior and consumer type projects<sup>2</sup>. The initial ideas for pursuing a specific direction may have been due to personal observations as in the case of a student who wanted to design biodegradable kids furniture where the idea came about from observing how her younger siblings' toys and furniture pile up in the garage as they rapidly outgrow them, possibly waiting to be handed down or discarded. Through identifying a problem, the student can attempt to eradicate this problem by a more sustainable design solution. One of the questions posed to students regarding what may be considered a sustainable product solutions would be that of 'If the product is left in the garden in the sun and rain, can it slowly return to the elements that it came from?' In the table below several projects are presented with reference to the student online portfolios for more specific content. The materials utilised in the experimentation phase of the project are mentioned, with an indication of the chosen material direction. Finally an image of part of the students design processes included, as well as the final design outcome with short description.

The fact that students are able to explore different directions, and as a group decide which direction seems most viable and suitable makes for an interesting spread of projects, all able to meet the project requirements. At the end of the project students complete a design reflection, which is a short write-up where they provide commentary looking back over the project. It is in these write-ups that it becomes evident that the students have learnt through the projects approach. The following are several comments from the student final reports, which would be submitted together with their final project submission at the end of the project:

- "The process taught me many things that I did not predict when planning and executing the assignment"
- "This project was a great learning curve and made me build a deeper knowledge of the material that was developed and have a better understanding of compression moulding."
- "Development of a natural material is not as easy as one might think as there are many aspects that you must consider such as drying time, the strength verses the purpose of the material, pigmentation, etc. It is basically custom designing the material to suit the end product. One thing I learnt is not to be afraid to try new techniques and different approaches."
- "It comes to attention that this was one of the most exciting and truly innovative projects of the year and would recommend for future students to pick up the material studies to a point where it becomes a multi-disciplinary material that is trial tested through different applications through different study year groups."

### 3. DISCUSSION & CONCLUSION

Through hands-on experience of processing their own materials by hand, students (and soon-to-be practicing industrial designers) are able to better understand the consequences of specifying materials which are negatively impacting

<sup>2</sup> Products included various types of furniture and homeware items such as seating, tables, cabinets, lamps, wall cladding, room dividers as well as consumer products fashion items and toys such as a torch, kids rocking toy, play structure, ceiling fan, travel bag, back-pack, board game and peak cap.

the environment. The following is a list of key benefits the undertaking of this project has directly on the students:

- Students learn through experimenting that there is value in attempting various approaches, and learning from what goes well, and when results are not satisfactory it is also a valuable outcome.
- Students are able to experiment freely and learn from their mistakes without the burden of failure. The documenting of what they learn from their failures assists them in the prevailing steps: Progressing through trial and error, and into innovative and sustainable outcomes.

Student / year	Experiments	Material Outcome	Design Process	Design Outcome
Designer Student: Leanne Moore 3rd year BA Industrial Design 2017 (Moore, 2017)	Leaves, Glucose, Vinegar, Wood Shavings, Sugar, Beetroot, Spices, Eggshells, Glycerine, Seeds.	 Seeds, Sugar, heated for 20 min, press-formed into mould.		 Reverse Side Table. Seeds, Sugar, heated till caramelised, press-formed into hand-made moulds, sealed with beeswax.
Designer Student: Faith Oletselangwe. 3rd year BA Industrial Design 2017 (Ole, 2017)	Gelatine, Oats, flaxseed, Flour, vinegar, orange peels, herbs, charcoal, sand.	 Seeds, oats and sand with a gelatine binder.		 RAK, a functional coat rack made from flaxseeds, animal glue, ash, white stones, charcoal and oats
Designer Student: Ryan Walters. 3rd year BA Industrial Design 2018 (Walters, 2018)	Bamboo, coal, carbon, grass, gelatine.	 Press-formed bamboo coal with a gelatine binder to form solid items, with woven grass to form the flexible parts.		 The Charcoal Watch, made from compressed carbon + gelatine binder, with woven grass strap. (standard internal components).
Designers Student: Anna Schmiedt. 3rd year BA Industrial Design, Exchange student from OTH Regensburg. 2018 (Schmiedt, 2018)	Bamboo, sticks, grass, leaves, gelatine, dextrin glue.	 Bamboo sticks and woven grass components.		 The Bamboo Board, made from bamboo and grass. (standard skateboard axle components).

[Table 1] Overview of several student projects.

- Students engage with and understand materiality of objects a lot more than just purchasing an existing material. They see that a usable material or object has already had a large amount of processing to get it to this point.
- Developing environmentally sustainable materials has large value for products, where the designer and user are able to fully understand the origin of the product and materials. This consciousness and transparency is empowering for the user and designer.
- The more natural the input materials into a product, the more natural the product outputs can be.

It has thus far been incorporated as a standard not-to-miss project to undertaken for students in this current industrial design course, and it is encouraged to other disciplines and schools to undertake similar practical projects with students. The goal should be developing equipped and ethical decision-makers in the fields of design and any associated manufacture.

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## **AUTOMATIC COMPOSTER FOR HOME USE**

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### **ABSTRACT**

Nowadays, many concepts such as sustainability, environmental-friendly products, green solutions, concern for the planet, etc. are recurring topics. However, very little is still done towards achieving these. Reversing the current scenario is only possible with the commitment of all those in different spheres: governmental leaders, industrials, companies, and especially individuals. Designers can be particularly useful in this process from a prominent position, since they can strongly contribute to the creation of new products, protocols and materials. This paper shows a project aimed at alleviating one of the major problems currently found: organic waste management. The solution proposed is a new concept of automatic composter for residential use.

Key Words: Residues; Composting; Product Design

**1. INTRODUCTION**

In Brazil, the generation of organic matter corresponds to more than 50% of the total volume of waste, according to the national Institute of Applied Economics Research (IPEA, 2016). Also, according to data from the Brazilian Institute of Geography and Statistics (IBGE, 2012), 50.8% of such wastes are deposited in open-air dumps, 27.7% goes to sanitary landfills and 22.5%, to controlled landfills. By analyzing these figures, it can be seen that these residues, for the most part, are deposited along with other types of waste without any prior specific treatment, causing negative consequences to the environment.

Among these, especially problematic is the manure originated from the decomposition of the organic matter of the waste, since it is a highly toxic liquid that can contaminate subterraneous water streams, which in turn, contaminates the water at a household level. It is also known that there is a need for a real and urgent change of thinking and habits regarding the consequences of our actions towards the environment in which we live in. It is also necessary to raise awareness to the fact that everything we consume generates waste and that this will most likely end up somewhere not suitable for such an end.

One big change would be starting to sort, treat and reduce all the waste right where it is generated. However, this can be very time-consuming and hence, regardless of conscientization and willingness, organization and attention with the waste produced are oftentimes forgotten or neglected. The challenge is to facilitate this process for the population, by sorting and treating their waste – specially the organic – in an automated way, reducing the negative impact of waste generation.

This work proposed the development of a product that makes organic composting feasible. The project was developed using the GOPD – Guide of Orientation for Project Development – established by Merino (2016), which serves as a support for process set-up and development. The GOPD is a methodology that aims to make product designing achievable by everyone by reaching as many users as possible and always taking into account, throughout the design process, the desire and expectations of the target audience, which is the object of the project.

**2. LITERATURE REVIEW**

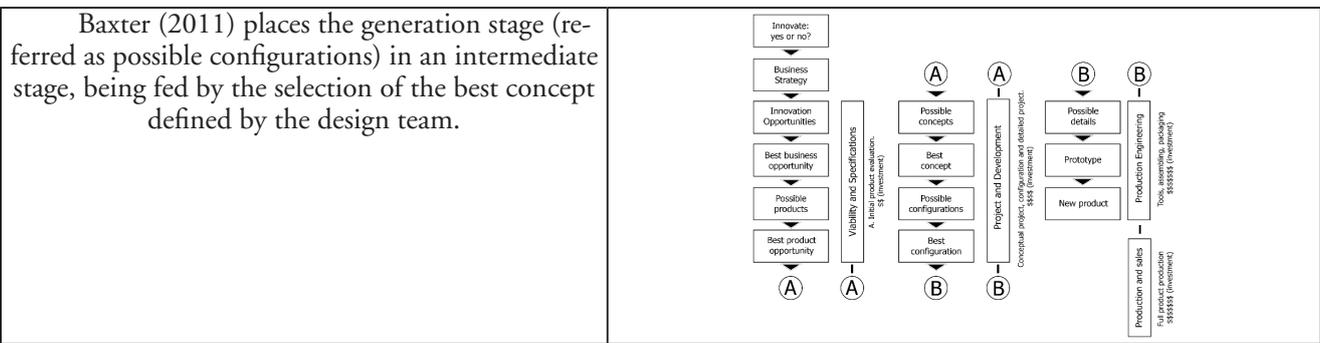
One way to provide an environmentally-correct destination to more than half of our waste is composting (Kiehl, 1985). The author defines composting as a controlled process of microbial decomposition, i.e. the oxidation of a heterogeneous mass of organic matter. Finding a practical, low-cost solution is key for spreading the culture of recycling organic waste. The development of the automatic residential composter shown in this article, can be presented as a solution to make composting a more simple, feasible way.

This work deals with designing a compact equipment that recycles food in only a few days, due to the super-oxygenation of its remains, which accelerates the composting process. This forces the microorganisms responsible for the process to multiply exponentially, drastically reducing the time of the decomposition cycle and making composting a practice compatible with our daily routine, without the problems observed in the traditional method: strong odors, constant dedication, garbage dirt and other restrictions.

The employment of a proper methodology is necessary when a designing a project, since it assists in the organization of tasks by making them clearer and more precise, i.e. it provides logical support for the development of said project (BONFIM, 1995).

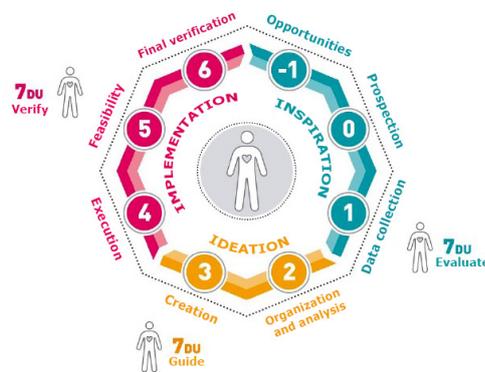
In Table 1, several design methods are presented.

<p>Method 3SDM - 3-Step Deployment Method. Also known as Open Method of Design. As a differential, the author places the stage of Generation of Alternatives linked to “conception”, which receives data from the previous step (“creative pathways”) and feeds the next step (“selection and suitability”).                  Source: Santos (2016).</p>	
<p>PDP - Product Development Process. Establishes the stage of Generation of Alternatives in the conceptual project, which succeeds the informational project and precedes the detailed project. Although it does not list numerical criteria for this, there is a suggestion of valuation of the conceived alternatives, in order to select the most appropriate.                  Source: Rozenfeld and others (2006).</p>	



[Table 1] Project methods. Source: Ferrolí and Librelotto, 2016.

As already highlighted, the GOPD method was chosen for this project. This methodology is presented in the form of a cycle, where it is assumed that every project promotes opportunities for its continuity or even the beginning of new projects, based on the previous ones. Thus being, step 6 (final verification), which in theory would wrap up the project, leads back to step -1, the opportunities stage, enabling the creation of further opportunities, thus establishing a continuous cycle. (MERINO, 2016). Figure 1 illustrates the GOPD.



[Figure 1] The GOPD method. Source: MERINO, 2016.

The GOPD methodology is based on input and output “tokens”, facilitating the projecting activity. The tokens serve as orientation tools and, if complemented with a timeline and a 5W2H tool, for example, promote a safe means of predicting the costs and the time of completion of the project.

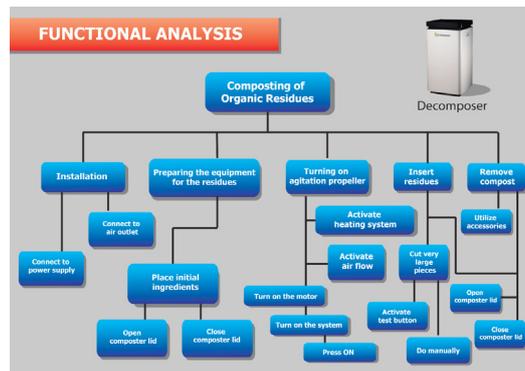
The GOPD steps shown in Figure 1 are as follows:

- Steps -1, 0 and 1: Inspiration. In step -1, the market opportunities are identified by analyzing the demands and possibilities. In step 0, the central problem that will guide the project is defined. In the last step of the inspiration stage, the data collection (including field visits, market study, bibliographic material survey, study and choice of analytical techniques, anthropometric survey, among others) is done.
- Steps 2 and 3: Ideation. In this phase, all the collected data are refined and with the help of analytical techniques, the project strategies are defined. Afterwards, the steps of creation of concepts, generation of preliminary alternatives and employment of tools will follow, since these will help choose the alternative that best meets the objectives outlined during the project.
- Step 4: Execution. At this stage, organization of and adjustments to the production process are carried out.
- Step 5: Feasibility. In this stage, already having defined the proposal that meets all the specifications, the product is tested under a real scenario, with potential users. In addition to this, further research is carried out (in the case of packaging, this can be done at sale points, for example, with potential consumers). In this item, evaluation tools of ergonomics, usability and apparent quality can be used.
- Step 6: Verification. It is the last stage; However, as emphasized previously, it can also serve to point out new opportunities, thus generating a new project cycle. This stage also involves the collection of results, the monitoring of performance and the verification of the impact throughout the whole life cycle.

### 3. DESIGN PRACTICE: DEVELOPMENT OF AN AUTOMATIC COMPOSTER FOR HOME USE

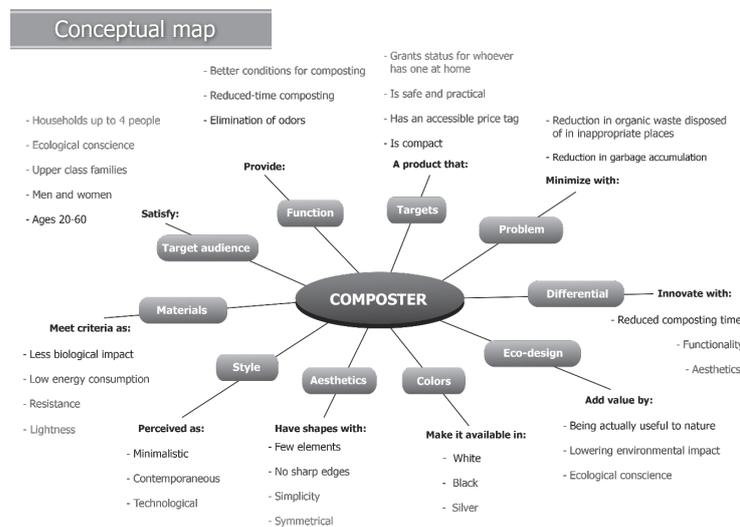
Following the proposed methodology and complementing it with project techniques described by Pazmino (2013), diachronic, synchronic, functional and structural analyzes were employed in this project.

Figure 2 illustrates one of the techniques used – the functional analysis – which according to Pazmino (2013), serves the purpose of visually presenting the functions of the products to be developed. It was based on the Decomposer GG-02 model from Oklin International.



[Figure 2] Functional Analysis. Source: prepared by the authors.

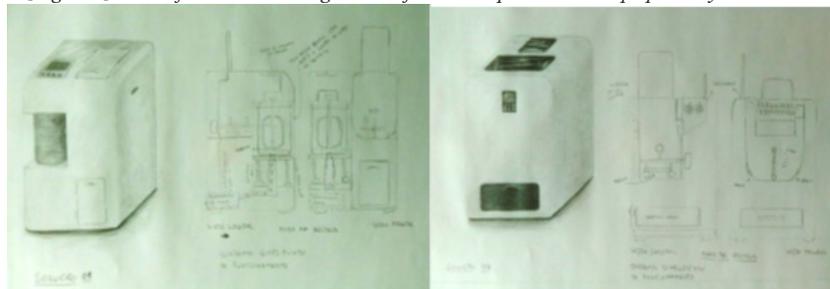
Figure 3 shows the conceptual map generated, which helped define the next steps in the project activity. According to Pazmino (2013), the conceptual map is a graphic visualization that helps simplification and organization of the data obtained in the field study. Its contribution to the project is the possibility of allowing the designer to obtain new information from the association of the data sets. Several alternatives were elaborated and four of these, due to being slightly more comprehensive were pre-selected, since the visualization and understanding of the final solution were clearer with them.



[Figure 3] Conceptual map. Source: prepared by the authors.

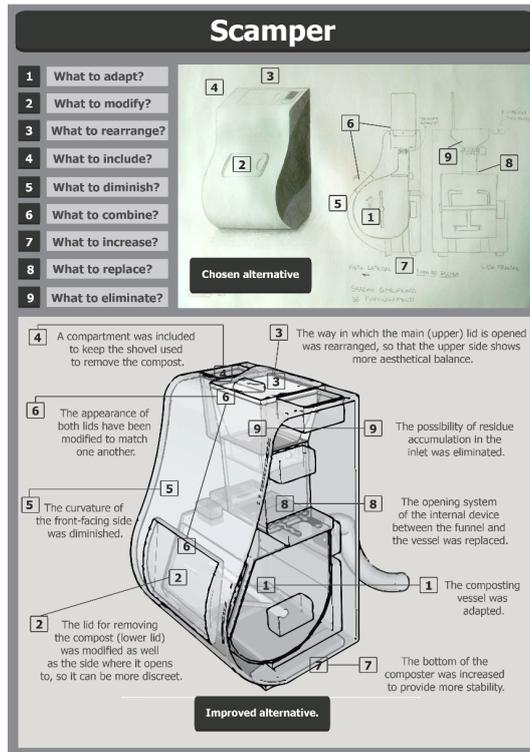
Figure 4 shows two of the alternatives created. With the chosen alternative, the next step was its improvement for obtaining a final solution that fulfilled the previously-determined requirements of the project. For refinement, a creative technique known as SCAMPER was chosen, which acts as a checklist to improve or re-work the chosen solution. In Figure 5, it is possible to follow the process and final result of the application of SCAMPER, a creative technique that allows the exploration of different ways of transforming an object, system or process. The tool name comes from the initials of seven words that in Portuguese mean: Substitute, Combine, Adapt, Modify, Look for other uses, Eliminate and Rearrange. SCAMPER is an evolution of another technique called MESCRAI (Librelotto et al., 2012).

[Figure 4] Some of the alternatives generated for the composter. Source: prepared by the authors.



The technique was applied after the decision matrix. The next step included the specification of the product materials. Choosing the right material to be used in the making of the actual design has always been one of the great challenges for the designer. This is increasingly complex because of the amount of materials available for them to use in their projects and also, these number has increased considerably in recent years. New formulations, blends, composites, additives, apart from novel achievements in nanotechnology and modern manufacturing processes contribute to this continuous increase, requiring a careful research by the designer. Figure 6 shows all the materials selected for the product and Figure 7 illustrates the final design.

[Figure 5] Scamper Application. Source: prepared by the authors.



[Figure 7] Final solution. Source: prepared by the authors.



### COMPONENT CHECK-LIST

Nº	COMPONENT	MATERIALS/OBSERVATION
1	Frame	Option 1: HIPS. Option 2: ABNT 2037 Duralumin
2	Upper lid	Option 1: HIPS. Option 2: ABNT 2037 Duralumin
3	Inlet funnel	PEAD
4	Composting vessel	PEAD (economical) or ABNT 2024 Duralumin (durable)
5	Lower lid	Option 1: HIPS. Option 2: ABNT 2037 Duralumin
6	Crusher	Option 1: stainless steel AISI 304. Option 2: Steel SAE 1045 w/ tin coating
7	Agitation Axis	Option 1: stainless steel AISI 304. Option 2: Steel SAE 1045 w/ tin coating
8	Shovel compartment	PEAD
9	Shovel for residue removal	PEAD
10	Control panel	Touch screen PEAD or PMMA
11	Moving internal dividers	PEAD
12	Flexible tubing	PP
13	Composter's feet	ABNT 2024 (duralumin) or zinc-steel SAE 1020
14	Low-power motor	Maximum power 210W (used in the agitation axis).
15	High-power motor	Maximum power 650W (used for crushing).
16	Temperature controller	Internal sensor in the vessel for maintaining ideal conditions
17	Fan	PA 6 or nylon
18	Colors	White, black and silver
19	Wires and power cables	Connect all the electrical functions to the control panel
20	Sound device and illumination	Led-powered lights

\* Numbers 9, 18, 19 and 20 do not appear in the following Figure

[Figure 6] List of materials and components of the product. Source: prepared by the authors.

### 3. CONCLUSION

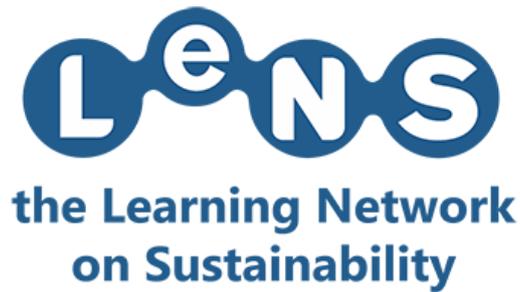
Designing a product using a sustainable approach is a current trend. Ecological factors have been increasingly essential to the success of a product and should undoubtedly be intertwined with other aspects of such project, such as the ergonomic, manufacturing, aesthetic, marketing and financial aspects, for example.

The project demonstrated in this work sought to take all these factors into account, resulting in a successful product from a sustainability point-of-view, with cost-benefit analyzes in the environmental, social and economic aspects, as recommended by the ESE (Economical-Social-Environmental model) approach.

The use of project methods in the design showed the importance of the systematized design procedure, with well-defined steps and using an “open” methodology. The experiments showed that this type of methodology is more adequate for the inclusion of a sustainability aspect in the design process than the use of methods considered as “closed”.

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## **SUSTAINABILITY IN THE PRODUCT LIFE CYCLE OF PAPER**

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### **ABSTRACT**

The paper explores and studies the issue of the life-cycle of paper products, specifically as it relates to the recycling of paper products as a feedstock or raw material for the manufacture of other goods. The environmental impact of paper production is important to note since it has many negative impacts. Developed countries consume more paper products than developing countries and as countries develop economically, their consumption of paper increases exponentially. One can anticipate that with the increased shift to consumerism in developing countries and with anticipated world population growth, the demand for paper is likely to increase. While there is a shift to electronic communications and data storage, however online shopping and globalized trade continues to fuel demand for more paper packaging materials. There will be as hiftin the types of paper products, but not a decrease in the overall demand for paper products.

Key Words: Paper Products, Life Cycle of Paper, Forest Degeneration, Recycling.

## INTRODUCTION

In this paper, I shall explore the issue of the life-cycle of paper products, specifically as it relates to the recycling of paper products as a feedstock or raw material for the manufacture of other goods. Within the limited scope of this paper, I shall examine how extending the product life cycle of paper can contribute to the environmental goals of “reducing emissions from deforestation and forest degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks (REDD+), [as] an essential part of the global efforts to mitigate climate change” (FOA, 2018). By extending the product life cycle of paper, I hope to delay the degradation of the paper with the release of the carbon to the atmosphere, as well as to decrease the pollutants and environmental degradation related to tree harvesting and pulp and paper production.

## THE NATURE OF THE PROBLEM

The environmental impact of paper production is important to note since it has many negative effects. Here are some of them:

- 40% of the world’s commercially cut timber is used for the production of paper.
- Pulpwood plantations and mills endanger natural habitats.
- Over 30 million acres of forest are destroyed annually.
- The pulp and paper industry is a big contributor to the problem of deforestation and is partly to blame for the endangerment of some species that live in the forests.
- The life cycle of paper is damaging to the environment from beginning to end. It starts off with a tree being cut down and ends its life by being burned – emitting carbon dioxide in the atmosphere.
- Paper production uses up lots of water. An A4 paper requires 10 liters of water per sheet.
- Most of the materials in landfills are made of paper. When paper rots, it emits methane, a greenhouse gas. When it is burned or composted, carbon dioxide.
- Pulp and paper mills discharge water that’s riddled with solids, dissolved organic matter called lignin, alcohol, inorganic material such as chlorates, chlorine and metal compounds. All of this contributes to soil and water pollution.
- The paper industry is the 5th largest consumer of energy in the world. It uses up 4% of the world’s energy.
- To produce 1 ton of virgin paper, it is estimated that 253 gallons of petrol is used (The World Counts, 2014).

The Food and Agriculture Organization of the United Nations (FAO, 2018) states that “forests and trees are key to a sustainable future.” When FAO completed its first assessment of the world’s forest resources 70 years ago, the major concern was whether there would continue to be enough timber to satisfy global demand. Since then, there has been a paradigm shift from the exploitation of forest resources toward a recognition of the ecological, economic and social relevance of forests and trees as a complex global issue of sustainability and survival. Forests are critical to the livelihoods of millions of the world’s poorest, most marginalized people who rely on the forest for food, fuel, construction materials and as a place of habitat. For everyone on earth, the forests are a major source and conservation of water, a carbon sink for the control of green house gas, and a source of lumber and a raw material for paper production. In part, the search for lumber is what fueled European, especially British, colonialism in North America to build naval vessels (Wynn, 2013). Lumber and, to a far lesser extent, charcoal were the main products of the industry.

With the rise of new technologies and consumerism, multinational corporations diversified from the lumber industry into manufactured paper products for which there were mass markets, from private household consumers to the commercial packaging industry to the newsprint and other paper uses in the communications sector. The pulp and paper industry is largely oligopolistic with multinational corporations in the United States, Canada, the European Union and Japan dominating the industry in 1996 (FAO, 1996). Currently, China, the United States and Japan are the leading producers of paper (Statistica, 2016). The exponential expansion of the paper industry created pollutants at every step of the industry, in addition to the eco-system devastation from clear-cut logging practices. The industry slowly shifted to reforestation techniques and tree farming approaches, both because of political pressure and because of economic factors related to the logistics of transport and the location of the investment in infrastructure (that is, the location of the pulp mills relative to the site of tree harvest).

The pulp and paper industry remain as one of the worst polluting industries, both because of the nature of the manufacturing process, as well as the lack of political will to impose on the industry the full economic cost of the product (FOA, 1996). The industry does not fully incorporate technologies to limit environmental impact because of cost and the impact on profits, and the consumers do not experience the full cost of the products because environmental clean-up either does not happen and the environmental degradation occurs in remote sites with sparse populations who lack political power, or because governments engage in the clean-up from general government revenues, allowing the industry a “free-ride.” There is no full-costing of paper products, from forest to eventual disposal so that market pressures do not reflect the actual product costs when fully costed in economic terms. The industry profits by reaping the revenues while various members of the public suffer the actual costs of living with pollution,

environmental degradation and clean-up costs.

Developed countries consume more paper products than developing countries and as countries develop economically, their consumption of paper increases exponentially: “the 1988 consumption per capita was: USA: 310 kg; Sweden: 246 kg; France: 142 kg; China: 6 kg. This data shows that western countries are consumer leaders. The consumption of a Chinese citizen is less than 2% of that of a US citizen” (FOA, 1996). By 2016, China had increased per capita consumption to 78kg and China had become the world’s largest paper producer (Statistica, 2016). One can anticipate that with the increased shift to consumerism in developing countries and with anticipated world population growth, the demand for paper is likely to increase. While there is a dramatic decline in the use of paper in newsprint, books and writing paper because of the shift away from paper-based to electronic communications and data storage, online shopping and globalized trade continues to fuel demand for more paper packaging materials. There will be a shift in the types of paper products, but not a decrease in the overall demand for paper products.

## RECYCLING AS MITIGATION

Recycling paper offers several benefits. The fiber already exists and some of the most polluting processes are not required to further process the fibers, no additional trees have to be harvested and the paper is diverted from landfills and continues to function as a carbon sink (Bajpai, 2014):

Every tonne of recycled fibre that displaces a tonne of virgin fibre results in the following reductions in usage:

- Wood - 100%
- Total energy consumption - 27%
- Wastewater, 33%
- Air particulate emissions - 28%
- Solid waste - 54%

Recycling has only been partially successful, because the economic cost of recycling decreases corporate profitability because there is no full-costing over the paper product life cycle apportioned to the paper producers, the commercial users or the end-user consumers. If paper were fully costed, rather than being a waste product of no value to be discarded in landfills, the paper would acquire a value as a raw material to be recycled and conserved. The cost of discarding in a landfill would also mitigate toward recycling.

Some of the issues involved in recycling paper relates to the way in which paper is adulterated by combining the paper with plastics, foils, glues and paints, that makes recycling difficult. In 1996, paper produced by a pulp and paper mill had approximately 30% recycled paper content (FOA, 1996). Through legislation and industry collaboration in Japan, by 2002, recycled paper accounted for 61% of the content of paper production in Japan (Bajpai, 2014). In Japan, businesses using paper packaging materials have to pay a fee per volume sold to the government, which is used to manage and operate recycling operations. In 2000, the United States was the largest exporter of paper waste for recycling and almost all of that went to China for reprocessing (Bajpai, 2014). By 2010, the United States was producing 71 million tons of paper and recycling 45 million tons, for a 63% rate (Bajpai, 2014).

Recovered paper fibres have several uses in construction and manufacturing. Paper can be reprocessed into raw materials for use as a building insulation component, in concrete repair, in asphalt for road construction, as a building paint additive and even in automobile brake linings (Bajpai, 2014). Research has shown the processed fibres to be stable, inert and long-lasting (for the full life of buildings and other products/projects) (Bajpai, 2014). For the life of the material, which is indefinite, the fibres remain a carbon sink. As a renewable, recyclable material, paper may be an environmentally sustainable material, if the initial forest degradation and pulp and paper mill pollutants can be made less damaging environmentally and the impact on marginalized populations and fragile eco-systems in forests and paper mill areas can be addressed. However, with such enormous environmental, social and economic costs at the forest and pulp mill levels in the early phase of production, paper needs to be fully costed and more valued than it is so that re-use and recycling of this valuable resource can be achieved.

## LAMPSHADES: A MODEST PROPOSAL FOR RE-USE OF RECOVERED PAPER

For my demonstration of a re-use of paper, I will demonstrate how recovered paper may be used as the raw material to make lamp shades. Please see Figure 1, Figure2. The manufacture of paper and paper lamp shades have a long history in Chinese culture. I use this example to demonstrate how recovered paper can fit within a cultural tradition and how such uses can be expanded to produce commercial products for retail and architectural purposes. This project also encompasses the idea of developing cottage low-technology industries that produce unique, functional products that are aesthetically pleasing and operates on a different level from large manufacturing enterprises. The business model for this style of manufacturing posits a sustainable approach to small-scale manufacturing that can operate in both urban and rural settings, with little to no capital start-up costs and a ready source of discarded raw materials from packaging waste. This kind of cottage industry is suitable for a small community to come together and do or for a lone person to manufacture. It is a non-polluting industry, apart from the cut-offs produced from the paper, which could be used as raw material for paper mache products so as to utilize all of the raw materials.

In terms of a channel of distribution to market the products, one would look to fair trade organizations like the non-profit Ten Thousand Villages, which markets products made in developing countries by artisans using local natural and recycled materials (Ten Thousand Villages,2018)



[Figure 1] Lampshades made with used paper [Figure 2] Lampshades made with used paper cups

## SUMMARY

Paper is a valuable product because the inputs to make paper are economically and environmentally costly. A full-costing of current paper production would account for the entire life-cycle, from forest-to-harvest-to-pulp-to-paper-to-manufacturer-to-end-consumer-to-landfill. As countries follow the lead of countries like Japan, who have moved toward a full-costing approach, paper becomes a more valuable commodity while simultaneously the cost of disposal becomes more expensive. Recycling becomes a viable option and, with time, paper might even become a valuable product in its own right as a raw material in non-paper industries, such as building insulation, road construction and automotive uses. My modest project of demonstrating how recovered paper can be used to make lamp shades demonstrates the versatility of paper as a material and the myriad of uses, both big and small, and business opportunities, that can revolve around the recovery of paper.

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## **BIOINSPIRED STRUCTURES IN LIGHTWEIGHT PRODUCT DESIGN WITH ADDITIVE MANUFACTURING**

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### **ABSTRACT**

Bioinspired lightweight product design involves complex geometries that are difficult to be made with traditional manufacturing processes. A unique way to create such complex geometries is through additive manufacturing. The overall objective of this research is to take a systems approach for the design of lightweight structure material systems. The system approach consists of four dimensions including unit structures, functionality, material layers, and physical properties. A case study is conducted based on aux, balsa wood, and auxetic structures for the lightweight material design. 3D model tests (e.g. finite element analysis and sustainability analysis) and physical tests are conducted on the developed materials and served for target purposes. The results of this research offers new insights into the design, manufacture and application of smart lightweight structures in engineering fields and contributes to the engineering management by providing a systems engineering approach to the lightweight material structure design realm.

Key Words: Bioinspired design, sustainable manufacturing, green design, additive manufacturing

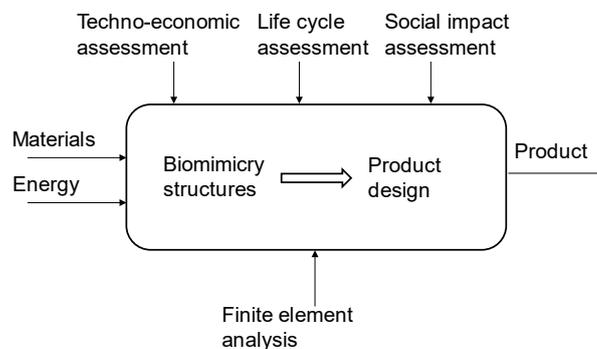
## 1. INTRODUCTION

The worldwide climate change imposes collaborative efforts from government, industry, and academia. In advanced manufacturing industry, efforts have been focused on reducing materials, energy, and enhance circular economy of final products. The Chinese government has released plans for “China Manufacturing 2025” including “The Development of Additive Manufacturing Industries”, “Industrial Green Development Plan”, and “Guidelines for Green Manufacturing Engineering Practices” (European Union Chamber of Commerce in China, 2017). Throughout a product’s life cycle, design is the most influential activity to determine the environmental impact and carbon footprint over the manufacturing, transportation, use, and end of life stages. Among many design theories and methods, bioinspired design learns from nature or biology to stimulate design ideas for various product purposes such as light weight, high strength, and resilience. The complex structures from bioinspired design are usually not able to be created with traditional manufacturing processes. A unique way of making these geometries is through additive manufacturing which creates complex structures layer by layer.

Research in bioinspired sustainable product design has created light weight structures (Zhang, Nagel, Al-Qas, Gibbons, & Lee, 2018), biomaterials (Zadpoor, 2017), as well as function based (Nagel, Stone, & McAdams, 2014) products. The complex structures that additive manufacturing is capable of implementing could increase the product’s overall functionality as a whole, while reducing the amount of energy and natural resources consumed during the production process. But of the few rigorous environmental assessments that have been completed, one study compared the different technologies used throughout additive manufacturing and discovered that laser-based methods had the greatest potential to reduce the environmental impact (Morrow, Qi, Kim, Mazumder, & Skerlos, 2007). Among the laser-based additive manufacturing methods Selective Laser Sintering (SLS) was found to be the most appealing when considering the environmental impact due to its low energy consumption, minimal waste products, and a favorable total energy indicator (Frazier, 2014). Overall additive manufacturing is considered more environmentally friendly than conventional manufacturing due to the reduce in material consumption, energy consumption, and water usage (Huang, Liu, Mokasdar, & Hou, 2013). Additive manufacturing also does not require near the amount of coolant/ auxiliary inputs nor does it generate the amount of material that enters a landfill compared to conventional manufacturing (Huang et al., 2013). Therefore, additive manufacturing is expected to become the preferred method of manufacturing due to its flexibility and long-term sustainability. Sustainability assessment research have been primarily focused on traditional manufacturing processes (Epping, Zhang, Epping, & Zhang, 2018), work cells (Zhang & Haapala, 2015), and systems (Zhang, Calvo-Amodio, & Haapala, 2013). While research have been conducted on separate areas of bioinspired design, additive manufacturing, and sustainability, the literature on bioinspired design and sustainable additive manufacturing is limited. Therefore, the objective of this research is to identify biomimicry geometric structures for product applications, assess the functionality, economic, and environmental impacts of the selected biomimicry geometric structures, and implement the biomimicry geometries through an additive manufacturing process.

## 2. Method

In this study we will be following the outline seen in Figure 1. This study begun with in depth research into the various additive manufacturing techniques (Deposit Energy Deposition, Selective Laser Sintering, Material Jetting, Sheet Lamination, etc.) and the associated materials that those techniques can utilize (Titanium, Aluminum, Polymers, Alloys). An additive manufacturing technique was selected based upon the conducted research that presented thorough information in the following areas, but not restricted to, material processing capability, precision and accuracy of the technique, projected environmental impact, machine purchase cost and local availability to the technique. Once a technique was decided upon, then research into biomimicry structures was conducted; focusing on: the most commonly used in industry, most commonly used in laser-based additive manufacturing methods, structure applications in different facets of industry, structure application to product needs.



[Figure 1] Research Methodology

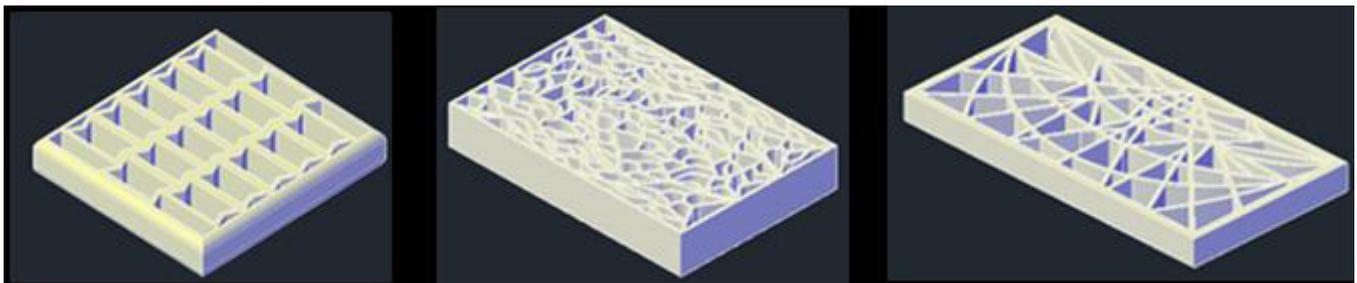
With an additive manufacturing technique, selected material of interest, and decided upon structures were discovered; came the need to develop multiple 3-D computer aided design (CAD) models. The models were designed to allow for each of the selected structures (diamond, honeycomb, lattice) to be applied to and in such a way to

reduce variation (or structure favorability) during the assessment of the structures. With completed 3-D CAD models, the techno-economical assessment (Life Cycle Cost Analysis), Life Cycle Assessment (LCA), and Finite Element Analysis (FEA) could be completed (by basing assessments off of the generated 3D CAD models). From these assessment results, there will be the identification of the best performing structure, with respect to economic feasibility and environmental impact.

Life Cycle Cost Analysis is a tool to determine the most cost-effective option among different competing alternatives to purchase, own, operate, maintain and, finally, dispose of an object or process, when each is equally appropriate to be implemented on technical grounds (Cole & Sterner, 2000). Finite element analysis (FEA) is a computer simulation to predict how a product reacts to real-world forces, vibration, heat, fluid flow, and other physical effects (Hughes, 2012). Finite element analysis shows whether a product will break, wear out, or behave the way it was designed. In a general sense, it is used as a prediction method for what is or might happen to the product once the product is used. Life cycle assessment is a cradle-to-grave or cradle-to-cradle analysis technique to assess environmental impacts associated with all the stages of a product's life, which is from raw material extraction through materials processing, manufacture, distribution, and use (ISO, 2006). The methods are integrated into the framework above to systematically evaluate the function and sustainability of the designs.

### 3. ANALYSIS AND RESULTS

The biomimicry structures that were chosen to create and test on were auxetic, bone tissue, and lily pad structures. To understand each of these structures, 3D models of the structures were created within AutoCAD. Multiple tests were conducted on each structure with finite element analysis, static analysis, and fatigue analysis as mentioned above. Figure 2 shows the cross section of the three structures selected in their 3-dimensional form. The tested structures have the geometries fill the entire 3 x 3 x 1 block in order to obtain accurate data on how they react under various forces and pressures. These models also more accurately represent how these geometries can be used in various parts and tools through various industries.



[Figure 2] Bioinspired structures: Giant Lily pad, Auxetic, and Bone tissue

FEA was conducted using Solidworks to test how different designs would react to minimal force all the way up to major forces to better understand how each structures properties are exhibited. For the static analysis 10lbs, 100lbs, 500lbs, 1000lbs, and 1500lbs force were applied from both the top and side of the model, as seen in the figure. As for the fatigue analysis the model was subjected to the same sources over 10,000,000 cycles in order to analyze the damage done to the part.

It was clear across all models that the 500lbs force showed significant change in the model. From the testing results, the auxetic structure experienced the greatest deformation and stress compared to the bone and lily pad structure. This can be due to the fact that the auxetic structure has the ability to expand perpendicular to side where the force was applied, which within the closed model cause too much stress throughout the entire structure especially under high forces. Where the properties of the lily pad and bone have high strength and stiffness which allow it to withstand high external loads.

Overall, it can be concluded that the bone withstood the lowest amount of damage over the 10,000,000 cycles at  $9.31679E-014$ . The lily pad took the largest amount of damage at  $1.56735E-012$  which was expected due to the fact that it had the highest porosity and vascular nature making it more likely to break under high sustained pressure. It should also be noted that the bone structure had highest life cycle meaning it is expected to fail later then the other two structures on both the side and top force results. In general the bone held up the best over time likely due to its high stiffness and strength allowing sustain high pressure.

Figure 3 shows the life cycle environmental impact results on energy consumption and carbon emissions. For the auxetic structure the total amount of energy consumed for material, manufacturing, transportation, and end of life was 24MJ with the majority of the energy consumed being in materials. Across all categories excluding air acidification materials had the greatest overall impact. This is due to the material consumption and energy use during material preparation for the additive manufacturing process.

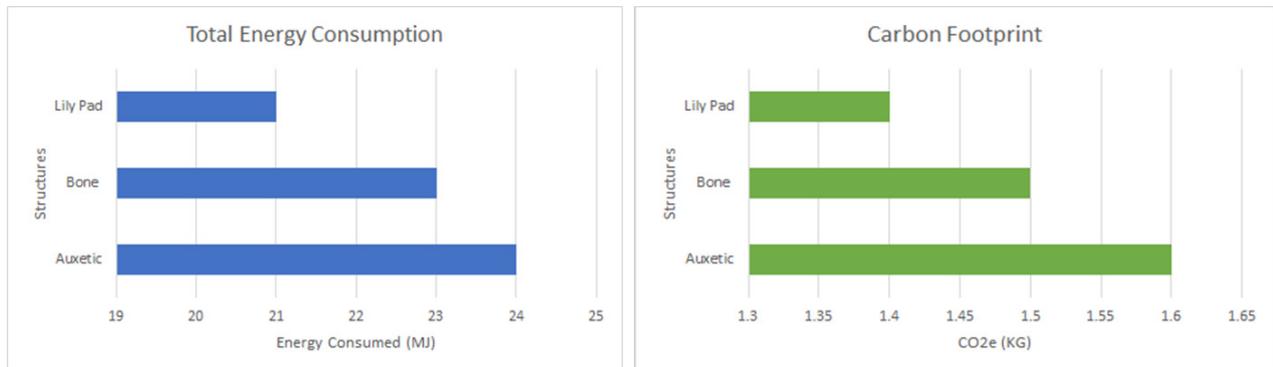
For the bone structure the material has the greatest contribution to carbon footprint at 1 kg and the manufacturing of the part at .445 kg. This number is much less when comparing to the carbon dioxide emissions from subtractive manufacturing. The total energy consumed is 23MJ with the greatest contributor being the material. The greatest air acidification factor can be attributed to the manufacturing at  $2E-3$  kg of sulfur dioxide.

Similar results were shown among the lily pad structure for the sustainability analysis with total energy con-

sumed being a total of 21MJ which is the lowest across all three structures. The material can be attributed as the greatest contributor among the carbon footprint, total energy consumption, and water eutrophication. Similarly to auxetic and bone the greatest contributor to air acidification is the manufacturing process. This lily pad structure is the most sustainable across all categories of our analysis.

Overall, the lily pad structure consumed both the lowest amount of energy and had the smallest carbon footprint. This is due to its high porosity and vascular structure which requires less materials than the rest of the structures.

[Figure 3] Energy consumption and carbon footprint from the three structures



#### 4. CONCLUSION

Additive manufacturing has tremendous capabilities across various fields of industry including automotive, aerospace, architecture, and medical fields. The major bottleneck seen in AM is the timely process design limitations. Through the introduction of bioinspired design presents solutions to structural integrity and material reduction. This paper aims to develop a systematic methodology to identify biomimicry geometries for product applications. The systematic methodology is intended for design engineers by providing a systems engineering approach to the lightweight material structure design realm. Furthermore, the end goal is to assess the functionality, economic, environmental, and social consequences from production with AM processes.

The method integrates concurrent considerations of multiple additive manufacturing design and bioinspired design factors including raw material quality (e.g., size, shape, internal porosity), processing parameters (e.g., laser power, roller speed), and functionality of the product (e.g., stress, strain, displacement). Sustainability assessment methods (e.g. life cycle costing, life cycle assessment) have been used for evaluating cost and environmental impact for processing different geometries. Finite element analysis is used for product functionality testing. A case study is conducted on making a unit Titanium product with selective laser sintering process. Three structures were examined: lily pad structure, bone structure, and auxetic structure. Cost assessment considered material, labor, energy, and equipment components. A cradle to grave life cycle assessment was conducted to assess environmental impact, including material, manufacturing, transportation, end of life plan. The results show that lily pad structure yields lowest cost and environmental impact. This study reveals that the model can be applied in additive manufacturing early product design and it assists researchers and engineers in their exploration of new bioinspired geometries that could be applied to industrial products. Future research will be focused more on physical testing of these geometries as well as modified versions and new designs. Some physical tests to be conducted include stress, strain, displacement, and different temperatures and environments. Topology of the product also needs to be studied with physical prototypes.

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## **SMART HOME GRID: TOWARDS INTERCONNECTED AND INTEROPERABLE ELECTRICAL MODEL TO IMPROVE THE USAGE AWARENESS**

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### **ABSTRACT**

In the last decades, the evolution of technologies for the smart home enabled users to control the electrical usage of system and appliances. However, despite the widespread of IoT solutions, there is a poor integration between electrical utilities and products or services. This is mainly due to disaggregation of electrical data and the lack of interoperability between actors. These weaknesses bring to a non-supervised electrical “last mile” and poor awareness of detailed users’ electrical consumption.

This work aims to introduce the concept of Smart Home Grid showing a first model with four main goals: gather data and extract usage patterns; improve the user experience by supporting the users through an electrical usage information system; share the usage between actors; push Energy-as-a-Service models for sustainability.

Key Words: Smart Home Grid, Energy-as-a-Service, IoT

## 1. INTRODUCTION

In the last years, smart technologies have experienced a period of wide spread. New devices with new advanced features show off on the market, both for customer (e.g. smartphone) and enterprise electronics (e.g. smart city grid infrastructures), promising enhanced functionality, connectivity and manageability.

Major technology developers, service providers and energy utilities are now lining up to extend smartness beyond specific devices towards home, considered in their complexity, and interconnected through meters, networks and cables belonging to energy suppliers. The advent of smart home, defined as a set of interconnected products and services and with an active role in sharing and processing data, can ensure that smart technologies become a habit of people's lives (Haines, Mitchell, Cooper, & Maguire, 2007).

Regardless the type of technology configuration of the smart home, its goal – according to technology developers – is “to improve the experience of living the home”, depending on different methods with as many different domestic conditions. (McLean, 2011).

Essentially, a smart home collects and analyses data from the home environment, transmits information to the users and to the service providers, and increases the potential to manage different home system, such as heating, lighting, entertainment (Firth, 2013). Smart home technologies include sensors, detectors, interfaces, appliances and interconnected devices to allow automation and remote control of the home environment (Cook, 2012). In particular, there are different categories of product and services with the aim of monitoring and managing electricity consumption: these categories of product use different communication technologies and protocols, preventing or limiting the consumption overall management. These differentiation in communication is mainly known as a lack of standard and usually is the cause of non-interoperability between systems.

Smart homes are also the final node in smart energy management system, which could enable energy service providers to respond, in real time, to the energy demand of millions of inhabitants.

This gives smart home the opportunity to align with the energy service provider's needs, to limit or change energy availability if, for example, infrastructures is overloaded, de-potentiated or out of service (Darby, 2010).

Therefore, the smart home should be not only an automation tool, but also an important part of an intelligent and efficient energy management system, which allows to reduce the overall energy demand and help to alleviate the overloading of power plants during peak periods (Firth, 2013).

The widespread diffusion of smart home technologies has long been expected by many public governments and it is considered an important component for the creation of smart grids; smart home experts agree that climate change and energy policies will drive the development of the smart home market. Italy, on the other hand, has adopted a new National Energy Strategy since 2013, identifying as priority developments the energy efficiency, the sustainable development of renewable energy sources and the creation of smart grids, with the aim of growing energetically with zero emission, and ensure the energy provision for the medium (2020) and long term (2050).

Furthermore, Italy was the first European country to adopt smart meters connected with the electrical power distribution infrastructure since 2000s. Enel's smart meters (Figure 1), since 2006 (Van Gerwen, Jaarsma, & Wilhite, 2006), have become mandatory for all Italian energy providers, establishing minimum functionalities in order to allow all the electrical company to correctly measure the quality of supply, directly through the meter.

Moreover, starting from 2017, “e-distribuzione” (the new name of the national electricity provider) is gradually replacing the old smart meters with the new generation ones (Figure 1), which allow a more accurate measurement and allow for interoperability with other devices, in order to prepare the infrastructure for an on-demand energy market (Balta-Ozkan, Boteler, & Amerighi, 2014).



[Figure 1] On the left the first Enel Smart Meter, installed during 2000s in 32 million houses. On the right Open Meter 2.0, e-distribuzione smart meter, the second-generation meter with higher accuracy, ready for the smart home and equipped with interoperable communication protocol.

## 2. THEORETICAL BACKGROUND

Since the 2000s, technological innovations created new market segments, made technology and connectivity more democratic and, above all, radically changed the users' habits and their interaction with the machines (consider how smartphone has radically changed everyone's life routine). The launch on the market of new technologies, such as

multitouch, smartphones, wearables and wireless connections have deeply renewed the relationship between man, technology and mobility, thus forcing companies to improve the human-computer interaction related to products and services, focusing on the user in every research and technological development process. Therefore, the human-centered design has led companies to perceive the importance of offering their customers not only high-performance product on technological point of view, but also usable products, pleasing in appearance and use, and easily configurable (Norman, 2010).

One of the technologies that most needs a user-centered approach is domotics. The home automatic has evolved from technologically advanced but too complex solutions, to more familiar and reliable solutions, perceiving a new opportunity for creating a home infrastructure which is pleasant, usable and easily scalable.

Until a few years ago, home automation solutions were produced mostly by the same companies that were demanded to the distribution of energy, lighting and automation. Technological evolution has brought domotics and the new smart home towards companies and manufacturers that until last years had been unimaginable: IT companies (Staff, 2013). Products and services move from being complex, painstakingly customizable and scalable domotics system (which require expensive infrastructures), to system designed to be a network of devices able to store every data exchanged with other products of the system. This new systems optimize their operation thanks to algorithms which profiles the users, in order to comply more and more users' preferences or, in some cases, to predict their behavior (Yang & Newman, 2013).

These services and products, or better the model of technological development connected and with intelligence, is more generally diffused with the term "Internet of Things" (IoT). IoT is the phenomenon of "connected things", i.e. devices, plants and systems, tangible products and materials, work and goods, machine and equipment, all connected to the Internet and able to exchange information autonomously with one or multiple objects connected to the same network, or communicate with other network thanks to standard communication protocols (LAN, WLAN, Bluetooth, ZWave, ZigBee) (Al-Fuqaha, Guizani, Mohammadi, Aledhari, & Ayyash, 2015).

Unlike home automation system, whose main business in the last two decades has been focused on a technology-push approach that led the companies to focus just on the stand-alone product, the brand-new IoT product, infrastructures and interfaces that make up the smart home are no longer considered as separated technologies. Instead, they became a complex ecosystem of different solutions led by underlying services, designed on the real people demand.

### 3. RESEARCH METHOD

As described in the previous chapters, the market is full of different solutions which can record and share data regarding energy usage and efficiency inside the home, but in most cases, they are stand-alone product and data are limited inside the house or in a private cloud, and cannot be used for statistics, profiling or improving the energy consumption. Analyzing the market of smart plugs (see chapter 2) it is clear that non interoperability problem is due to two main problems:

- Lack of communication standards and "lack of API" (there is no standard in traditional/legacy like BTicino and KNX); API could enable and simplify data exchange between different systems and interoperable communication processes between machines/devices.
- Lack of full-cloud logic: in a product-service system, the cloud allows for the complete remote management of a system, the control by the user and, theoretically, by the energy supplier. These features could also allow for the ordinary, extraordinary and predictive maintenance of the installed product. This logic is currently available in IoT products and services, but rarely in traditional/legacy product because gathered data are bordered within the home environment.
- These two technological lacks bring to:
- Fragmentation of energy consumption information which cause a lack of awareness of the user because he has to interact with more touchpoints in order to know the exact amount of energy the user is consuming.
- Flawed user journey: the presence of multiple non well-managed touchpoints, together with the different service levels, prevents controlling the acquisition of energy consumption information by the energy suppliers and consequently, fails to guarantee a good service quality from an information point of view, also in case of malfunctioning.

[Figure 2] The Electrical Flow of Information: difference between as-is (red) and to-be (green) flow in order to increase usage awareness.

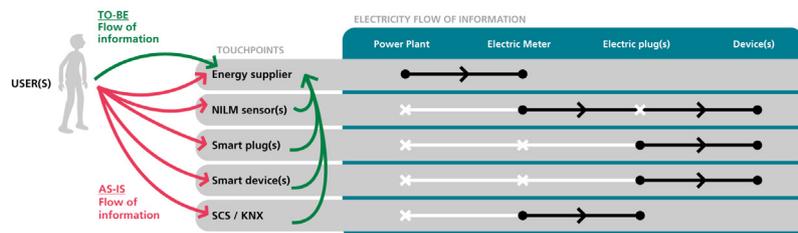


Figure 2 show the matrix of energy "miles" with the various touchpoints. This matrix has been studied by means of research on different touchpoints and interview with stakeholders, in order to identify all the phases of the

user's journey and the communication shortage between touchpoints.

Figure 2 shows:

- in red the information flow in the current state (today): the user needs to poll each element which measure energy consumption, then take care himself of creating a “sum” and eventually managing the consumption according.
- in green the information flow as it should be: the information coming from the single elements that measure energy consumption act in an “underlying” way, transmitting all the data to the energy provider. This process them and resend back to the user, who no longer has to worry about interrogating all the meters but only have the energy provider as single touchpoint (who could access through the app at any time, or at the end of the month though a bill enriched with details of individual consumption (i.e. by type of products, consumption category, etc.).

Innovation brought by IoT has allowed to the energy sector (electrical, energy, heating and air conditioning, etc.) to develop new strategic assets, influencing the consumer choice of more than 30%, who are increasingly oriented towards technologically advanced solutions able to offer a huge quantity of information (Vodafone, 2018). The advent and adoption of these new technologies has allowed the evolution of smart grid.

The smart grid is, at the origin, a combination of an information network and a distribution network, which makes it possible to smartly manage the electricity grid under different aspects or functionality, as it is able to distribute electricity in an optimized way (Belcredi, Modernell, Sosa, Steinfeld, & Silveira, 2016). Smart grids are constantly evolving, scaling more quickly and adapting to the needs, such as at urban dimension level, industrial or commercial centre, down to smaller systems for home management. In such cases, these grids take the name of micro grid (tens, up to thousands of housing and commercial) and nano grid (single housing or commercial) (Hebner, 2017).

When nano grid has smart and intelligent component which is able not only to collect data, but also to process them we can call it smart home grid. By means of a decision support system based on user energy profile, smart home grid is able to take decision and talk both with energy provider and home actuator with the aim to minimize wastefulness and request energy only when needed.

#### 4. RESULTS AND ANALYSIS

Most of the homes and buildings appliances don't support smart environment yet, due the lack of APIs and legacy operating systems. This causes information silos and limit data gathering. Brand-new technologies for smart home, like Google Home or Amazon Alexa, are partially solving this issue: they can be used as a hub for connecting different devices and services, form multiple operators and company, and analyze gathered information in order to extract data which can be useful both user profiling but also for energy saving. An example are the smart thermostats (e.g. Nest) which can be controlled by the smart assistants but, at the same time, work in connection with other sensors inside the house in order to smartly control the temperature to optimize comfort and efficiency; some other thermostats, directly produced by gas supplier or boiler manufacturers, directly send information to the producer with the aims of optimizing boiler operation forecasting an ad-hoc maintenance, and of effectively measuring gas consumption.

	<i>Home automation (Domotics)</i>	<i>IoT-based Smart Home Grid</i>
<i>Goal</i>	Application of information technology and electronics to the home management	Devices recognize each other and acquire intelligence because of their ability to share information with other devices and retrieve pooled data within the network
<i>Architecture</i>	Hierarchically designed network and facility	Single and independent devices
<i>Intelligence</i>	“Dumb” devices	“Smart” product and services
<i>Industry (market)</i>	Electrical Builders and Facility solutions manufacturers	Electronics and information technology manufacturers
<i>Connectivity</i>	Centralised and managed by a system	One-to-one connection between network and device
<i>Output</i>	Just offline data for the user, without suggestions or improvement for usage	Integrate and merge data from different touchpoints and sources; compare them with external dataset to enhance the accuracy; improve the development of new energy-as-a-service solutions
<i>Strengths</i>	<i>Load monitoring; priority consumption management</i>	<i>Load monitoring; high infrastructure flexibility; plenty of API and data sharing services</i>
<i>Weaknesses</i>	<i>Lack of infrastructure flexibility; lack of API; no data sharing</i>	<i>Expensive technology; rare priority consumption management</i>

[Table 1] *Main difference between Home automation (Domotics) and IoT-based Smart Home Grid.*

This is a first attempt to connect different touchpoints. By introducing the concept of smart home grid in the

domestic environment, it is possible to extend the chance to gather data, both from smart and non-smart appliances and services. Specifically, a set of electrical sensors, both native or 3rd-party, can measure the electrical load of each appliance or service. All the data from sensors can be stored and processed in a single data system or a distributed one in order to maximize safety and reliability. All the data can be then aggregated in order to have all the information about the electrical usages and automate the energy loads according to users' needs and choices. At the same time, algorithm of machine learning can profile users from their data with the aim to provide energy on demand maximize efficiency, minimize wastefulness and costs. Table 1 shows the main differences between the home automation technology (domotics) and the IoT-based Smart Home grid.

This new paradigm of IoT-based Smart Home Grid mainly consists of smart plugs and appliances capable to measure their own electrical consumption and transmit them to the energy providers. This feature would allow to create a mesh of interconnected final touchpoints inside the home, defining this new "interoperable network of the energy" between the same users, energy providers and other services. Interconnectivity and interoperability would produce new benefits both for users, which can control and optimize energy usage thanks to a detailed (plug-by-plug) consumptions, and energy suppliers which can provide energy based on real needs without overcharge the network.

Thanks to this improved circulation of information about the electrical performance, the above-mentioned network can represent a new model to raise the awareness of the consumptions. In fact, a new kind of set of information, based on single usage data and no longer on aggregated one, can support the user to be aware of his habits, every time he turns on an appliance, even if no necessary. Another assumption could be in the association of these data with average usage data (i.e. per zone, time frame, usage habits per similar users, back data, etc.). This association can contribute to create and enhance new models that aim to make the user more capable to manage his usage and energy habits.

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## **ZERO WASTE: EXPLORING ALTERNATIVES THROUGH FOLDING**

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### **ABSTRACT**

The paper discusses a new approach to eliminate Cut and Sew Waste (CSW), at the construction stage of garment-making called DPDC, a synthesis of designing, pattern-making, draping and cutting & incorporating zero-waste techniques using one-piece fabric. The objective is to create an open source of templates for the design community to integrate in their pattern-making frameworks. Taking reference from step-by-step origami, using only a rectangle or a square paper as the starting point, the translation of folds from paper onto fabric led to interesting discoveries in terms of construction and wearability. Since the construction of the garment follows a very simplistic approach, it moulds in accordance with the wearer's body. In addition to effective fabric management, this technique offers production and financial incentives in terms of fabric utilisation.

Key Words: Zero Waste, Folding, One-piece fabric, Template

## INTRODUCTION

Producing fashion and textiles involves some of the longest and most complicated industrial chains in the manufacturing industry. The conversion of raw textile fibre to finished fabric and finished product draws on labour, energy, water and other resources and cumulatively makes for a high-impact sector (Fletcher 2014, p. 51). As was recently stated in Pulse of the Fashion Industry Report 2018, the fashion industry is not the second most polluter in the world, but the fifth most, falling after electricity and heat, agriculture, road transportation, and oil and gas production and equal to livestock. The current waste stream from the fashion industry is the result of an energy intensive complex linear supply chain that was shaped over 150 years ago during the Industrial Revolution. The system created a one-way track for goods, which the World Economic Forum refers to as the ‘take, make and waste’ model (Whitty, 2015, p. 620). All the stages in the supply chain (See Figure 1) produce waste in one form or the other and in varying quantities.



[Figure 1] The linear system of fashion (Whitty, 2015, p. 620).

A fundamental shift is required from a view of the economy as a linear system where we ‘take, make, waste’, in which over 90% of the resources taken out of the ground today become waste within only three months (Chapman, 2005, p. 8), to a cyclical one where resource circle around the economy becoming source material for new goods (Fletcher, 2014, p. 127).

The textile waste is created in two broad categories: Pre-consumer waste and post-consumer waste. While the latter is mainly concerned with the clothing waste created by consumers, after it crosses the use-phase of its life-cycle and can be controlled very little by the designer, the pre-consumer waste that involves the waste generated during the construction phase of a garment, termed cut and sew waste (CSW), is where the designer can intervene and take control. This waste accounts for an average of 15% of fabric waste and as studies report, the world now consumes about 80 billion new pieces of clothing every year (Ross & Morgan, 2016), this 15% is of a grave concern.

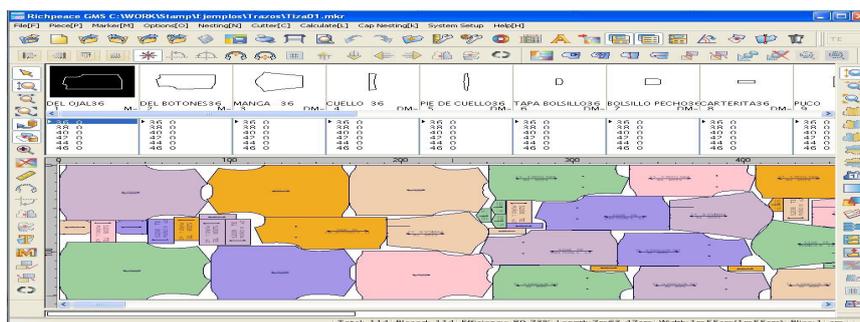
My research is aimed at eliminating this 15%. Instead of thinking how to use the waste generated, why not to avoid generating it in the first place. Is it possible to make garments without any waste? How can designers adopt this model in a more simplified manner without compromising on aesthetics? Is it possible to scale up this zero waste model to mass-manufacturing? This research paper aims at how the pre-consumer fabric waste can be brought down to zero during the designing, cutting and sewing phase of clothing manufacture.

## 15 PERCENT TO ZERO

The current way in which garments are being made in the fashion industry is using up resources in an inefficient way. The general process from design to production follows: design, pattern making, construction, and production. The separation and hierarchy of these processes has led to a cut and sew fashion system that results on an average of only 85% of effective textile use, leaving the other 15% on the cutting-room floor. These are generally termed as ‘off-cuts’, and can vary between 10-20% of fabric waste, depending on the garment design (Rissanen, 2008).

Between the initial conception by the fashion designer and a retail store, a mass-produced garment passes through several steps. The pattern cutter makes a pattern (on paper or computer) based on the designer’s sketch and the pattern guides the cutter in cutting fabric (See Figure 2). Before the cutting of multiple garments in production, the marker-maker creates a marker (on paper or computer), which contains all the pieces of all the sizes to be cut. In response to the statement made by Rissanen (2013) “the responsibility for this wastage belongs with manufacturer, which is constrained by what has already been designed and pattern cut”, it can be inferred that the actual ownership of fabric wastage lies with the people involved at the designing stage.

Why is it that even the most precise marking-making technique in patterns cannot utilise the complete fabric?



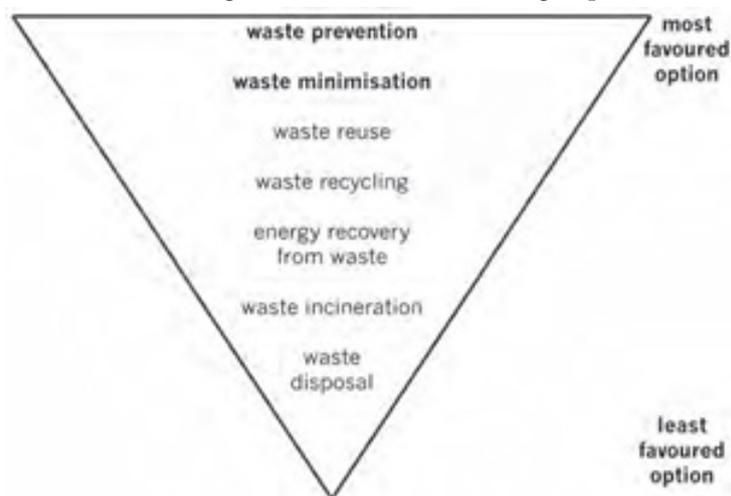
[Figure 2] Marker -making software. Retrieved from <https://www.brstudio.com/news/richpeace-garment-cad-marker-system-gms-dongles-emulators.html>

The reason is the irregular shape of the pattern pieces that makes them impossible to interlock perfectly to be able to use complete length and width of the fabric. The curves as seen on the pattern pieces are there because the garment has to fit along the body contours. When these curvilinear pattern pieces are placed together, the white/negative areas (See Figure 2) contribute to 10-15% fabric wastage and in mass-production cutting, dozens or hundreds of layers of fabric may be laid out on the cutting table, resulting in layers of this fabric waste percentage.

Fabric wastage is not just a waste of material, but it means wasting all resources, such as fibres, dyes, chemicals as well as water and energy that are used in producing the raw fabric. All fabrics embody the time and efforts of various people from fibre extraction to spinning to textile design and weaving and knitting the fabric; wasting a portion of fabric is also a waste of the embodied contribution of those people (Rissanen, 2013). Granted, the leftover fabric can be utilised in other products or as scraps, but it can be argued that this is not a sufficient way to manage the fabric (Aakko & Niinimäki, 2013a, p. 70). Current practices of getting rid of fabric waste include recycling, sending it to the landfill or incineration for energy production or using the scraps for patchwork, as stuffing material or down-cycled by shredding and tearing to make yarn used to make shoddy (Fabric made from recycled fabric waste at places like the recycling factory at Panipat, India (Gupta & Berardi, 2016)). Fletcher (2014) notes the largest problem posed for recycling is the sheer diversity of fabrics: synthetic and natural fibres are often blended into one fabric, and sorting fabric waste by fibre type and colour can pose a huge problem. Mechanical recycling also shortens fibres, resulting in lower quality yarns and fabric (Rissanen, 2013). When the fabric waste is not recycled, it is sent to the landfill or is incinerated. In the former case, fabric decomposition results in release of toxic chemicals and gases like methane and ammonia (Fletcher 2014) while in the latter, energy recovery is one of the reasons for incineration for energy production. At times, the waste is not incinerated for generation of energy, but the aim is to reduce the volume of waste going to landfill. When there is such an enormous investment of resources embodied in the fabric, why waste fabric?

### ZWPC (ZERO WASTE PATTERN CUTTING)

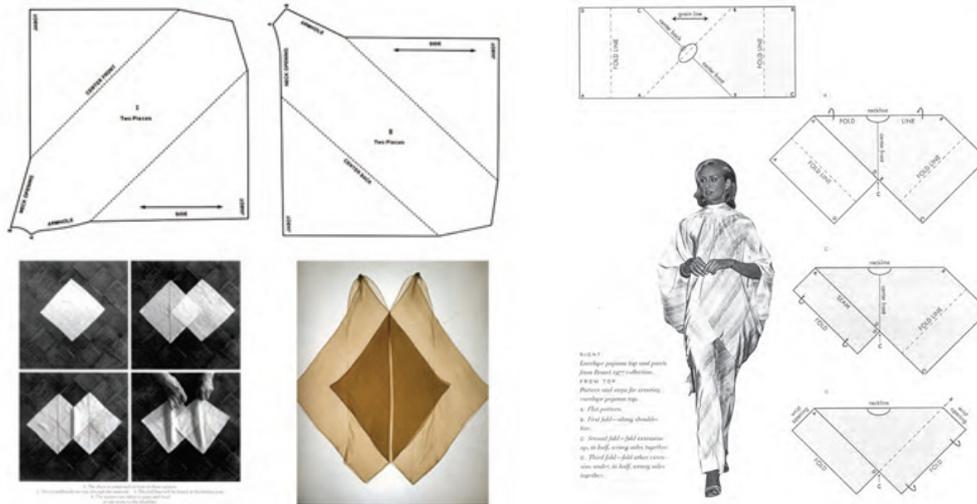
Zero waste fashion design is a tool for eliminating fabric waste and increasing the efficiency of fabric use in garment production. As the terms defines, a zero waste garment is designed and pattern cut in such a way that results in no off-cut waste being generated. Such a garment focuses on the top of the pyramid (waste prevention) as depicted in the waste management hierarchy graph (See Figure 3). Zero Waste Pattern Cutting (ZWPC) method integrates the processes of pattern making and designing. This simultaneous process enables the complete usage of the fabric: design decisions can be made during an evolving process of pattern making guided by the aim of zero fabric waste (Aakko & Niinimäki, 2013b, p. 6). One is seeing the garment evolve instead of visualising it or sketching it on paper. The process becomes more intuitive and generates more creative design options.



[Figure 3] Waste management hierarchy, adapted from White, Franke & Hindle (1999, p. 20)

Zero waste as a concept isn't a new phenomenon. Today, the term suggests a focus on avoiding waste, whereas earlier the main concern was to fully utilise expensive fabrics. Throughout history, various cultures have produced clothes in a way that wasted little or no fabric, be it the Greek and Roman drapes, the Japanese kimono, the Scottish kilt or the Indian drapes (sari, mundu, mekhala, gamcha, lungi, etc.). Design elements often included gussets or gores, minimal arm shaping, rectangular sleeves or pants, and people engineered garment pieces to match the available fabric's length and width. In modern Europe, the Parisian couturier Madeleine Vionnet incorporated zero waste in some of her creations, such as a dress made out of four squares (See Figure 5). Historical and contemporary examples of such designing show that it is possible to design without creating fabric waste, but the rarity of the contemporary examples implies that designers are still hesitant to adopt zero waste approach in their practices.

[Figure 4] Envelope top by Halston, 1977 (Gross & Rottman, 1999, p. 118)



[Figure 5] Dress by Madeleine Vionnet (1919) from Kirke (1998) and Demornex (1991) square dress, p. 51

**DPDC : DESIGNING, PATTERN-MAKING, DRAPING AND CUTTING**

In a general fashion industry practice, a pattern is cut for a garment based on a sketched idea. When a fashion designer is sketching a garment, the design of the garment is more of a consideration than the shapes of the pattern pieces or the width of the fabric. The main aim of the sampling or production unit is to realise the sketched idea in three-dimensional form. Rissanen (2013) said “the key impediment to zero-waste fashion design is the separation of roles of fashion design and pattern cutting”. This separation (See Figure 6) is the main reason that distances fashion design from issues it could address, such as fabric waste. People involved in the garment-making process work at different physical locations, at times separated by continents. Even in an independent designer’s studio, the tailoring unit is segregated from the design unit, the interactions happening at different floors/units.

[Figure 6] Verticals in a typical design studio

DPDC, a synthesis of designing, pattern-making, draping and cutting, incorporating zero-waste techniques,



using one-piece fabric, is an approach that challenges the predominant roles and relationships between and among designer, pattern-maker, cutter, etc, instead of them working in isolation. ‘Space Between’(Whitty, 2015), a model of social innovation for fashion, makes a strong assertion for the potential of working collaboratively in a multidimensional capacity. It encourages a shift in industry practices whilst setting up new opportunities for designers, producers, and new participants (Whitty, p. 625).

DPDC takes into consideration a form of design activism called participatory design or co-design and the potential of designing together to foster a more connected and active engagement with fashion and textiles. According to Ehrenfeld (2008), “Participatory design involves a shift in emphasis away from control; a change in the distribution of power, where systems of production and ideas about design, manufacture, work and outcomes alter. A broad distribution of fashion ‘power’ would foster skills, pieces, relationships and experiences that allow us become better engaged with ourselves, each other and the material world”. DPDC aims for equal participation by all the people involved in the process especially, the pattern-makers, to be working closely with the designer, merchandiser, the cutter and the tailor.

Current ZWPC approach looks at how zero waste garments can be made through intelligent pattern-making and designing techniques. In addition to this, DPDC looks at the approach of cutting and draping, including the roles of designer and merchandiser as well. The whole process, is like a narrative getting formed with the transformation of a 2D into a 3D form. It is a form of discovery. Zero waste design practitioner, Mills, draped each of her garments instead of starting with the paper pattern as she preferred to allow ‘the fabric to show her the way’, instead

of her ‘forcing the fabric to fit the pattern’. Calderin (2009, p.171) explains “Taking the fabric to the dress form is a good way to gauge how the fabric breaks, fold, and drapes. It also provides a better sense of body and bulk of a fabric, affecting decisions about finishing details” (Townsend & Mills, 2013, p. 10). One is constantly moving back and forth from the pattern-making/cutting table to the dress form, making alternating decisions since at times some decisions that cannot be taken on the table (e.g. how the garment falls/ movement aspects. openings, etc.) can very easily be taken on the dress form.

DPDC is about breaking the rules of pattern-making and questioning the set definitions. Unlike the conventional process of pattern-making where the final look is generally predictable before the cutting process is finished, it is the intuition and creativity that guides the process. This practice-based approach allows people involved in the process to take on different roles; blurring the hierarchical roles: the pattern-maker become the designer, the designer becomes the cutter the cutter is the draper, so on and so forth.

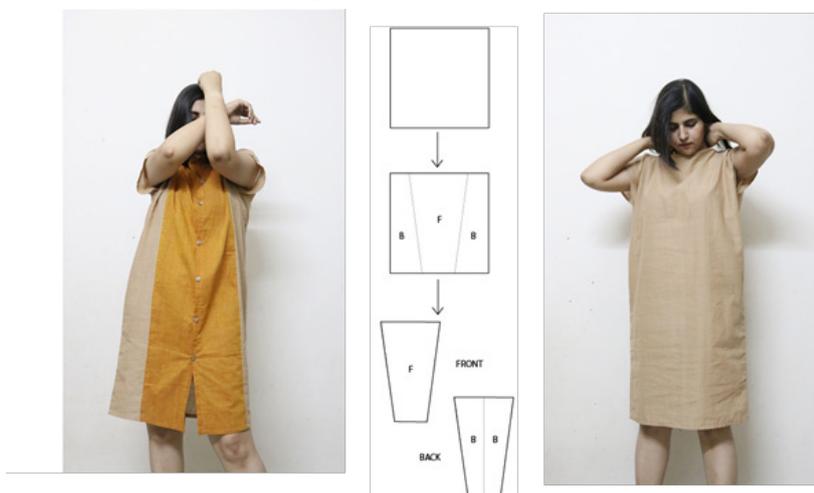
Practicing DPDC approach involves a lot of uncertainty. McQuillan (2009) sees a creative advantage in uncertainty; “I realised that uncertainty can be a great innovator and that as long as you have a destination in mind, you don’t really need to know how you are going to get there... the process of risk and uncertainty and subsequent sensitive reaction to this can lead to unexpected positive outcomes that respond sensitively to material, form, and environment. It begins by greeting the raw materials of garment production with integrity”. Although DPDC is about breaking rules, it also means one is thorough with one’s research in sustainable design and is aware of existing and new-age industry practices. “The more elements of the proposed theoretical model are combined into a designer’s work, the more it would potentially enhance the practice of sustainable fashion design” (Aakko & Niinimäki, 2013b, p. 5).

## PERSONAL EXPERIMENTS

Initiating the practice with step-by step origami, taking reference from ‘Secrets of Origami’ (Harbin, 1997), starting with a square-sized piece of paper and creating folds, it was a curious and an inquisitive process as to how the folds on paper would translate onto fabric in the form of a garment. The translation lead to interesting discoveries in terms of construction and wearability. Although one of the initial challenges in this approach was the way folds on fabric were behaving differently than they do on paper. But this was an interesting point of discovery. Some of the folds were tucked here and there or at times draped at certain areas, a piece cut and adjusted elsewhere or just made to fall naturally. This simultaneous process of working on the table and taking the garment on the dress form and back and forth, is what DPDC approach entails. When a half-folded fabric was put onto the dress form, the folds could be draped around the body in interesting ways, or pieces were cut and accommodated at another part of the drape, and any piece cut from the square piece was accommodated as a pocket, layer or just as a reinforcement. Thus, in addition to using a whole piece of fabric and not creating waste the garment is also designed for endurance (Aakko & Niinimäki, 2013b, p. 7).

## NOT ALL WASTE IS WASTE

Improving one aspect towards a better fashion system model is not enough. One needs to look at the system holistically, in order to address multiple issues at the same time. Strasser said, “When someone deems a material entity undesirable or unnecessary, it becomes waste” (1999, p. 5). One of the main goals of DPDC is to use waste as fabric source instead of virgin material. The aim is to arrive at a square or a rectangular shape achieved through patch-working waste (sources of which could be end-of-roll waste, cut and sew waste, etc). One of the techniques for patch working that has been used is pojagi: a traditional Korean wrapping cloth (See Figure 8). In my practice, any rectangular or square waste generated was not considered waste. While majority of the shapes in cut and sew waste



[Figure 7] Paper house dress Front-back dress



[Figure 8] Pojagi sample

are curvilinear and difficult to patch together, contrary to this, the rectangular or circular waste can be used to make a different garment without any further wastage being involved, since the off-cuts can fit well as in a jigsaw and for that matter even triangular waste can also fit well. Thereby, not all waste can be rendered as waste in its true

[Figure 9] Paper house dress

[Figure 10] Slash and arrange dress



When it came to utilising and arranging fabric around design, it offered a lot of possibilities. Some of the fabrics were engineered around the zero waste design (See Figure 10). The garment can be worn front-back thereby offering two different possibilities to the wearer: plain front or button-down front (See Figure 7). So there were possibilities of multiple variable designs within one cut of cloth. The approach also takes into consideration fabrics and aesthetics, opening, functionality etc and nothing is known beforehand on paper (unlike how the design system usually operates). The entire decision making is happening while the fabric is being cut, stitched, draped, finished etc aiming for more interconnectedness in the whole fashion system.

The above personal design experiments are scalable and can form an open source design which is built on the premise that people have skills and are willing to share them and can successfully collaborate on large-scale projects without being controlled by markets or management. It offers the prospect of a more inclusive and participatory model for fashion and textiles. In the case of DPDC approach, individual designers as well as big retail companies can use these designs, incorporating their aesthetics alongside.

The width of the fabric is crucial for the design process because it imposes limits on the patterns (Aakko & Niinimäki, 2013b, p. 8). It was analysed that the garments made through the DPDC approach are fabric width dependent (majorly since the fabric is being designed through pojagi or bigger patchworks, the width is also in control giving flexibility in terms of the many sizes that can be accommodated. The width of the fabric will define the size of the garment. It becomes the definition of size for a garment. The garments are labelled as fabric widths, giving the consumer an insight into how the garment came into being. The longevity of any garment is also affected by how interested the consumers are in the story/process behind their clothes; in this case, how the garment design was based on an origami shape. Once the garment has been worn completely, the individual pieces can be put back together, since they were all the part of the same garment, and can be brought back to the original square shape. First Son (McQuillan, 2005) explored the potential of dresses made from a single piece of cloth that could be returned back to that single piece of cloth. They transformed from 2D to 3D and back again.

Another advantage of this technique, in addition that the garment can be worn in multiple ways, is that it can be worn by different body types as well. On a particular body type, the same style in different widths would drape differently. The wearer, in essence, is giving a certain character to the garments, and is independent of the size the wearer chooses to buy.

## CONCLUSION

The way in which the current fashion system is operating needs to be altered at a fundamental level. As Fletcher (2014) stated, a profound shift in perspective is required from accepting waste as an inevitable by-product of the sector to a future where the provision of fashion and textiles and their consumption is connected differently (Fletcher, 2014, p. 126). It is better to avoid waste than to fill the planet with things made from it. Zero waste is a promising waste reduction technique to be adopted by an independent designer working in his/her studio as well as the people involved in the retail sector. It can change industry's attitudes towards better resource use. DPDC, as an approach, if further investigated and researched can lead to significant reductions in cut and sew waste. With global production now exceeding 100 billion garments a year (Cooper, 2018), even if few brands can take a constructive step in this direction, substantial waste reduction can happen.

As Mark Liu said, "[To] sit back and be part of the system is not good enough. We have to try to invent new ideas and be continually researching" (Black, 2013, p.248).

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## ENVIRONMENTAL PRODUCT OPTIMISATION: AN INTEGRAL APPROACH

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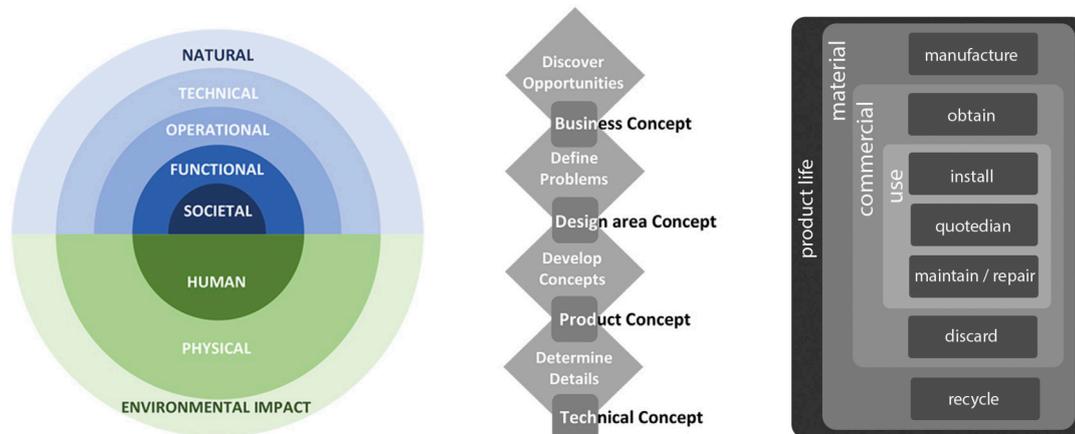
### ABSTRACT

For environmental product optimisation, an interdisciplinary design team needs to mutually align and assess the physical- and human impacting factors of a product system. This paper argues that this optimisation can be supported by a fast ‘back of the envelope’ recurring inventory- and analysis based intervention strategy that timely aids team members adequately document, present, and mutually align and assess interrelated product aspects among relevant stakeholders from within and beyond the team. Various distinguished design phase related environmental activities and -contribution types can further aid tailor the strategy. The use of natural and uninterpretable language and methodical concepts, as well as support of non-designers in creation, visualisation, and selection endeavours are suggested for improving interdisciplinary collaboration. Additionally, design team assistance is requested in verifying the full environmental potential of a design brief and illustrating its potential corporate gains, as to stimulate clients too to aspire to environmental product impact minimalization.

Keywords: product system analysis, environmental product optimisation, design process, lifecycle approach

## INTRODUCTION

This paper proposes additions to product design activities with the intent to improve the integration of environmental considerations. In order to illustrate the scope, the introduction initiates by addressing how, why, and when the product's environmental impacts are generated and destined. The introduction ends with the demarcation of a search area on which the following presented research is based.



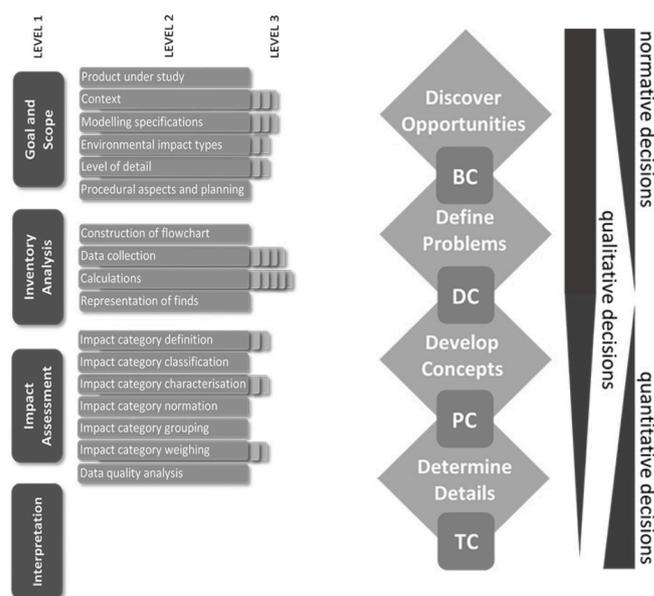
[Figure 1] product system levels [Figure 2] generic product design process [Figure 3] product lifecycle

A product's environmental impact originates from five product system levels ([Figure 1]). The technical level concerns the artefact and the thereto related up- and downstream auxiliary means, like, for instance, for manufacturing and logistics (Ullman, 2009). The operational level adds the auxiliary products and services needed for product functioning, like power and maintenance equipment (Vezzoli, Ceschin, Diehl, & Kohtala, 2015). At the functional level the consumer behaviour is integrated, comprising the use interactions between man, product, and use context (Wever, van Kuijk, & Boks, 2008). The societal level is where the customer makes decisions, for example, about why, what, and how to obtain and discard the product (Shove, 2004). The natural level, or the environment, encompasses the previous levels (McKinney & Schoch, 2003). From this product system level systemisation can be gathered that although the actual environmental impact is physical, the corresponding technical and operational physical impacting factors often originate from functional and societal human impacting factors ([Figure 1]) and that environmentally optimal design requires regard for the product system, which includes corresponding auxiliary technical and operational means.

For any product, each system level can contain multiple product aspects. For example, for an electric coffee machine the operational level contains product aspects like electricity, coffee, water, and possibly even Wi-Fi. These product aspects can directly and indirectly interrelate within a system level or over various system levels, either concurrent or with other lifecycle phases (Figure 3). For example, during use the environmental product aspects wear and tear are directly related to the user's behaviour on a functional level, auxiliary means on an operational level, and construction on the technical level, as well as indirectly related to the product's lifespan. A concrete situation from the coffee machine example is that boiling (functional) water (operational) causes vapour immediately (functional) and calcification over time (natural). Decreasing its environmental impact due to that calcification can be done by, among others, using decalcified water (operational), making relevant parts of non-stick material (technical), as well as improving, or even enabling, possibilities for maintenance and repair (a technical aspect with implications for aspects on other levels).

The reason for focussing on design is because a product's environmental impact is mainly destined during the design process (Rebitzer et al., 2004). The earlier illustrated interrelatedness of product aspects illustrates that environmental product optimisation requires interdisciplinary collaboration throughout the design process (Figure 2) (Young, 2010). Although there are many adopted, adapted, and dedicated methods and models for addressing environmental product aspects, a strategy that aids design teams align product aspects across product system levels, hence interdisciplinary, and throughout the design process is lacking (Fiksel, 2007; Senge, 2008).

This paper presents a research on the possibility to create an environmental product optimisation strategy which fits current design practice. In order to explore both possibilities and challenges for creating interventions, the methodologies of the two main domains, product design and environmental sciences, were researched on existing lingual, cultural, and political similarities and differences for founding a so-called boundary object on (Kimble, Grenier, & Goglio-Primard, 2010). The lifecycle assessment approach (LCA) was chosen as common ground because of its existing application in product design, the overlap in terminology with design, and an overlap in activities with other design involved research orientated domains (Baumann & Tillman, 2004; Guinée et al., 2011; Roozenburg & Eekels, 1998). Another choice which is meant to increase the likeliness of adaptation is the precondition to suit the strategy to the generic, well founded, design process (Joore & Brezet, 2015).



[Figure 4] LCA based card sorting cards [Figure 5] contributions types and their position

## METHOD

As to explore the possibilities and challenges to imbed the lifecycle assessment protocol into product design, expert interviews with a card sorting session were performed. Card sorting (Spencer, 2009), with the lifecycle assessment approach steps (Baumann & Tillman, 2004) presented on the cards (Figure 4), was introduced in order to challenge respondents beyond their existing convictions and maximize the likeliness of obtaining concrete results. The respondents were asked to link the cards to phases of the design process on an underlay of a generic product design process (Figure 2). Along with the card sorting procedure, respondents were stimulated to reason aloud.

For establishing common ground within design, the majority of the respondents had a product design background with environmental product design experience. The inclusion of an equal number of respondents from domains that link to the various product system level was chosen to ascertain overlaps and differences with the results from the designer group. The results were analysed by enumerating similar cards per phase and abstracting outings from the corresponding interview.

## RESULT

### General remarks

Many general remarks were made about suiting the design context. For one, investments will be more easily justified in case an intervention is designed to demonstrate financial and imago gains. And since it is not uncommon that environmental optimisation requires a lengthy process of successive system changes in order to overcome the lock-in effect of existing production facilities and product systems, roadmaps and long-term planning are said to be needed too. One respondent added that for convincing clients and managers, it is also important to keep the intervention's overview model easy to pitch and memorise. As approach for suiting a variety of project objectives and investment possibilities, was suggested to offer an essential, medial, and extensive version of the intervention. To increase the likeliness an EPO strategy will get imbedded in design, it was suggested to offer an easy, professional, and expert version, as well as include alternative gains, like efficiency improvement.

Another often addressed aspect was managing the effects of product complexity. Respondents mentioned and illustrated many intricate dilemmas, like, for example, the increase of environmental e-waste burdens of LED and electronic cars versus their respectively energy- and CO<sub>2</sub> savings. In order to make comparisons and trade-offs between incompatible impact aspects, there was a difference of opinion about how to handle this best; some respondents proposed transferring all impacts to a common unit like restoration costs, while others preferred mutual analyses and debate over the risk of 'oversimplifying' decisions by obscuring possible effects. In support of affronting complexity, respondents prefer using guidelines, checklists, and brokers over rules, not only because of better suiting the 'design way', but, more importantly, as to not hinder innovation. To 'ensure a considerable overall improvement at the end' of a design process, the need for a 'factor 2 to 3 design margins' on any particular environmental aspect was repeatedly mentioned. Even higher margins are said to be needed for new-to-the-world products.

Also, interdisciplinary collaboration issues were a recurring topic. Where the design's creative culture was characterised with statements like 'collaboration by walking around' and 'back of the envelop decision making' and 'educated assumptions', the environmental sciences' culture was characterised with the precautionary principle's notion to 'avoid unintended effects'. To support full interdisciplinary design activities, both designers and assessors men-

tioned that support is needed for non-designers in creation and selection endeavours. Also, the 'language of design', the use of visualizations, is mentioned as a compulsory skill for which non-designers could use support. On the other hand, designers need encouragement to improve documentation, both for managing interdisciplinary considerations and eliciting shared responsibility. Regarding linguistic aspects, the use of neutral, understandable, and uninterpretable language and methodical concepts was advised, as to avoid misunderstandings and domain preferences.

An unexpected emphasis was placed on the limited extent to which design teams are able to carry out the optimisation. The lack of involvement for setting the design brief, as well as the design team's dependency on a client's or superior's support for optimisation are seen as grave derogation risk. Respondents agree that the designers' leeway will stay limited as long as companies fail to see financial gains and customers are satisfied by mere 'greenwashing'. It was also mentioned repeatedly that the execution of subsequent corporate alterations by all involved stakeholders is necessary in order to avoid losing environmental improvements along the production process. As an example was mentioned how optimisation gets annulled if allied departments are separately assessed on mere finances.

## DESIGN PROCESS

Then about the design process. According to one respondent 'the exercise is to see if postponing is possible', since, as someone else stated, 'the curve for determining the environmental impact is steepest at the start'. These remarks characterize many discussions and doubts during card sorting, as to where lifecycle protocol cards could best be represented on the product design process underlay. Another overall aspect is the repeated explicit mention of recurring inventory- and analysis activities; first exploring of possibilities for pinpointing opportunities, then comparing possibilities for selections in various design stages, and finally assessing possibilities for optimization.

Under the first phase, discover opportunities, many cards that fall under goal and scope were placed. Quite some respondents remarked a distinct difference between redesign and innovation. For redesign, environmental benchmarking of similar products' business- and product characteristics can offer immediate insight and, therewith, be used for the development of the business concept. For innovation, trend explorations are first needed in order to establish a business niche, before benchmark studies on products with similar functions and functionalities can be deployed. In either case, redesign and innovation, environmental trends were mentioned as an important means for setting the conditions of the other product system levels. Because design teams are often given the business concept, hence not involved in its development, respondents see any interventions for this stage as a welcome additional means for verifying the design brief.

The second pre-product phase, define problems, is seen as the phase for further concretizing the product under study and the therefore applicable criteria. Functional units are expected to become evident as a result of ongoing product system's flowchart- and system outline development. These environmental outlines can be made alongside readily made benchmark inventories of similar products or products with similar functions and functional aspects. It is noteworthy that the card 'context' was either interpreted or relabelled as the product context and not the project organisation's context. As a result, the cards under modelling specifications are contributed to the card context.

The first design phase, develop concept, initiates 'design', which respondents consider to be iterations between creating, analysing, selecting, and researching. Respondents state that at this stage inventory analyses for benchmarking ideas and concepts are omnipresent. Emphasised is that thorough pre-design research should assure that at this stage the goal and scope requires marginal changes at most. The impact assessment cards are placed most often here as well. These cards are remarkably often placed as a stack, accompanied by a remark of how this is mostly done 'with the push of a button' by the use of software programs. Interpretation during this phase is seen as an integral part of idea and concept selection, as fact-based decisions are neither desirable due to budgets nor feasible because of design's earlier mentioned inherent unfamiliarities.

In the second design phase, determine product, the 'intricate relation between product and production dictate contemporary development'. This is where design 'turns on the calculation road' and 'sense making flips towards assessing'. Here too, most decisions will be based on relative comparison of alternative solutions. The need for assessments is said to start here, and the amount of assessments to increase for and due to the final decisions for all not yet determined product aspects. Along with placing of the cards was said that in this phase merely optimisation of physical details, like material, construction, and production, take place. Despite the fact that 'only marginal room for improvement' remains, respondents from design practice acknowledge that most design practices only here start making environmental considerations.

The phase 'implement market' was added to the design process for absolute completeness, since it is present in some design process models. Under this phase little cards got placed, because, as respondents pointed out, at this stage there are no design activities regarding the physical product left. Respondents did, however, stress that here an all-encompassing assessment becomes possible, now that the product is actually in use. The relative worth of the usual use assessments was debated, by design and environmental orientated respondents alike, since these assessments are usually based on statistics, like amount of battery recharges, rather than actual behaviour driven use scenarios.

### Interpretation: Guided design iterations

Indirectly deduced results are presented under five additional denominators: environmental considerations from the outset onwards, a motivation for documentation support, the assignment of phase specific environmental contributions, the recognition of environmental contribution types and their positioning, and the use of domain transcending inventory and analyses recurrences.

### **Environmental considerations from the outset onwards**

Throughout the sessions the interviewee illustrated how business concept decisions influence the entire design process. A given example is for the design of a car. Selecting car lease as part of the business concept is more likely if during discover the following is considered; the increase in material prices due to depletion (operational and natural), people's less defined expectancies regarding work and relations (societal) as well as their decreased ability and interest in DIY (functional), and the readily available network of car workshops (corporate). The premise of car lease, then, ensures setting criteria and creating concepts for, for example, minimizing the costs of customer service aspects as, for instance, maintenance and repair, and for optimising corporate benefits from the altered car ownership, such as reclaim, reuse, and recycle strategy. Without the lease concept in mind, so without the idea for the producer to stay proprietor of the car, it is unlikely that product imbedded maintenance and disassembly 'scripts' get optimised or the use of expensive materials can be made worthwhile.

### **Documenting lateral, chronological, and anachronical product development**

As endorsed earlier, EPO requires alignment of interrelated product aspects throughout the product design process. The thereto performed design iterations are not only related to a particular instant in the design process and in a chronological order, but also in a contra chronological order, or anachronical. An example of anachronical iteration expressed in one of the interviews is that the idea for incapsulating CO<sub>2</sub> in order to avoid CO<sub>2</sub> exhaust, leads to researching the results and effects of incapsulating CO<sub>2</sub> relative to earlier researched option in case incapsulating was not considered an option in an earlier stage.

As the example illustrates, anachronical alignment of product aspects is needed in case new ideas fall outside the earlier design scope, in order to establish the idea's effects on the overall product system and compare these effects to those of other ideas. The need to reconsider the design scope increases with the idea's degree of innovativeness, since a lack of comparative products inhibits direct benchmark studies. In support of anachronical research, structured documentation for monitoring of earlier found product aspect interrelatedness is proposed. In other words, in support of lateral, chronological, and anachronical iterations, EPO requires structured documentation for monitoring interrelated product aspects throughout the design process.

### **Phase specific environmental contribution**

The interview outcomes clearly marked specific environmental contributions for each design phase. For the discover opportunity phase, environmental trend research firstly and environmental aspects benchmark studies of comparable value propositions secondly improve the likeliness that, respectively, the proposed search area and business concept support later environmentally optimisation activities. For the define problems phase, benchmarking the environmental side of both comparable product systems and product systems with comparable purpose and product aspects leads to setting the core criteria that demark the design area concept. For the develop concepts phase, it is possible to actively participate by contributing and aligning environment driven physical and human product aspect ideas and to aid make environment proof educated selections. In the determine details phase, environmental knowledge can again be used for proposing alternative ideas and for the selection processes. Incorporating this insight into the intervention can aid participants realise a design phase related contribution.

### **Environmental contribution types and their positioning**

The type of environmental contribution and its positioning relative to the other domains vary during the design process ([Figure 5]). To start with environmental targets. These can proactively be positioned for establishing the design goals. This environmental contribution has a normative character towards other domains and is indispensable during the pre-product phases. Then environmental designs and -considerations. These can actively be proposed alongside other creation and selection activities.

The environmental contribution to cross-disciplinary creative and reflective alignment has a qualitative character and can be found throughout the design process. Finally, environmental assessments of concepts for determining compliance with conditions and constraints is a reactive activity. Here the environmental contribution has a quantitative character and will increasingly take place during the design phases.

In short, the environmental contribution can have a normative, qualitative, and quantitative character and over the course of the design process the positioning of that contribution changes from leading to following. Incorporation of this insight into the EPO strategy can stimulate participants bring forth an appropriate contribution, at an appropriate instance, and in an appropriate way.

### **Domain transcending inventory and analyses recurrences**

Respondents acknowledged the earlier premise that similarities among domain dependent inventory- and analysis methods can be used to base an interdisciplinary approach upon. The inventory and analysis activities, which progressively outline the product system's parts and -interactions, can be made for exploring the physical- and human environmental impact aspects and effects, as well as arranging and ranking these mutually with the corresponding product aspect. For this, the research indicates that the lifecycle assessment protocol offers a rich and specific domain transcending basis. In summary, in support of interdisciplinary collaboration, design involved inventory- and analysis methods, among which the lifecycle assessment, can be used for constructing a neutral domain transcending commons.

## DISCUSSION

What is open for debate regarding the card sorting procedure, is keeping the lifecycle assessment protocol cards in one particular order, since other orders, or a random order, would most likely have led to different outcomes. Taking into consideration that it is an explorative research, intended to find logical connections between the lifecycle assessment approach and the design process, the applied order has consciously been applied, with the motivation to support logical reasoning and avoid misinterpretation.

## CONCLUSION

It is feasible to create a domain transcending environmental product optimisation strategy from a merger of the lifecycle assessment approach with the product design process. This research's outcomes suggest a stern inventory- and analysis foundation and provides ample suggestions and requirements for developing and assessing such a strategy. Hence it provides a search area for further study into creating an actual environmental product optimisation strategy.

By offering design teams a strategy that runs throughout the design process and suits interdisciplinary product aspect alignment, the participants are offered a means to reduce or, ideally, eliminating its environmental impact destination. As such, it has the potential to become a hands-on way to decrease the product system's generated technical-, operational-, but also behaviour-, and decision- environmental impact.

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## **SUSTAINABLE DESIGN 4.0: METHODS AND TECHNIQUES OF THE CONTEMPORARY DESIGNER IN THE KNOWLEDGE SOCIETY**

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### **ABSTRACT**

When confronted with the problems of contemporaneity, designers often tend to use their own creativity as an answer to a specific need, maintaining divided design fields and methods, this leads to a lack of attention to actual society problems and goals, which have already been defined and highlighted from UN – with the 17 Sustainable Development Goals – and from the theoreticians of the industry 4.0.

The research method proposes the convergence between innovative production technology – such as open technologies – and different design approach, the parametric one and the participatory one, because their hybridization could lead to the design of artifacts through a unique system and, as well, customized on the need of each user emerged through the participation of the same.

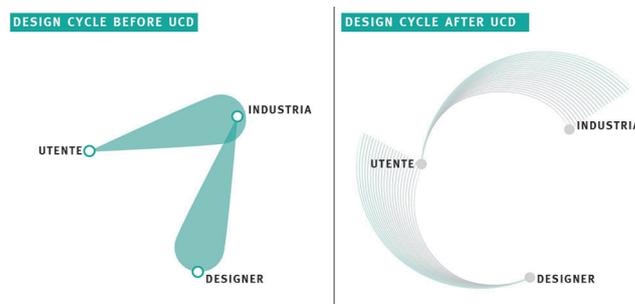
It is clear that a convergence like this will have an important impact on the society, thanks to the attention on sustainability, inclusivity and iterability, of the process and products.

Key Words: Industry 4.0, Parametric Design, Participatory Design, Specialized Processes

## 1. INTRODUCTION

The evolution of the design dimension, which has been witnessed in the last years, thanks to the innovation of tools and technologies of the industry for the production of goods and services more and more *user friendly*, has been gradually defining an increasingly heterogeneous scenario, in which the standard product, at the time defined by industrial design, is no longer sufficient to satisfy the diversified needs that characterize the vast landscape of users.

As Maldonado said, the task of industrial design had become that of coordinating, integrating and articulating all the factors related to the production of artifacts, related to their consumption, both on an individual and social level: in fact, often design is understood as a link between the production system and the consumption system. But since the 90s, this idea of design begins to become obsolete, especially if we think that the effort of the designers is dedicated to the definition of functions and morphologies more and more shaped by the needs expressed by users - User Centered Design, UCD – Figure 1.



[Figure 1] The design cycle before and after the introduction of User Centered Design method.

Design oriented to building human scenarios consistent with technological advancement, today faces the challenge of defining products and services that are increasingly in line with users' expectations: the digital skills that the industry is getting richer, open the road to dynamics on-demand interaction in which the user becomes a sort of co-worker, an active part of the network of stakeholders involved in the creation, management and distribution of goods. In a scenario of this kind, the designer has the role of director, becoming a figure of mediation between idea, materials, production and realization. To understand the motivations of what has been stated, it is important to carry out an analysis of the different actors in the design cycle, understanding how industry, designers and consumers interact with each other, projected towards the definition of a network in which each part sees its specific boundaries dilate and its own roles hybridize with the others.

## 2. INDUSTRY

Industrial dynamics and manufacturing systems lose in this modernity the obsolete definition of place of mechanical production that destroys man and his efforts, in an anachronistic vision of the factory as the protagonist of Chaplin's masterpiece – *Modern Times*, to become instead spaces in which new relationships are defined, which introduce the user in the process of defining the value of the consumer good, in terms of active participation in the configuration of tangible and intangible contents. Driven by digitalisation and automation, industry is overwhelmed by technological transformation, evolving itself into Industry 4.0, the fundamental objective of this phenomenon is to make innovations converge towards a widespread and permanent improvement of the quality of life.

Among these technologies, we want to mention the most relevant compared to the research presented:

- *Big Data*: represent nowadays the richest source from which to draw in order to define, elaborate, transmit and store huge masses of data, whose basic technology is the storage of data on immaterial storage archives and no longer on hard disks. Data can come from two large source families: the first includes databases, files and document archives, social networks and messaging systems. In a system like this, users insert the information, more or less structured, into different applications. The second family concerns data coming from devices that automatically acquire them, by using specific sensors, surveillance cameras or computer edge of vehicles, and transmit them in system, network, etc. As a tool, data becomes elements for the explanation of dynamics of everyday life, creating knowledge in *real time*, generating relationship and developing systems fed by continuous connections to networks.
- *Industrial Internet of Things*: with millions of devices daily connected online, we are seeing a deep change that is happening in different levels and fields of design, what is achieved are expressions of product design, services design, communication design, etc., which communicate in real time with other items. Everything is potentially connected and interactive, constantly changing, allowing a continuous updating of the operating routines of the single objects in the system that communicate in real time with other objects. At the base of such technologies there is the annulment, absolute and / or partial, of the time factor, no longer calibrated with respect to space, but to software and to the computing and interconnection capacity of digital systems (Bauman, 2002).
- *Additive Manufacturing*: the term identifies a series of techniques and production technologies in which the finished product is created without the need to melt the material into molds or using the classic techniques

of subtractive production. The additive production - AP - allows great freedom in the design and realization of the artifact, indefinitely extending the range of geometries and complexities achievable, breaking down the constraints and obstacles of design and processing, offering the possibility of obtaining easily and quickly the realization of prototypes and small series. The techniques of additive production consist in the stratification of material that is, in fact, added by levels: it is from this that derives the now popular meaning of “3D Printing”, emblem technology of additive manufacturing - AM -, which has radically changed the perspective of how engineers design the production process: no more molds and assembly of different pieces, the 3D printed object is made in one piece starting from the virtual model turned into files for printing: as stated by Marinella Levi, engineer at the Politecnico di Milano, “3D printing is the closest case to teleportation. 3D printing is used to do what you need when you need it”.

The digital dynamics of manufacturing systems, allows us to offer customized products, a feature that has always been recognized as an added value to the manufacturing system itself: customization requires the definition of an intelligent factory whose versatility and flexibility makes it possible to find “specific solutions for variable requirements: product families, individualization of needs to be met, variable segmentations of demand” (Lombardi, 2017). The intelligent and performative dynamics of the production system, offers the possibility of arriving at the conception of a new class of artifacts, equipped with technological equipment, which connects the end-user with tangible and intangible products and services, through new forms of interaction and experience. An example of application can be represented by the *Sound Shirt* – Figure 2, a wearable technology designed to allow deaf people to enjoy listening to music: it was possible to carry out a project of this kind thanks to the constant involvement of end users - a group of deaf people - who for the six months of prototype testing have constantly oriented the outcome of the final product, commissioned to a company producing hi-tech clothing (CuteCircuit) from the Jugend Symphoniker in Hamburg.



[Figure 2] *Sound Shirt*: CuteCircuit, 2016

The introduction of these technologies offers the possibility of completely revising the role of industries that today have the ability to provide a sort of humanity to products, much higher than ever before, this offers to designer a new awareness, that of being the director of the flow that connects the Business-to-Business (B2B) and Business-to-Consumer (B2C) worlds, this flow made up of information that is turning into knowledge, becomes *value*.

### 3. DESIGNER

By definition, designer has always been the *mediator*, who therefore, thanks to his creative skills and design capacity, is able to conceive artifacts that the industry can produce and offer to the widest possible landscape of users.

The contemporary reality of design, and in particular of the figure of the designer, consists in its renewed role as director, becoming the one who has the role of weaving and establishing processes of value creation based on design dynamics in which the project focus is not on the author's artifact, but on understanding and analyzing the vastness of languages, contents, data, codes, which throw the designer himself towards open and participatory project practices, suitable for build new narrative points of view. This is possible by incorporating all the parts in the creation of the value chain, in which both users and industrials become *co-workers*. A system of this type “can be considered as a network of stakeholders and users, whose actions are closely related and interdependent” (Sbordone, 2017). The (*new*) designer must therefore be able to identify opportunities for new configurations with ever-different resources and application contexts that develop as organisms, and as such live in a state of constant dynamism, must be able to create automated configurations and allow the total personalization of performances, through participation and sharing of resources and processes.

### 4. USER

The history of design teaches that, since the dawn of this discipline, the founding goal of the same was to bring together form and function in the definition of products reproducible in a serial manner, therefore on a large scale, this was essential to achieve a democratization of the products themselves that could thus enter everyone's homes. This philosophy, which finds its highest historical expression in the Bauhaus School, has been the reason for many debates among the designers and theoreticians of the project culture. Ettore Sottsass Jr., in an interview, states that “the problem of design (...) is that it has various aspects. There is design as the Americans say *Business or nothing*, i.e. design that is oriented to the consumer product, to the product to be sold, or to the product to be used tout court. But I think there are also some design where one imagines things (...). Because design also has a profound relation-

ship, always, with existence. “(Sottsass). Until the 80s / 90s of the twentieth century, the consumer has often found himself in the condition of passively enduring that definition of design that from Sottsass is connected to the American method - *Business or nothing* - thus purchasing goods only for a question of style or fashion, which from time to time were proposed by the manufacturers. But since the early nineties something changes: the design process was reversed because, if in a first moment the company requested a shape from the designer, who consequently responded according to the canons of function and aesthetics, which was then produced and marketed and only arrived in final stage to the consumer, from those years onwards there is an ever greater importance given to the latter, until becoming a central part of the design process: designers design what users require through their needs, expressed or unexpressed, and only later the company experiments and finally produces. This method, called *User Centered Design - UCD* - has its roots in issues such as inclusivity, sustainability and experience: according to ISO / DIS 13407 (*Human Centered Design Process for Interactive Systems, 1998*) for UCD we mean a design approach identified by 4 different principles: an appropriate allocation of function between user and system; active involvement of users; iterations of design solutions; multidisciplinary design teams. In addition to this it is important for a truly user-centered design approach, to ground the design process on observation of the users’ practices in the real world.

## 5. CONTEMPORARY DESIGNER IN THE KNOWLEDGE SOCIETY

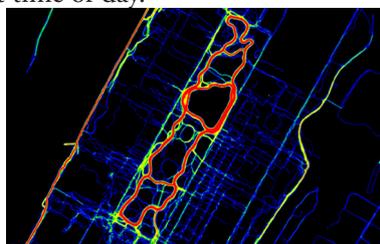
It is right to offer a reflection: if we look more closely at the object reality that makes up our contemporaneity, what we can easily notice is that, despite all the efforts of the theoreticians of the project culture, there is still a difference between what is preferred to do and what is done. What happens is that approaches such as participatory and parametric ones, as well as tools such as 3D printing and IoT, are converged by certain (*few*) with the intent to design sustainable, inclusive and iterable products (as is desirable), and from (*many*) other treatises as a form of fashion: this may be sufficient as long as we talk about doing technical training on designers (think for example to the academic course, where it is necessary, at least to begin with, to offer students a field of experimentation in which to feel free to *make mistakes*), but not if you enter the specific process of designing and producing goods that then end up in the hands of the end users.

We want to remember in particular the various experiments carried out within the university laboratories and the FabLab, where the students have the opportunity to *learn by doing*: the paradigm, introduced for the first time by the Bauhaus School, finds today with this formula - learning by doing -, its maximum expression. In fact, it is no longer enough, to educate future designers on the theory or to teach them how to design the lamp, the chair, the magazine, but it is necessary to train them on how hybridization has become a fundamental paradigm for designing (always) with attention to heterogeneous needs: doing an operation of this type means dominating the process, offering scalable application models that can be customized to specific requests.

### 5.1. Case Studies

Starting from an investigation on the literature, concerning the state of the art of scalable models and customized products, designed through the convergence of the approaches and technologies mentioned above, we want to mention some case studies, considered emblematic because, although belonging to different branches design, rooted in an active involvement of users, as well as in the establishment of multidisciplinary design teams.

*Nike + Data Viz Highlights Urban Running Routes* – Figure 3, it is a project of data visualization born from the collaboration between graphic designer Nicholas Felton who, together with 14 of his students at the Manhattan School of Visual Arts. The project aim is to analyze the metadata based on runners, Nike + users, in the period from September to December 2010. The strength of the project lies in the idea of movement, the runners are variable in movement in the definition of dynamic infographics, which represent a picture of the daily life of a slice of citizens, illustrating where people run and at what time of day.



[Figure 3] Nike + Data Viz Highlights Urban Running. 2010

*Bianconero* – Figure 4, is defined as a high readability font, designed by Umberto Mischi, with the technical supervision of Luciano Perondi (designer and at the time professor of type design at ISIA in Urbino) in collaboration with Alessandra Finzi (cognitive psychologist) and Daniele Zanoni (expert in study methods in disorders of learning). The strength of this character lies precisely in its morphology, studied in every detail to facilitate reading for the *able-reader* and to avoid for those with dyslexia disorders any difficulties in reading. To do this, every single glyph has been redesigned, proposing a differentiation between them, in order to avoid the possibility for the reader to get confused, between similar elements, recognizing them more easily within the text, thus taking care of the efficiency and overall typographic quality. During the letter design phase, a fundamental role was played by the publishing house, which carried out constant tests in collaboration with CRC Balbuzia - the learning division of Rome - thus

offering designers the opportunity to boast constant feedback on the work already done.

[Figure 4] *Bianconero*. 2011

bianconero® regular 15,5/22,5 pt

Virus è un gatto, un gatto vagabondo,  
attaccabrighe e prepotente.  
Il terrore di tutti i gatti perbene  
che vivono sicuri con gli umani...

times new roman regular 15,5/22,5 pt

Virus è un gatto, un gatto vagabondo,  
attaccabrighe e prepotente.  
Il terrore di tutti i gatti perbene  
che vivono sicuri con gli umani...

*Algorithmic Lace* – Figure 5, is an innovative biomedical project, born from the intersection of craft research and algorithmic design. The product is a three-dimensional lace bra for breast cancer survivors, *taylor-made* using a new methodology that exploits the algorithmic patterns, this type of texture allows to avoid certain aspects of the bra, that create discomfort after surgery, offering each woman to re-appropriate of her own self-confidence. The project, created by Lisa Marks, recent alumni of MFA Industrial Design at Parsons SCE and currently faculty at Georgia Institute of Technology, has been named one of the Lexus Design Award finalists for 2019

[Figure 5] *Algorithmic Lace*, 2018



In closing, there are two productive and tangible realities, considered important because they represent a general tendency in the definition of products that through the convergence of methods and techniques, allow to obtain high performing artefacts, showing however a very high attention to the presented needs as well as for the sustainability.

*Enneper Pavilion* – Figure 6, projected by Medaarch design studio, makes the parametric approach and the advanced manufacturing its theoretical and design basis: the system offers the possibility to modifying the conformation of the pavilion according to specific needs in terms of space and volume available. Thanks to the platform, end-users, in this case a company operator that requires the construction of a specific structure, can, through simple parameters – size and volume available – adapt the shape of the pavilion. This implies a consequent optimization of the resources, with consequent reduction of the waste of material and labour in the realization of the pavilion.

*Fold Panel*, realized by Wood-Skid, are sound-absorbing panels, designed to adapt to all possible requests related to specific needs, performance, functional and aesthetic. To do this, the company has designed a process in which, defined an area within which the panels are assembled - 110x110cm or 220x110cm - every single user, through the use of an interactive system, can decide the material and the type of structure - choosing how to distribute the three-dimensional texture - that best suits his needs.

## 6. CONCLUSION

Perhaps the most significant aspect for the realization of such projects is the exploration of a scalable model, able to act on many factors, over time, space and individuals, not only optimizing the design and production of individual artefacts, but also by enhancing the user experience, enriching the ways in which users interface with individual products, exploiting the possibilities offered by new ways of sharing knowledge. The knowledge society, characterized by complexity (Morin, 1993), globalization (Bauman, 199, Robertson, 1995), multiculturalism (Galli, 2006) and mutability (Schön, 1973), attributes to the moment of formation the very important function of “instilling both the desire and the pleasure of learning, the ability to learn to learn, the intellectual curiosity” (Delors, 1997, p.17), on which depend the quality of life of man in the third millennium and the possibility for society itself to guarantee innovation, development and progress.

A vision of this type embraces all the issues highlighted by the 17 UN Goals, among which perhaps the most emblematic in relation to the research topic addressed is: Make cities inclusive, safe, resilient and sustainable. Cities are places where one must live well and where everyone must have the opportunity to live in dignity. The gender difference, the social class and the economic condition, must no longer be factors of discrimination.<sup>1</sup>

<sup>1</sup> <https://www.un.org/sustainabledevelopment/sustainable-development-goals/>

<sup>2</sup> International Design Council – Ico-D – is a Council of independent Member organisations – a global network that shares common issues, commitments and standards. Members create a unified voice for the global design community and drive a high level dialogue on the leading role design plays in society, culture

This vision is aligned with the practices shared and disseminated by the International Council of Design<sup>2</sup>, which Montreal Design Declaration states that “All people deserve to live in a well-designed world”. The same David Grossman, president of the ICO-D from 2015 to 2017, argues that “the declaration reflects on two great results. For the first time, the design community, through multiple disciplines, speaks with one voice. This consolidation leads to the second result: international agencies are eager to collaborate with a united world of design. These results impact every designer “ (Grossman, 2017).

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and the economy. Ico-D is the world's largest representative of the international community of professional designers.



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## **NEM, NEAPOLITAN EVOLUTION MEN'S WEAR: A BIO PROJECT OF MEN'S TAILORING**

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### **ABSTRACT**

Want to propose in this paper is the researches carried out by the FA.RE. Fashion Research Lab of the University of Campania Luigi Vanvitelli is related to an ideal model of Zero Emission fashion industrial district in the Italian textile clothing sector. Starting from an analysis of the men's tailoring sector in Napoli, we will analyze the real case study called NEM Neapolitan Evolution Menswear, realized with the tailoring company of excellence KITON and the capsule collections realized with the Master's degree in Design for Innovation, Fashion Eco design curriculum of the University of Vanvitelli. The theoretical background of the paper starts from the design strategy that derives from the Design Thinking and that the FA.RE. lab research group has called listening design, a method of listening to the territorial, environmental and productive problems for the realization of a bio capsule collection.

Key Words: bio project, zero emission, tailoring, handmade.

## 1. INTRODUCTION

If it is true that tailor-made bespoke tailoring production is a virtuous case of environmental sustainability in the Italian fashion system, it is even more true that the potential use of natural materials is processed according to an eco-mode oriented in the use of natural fibers also in dyeing, creates a zero-emission production process. Nettle, soybeans, bamboo, cotton and hemp are the materials used for this collection named "NEM: bio project men's tailoring project" that has already been presented at the men's fashion week in Milan in June 2017 at Palazzo Kiton.

For many years, in knowledge of laws regarding quality management, safety and above all environment. If one shares an innovative vision of the fashion-design oriented productions, it is useful to be able to count on managers responding to this global-changing challenge, represented by industrial productions being coherent to requirements of environmental sustainability within the production processes. Such innovative visions, especially in the fashion industry which usually does not give birth to processes which have a very high impact on the environment, can launch new "green-oriented" productions, still not very frequently adopted in Italy but highly developed in Northern European countries, and able to solve problems as for processes and products.

This research has been carried out within the FA.RE Fashion Research Lab of the University of the Studies of Campania, Luigi Vanvitelli, also thanks to the contribution of a number of graduation theses which dealt with these topics. This research path starts from a restoration strategy of Campania handmade traditions, and of fashion enterprises analyzed as real "cultural veins", and takes its steps from some almost-forgotten fashion manufacturing, to the elaboration of experimental contemporary styles for Neapolitan men's tailoring. This research path analyzes, first of all, the traditional production ways of the Neapolitan tailored jacket, which we are going to try and go deep into, thus to create new models to approach the topic of customization of fashion products.

The main characteristic of Neapolitan tailoring tradition lies in the centrality of the human body. It is scanned through very attentively, in order to carefully draw the necessary measurement to adjust the item to the client's body, and then manufacture the chosen fabric in the best way.

## 2. NEM: A BIO PROJECT OF MEN'S TAILORING

Starting from the Neapolitan tailoring that has been carrying out a completely handmade tradition for more than a century, the study of a capsule collection of jackets produced by a successful Neapolitan company that has worked since its origins on the concept of tailoring and tradition has deepened. The KITON company has "serialized" the production of the jacket, keeping intact the whole Neapolitan sartorial tradition, from the measurement of the garment on the customer, to the cut of the selected fabric, up to the realization of the final product. In this sense, having under control all the production phases, it was possible to create a product with a control of all the processing phases. The men's sartorial chain, in fact, that develops in the Neapolitan territory towards the end of the 1800s, has solid roots and rooted in the essence of Made in Italy. Born from the English sartorial tradition but develops autonomously in the Neapolitan territory thanks to the creativity and the genius of its tailors who perform an important work of deconstruction and modification of the jacket. The armor of the jacket is the same but the materials are different; this is due in particular to the different climatic conditions that the Campania climate has compared to the English one. A much more temperate and warm climate, in fact, conditions the use of much lighter and more breathable fabrics, so the tweeds and the English heavy wools replace the fresh wool and the very light silk cashmere often mixed with silk that allow the use of jackets even in the Neapolitan temperate climate. Another innovation is the partial or total elimination of the inner lining. The Neapolitan unlined jacket is in fact the real surprise in the men's tailoring that makes the garments of many Neapolitan companies very light and wearable in all seasons. This path of adoption of increasingly particular materials of the Neapolitan tailoring shoulder is developed thanks to the constant reference with companies in the industrial district of Biella, which is consolidated for the Kiton company system thanks to the acquisition of the historic Barbera company in the same group. Our project experiments a capsule collection of 4 jackets designed in collaboration with the Alta Sartoria course present in the Kiton company, to develop a system of jackets with a low environmental impact. The first step of the research method was to look for materials with low environmental impact in production, and in particular, companies were selected to produce natural yarns with certified techniques.

Natural fibers and eco-friendly yarns are becoming an increasingly concrete choice in the field of clothing and furniture and for this reason the fashion system is increasingly attentive to the use of these fibers that respect the environment and ensure the union between well-being, economy and ethics that characterize the entire path of the production chain. Natural fabrics are produced using yarns coming from naturally existing fibers, through mechanical processes without undergoing chemical procedures that modify the structure. For the NEM project were mainly analyzed types of natural plant fibers, such as hemp, cotton, flax, nettle, soy. The main source of impact of the fabrics in the textile supply chain is definitely the dyeing sector and for this reason we have gone towards the research of a company that produces yarns and dyes from natural fibers with an eco-sustainable process. The dyes derived from vegetable or mineral extracts have been since the first civilization the only way to dye fabrics and yarns, later, with the use of chemical dyes, the slow processes and natural extracts have been almost completely abandoned or forgotten. Our research has therefore focused on companies that have recovered some ancient dyeing recipes that, carried out with modern equipment, have allowed to obtain soft or intense colors of particular beauty and quality results that guarantee replicability.

The optimization and standardization of dyeing processes achieved by these Italian companies, allow to determine a range of primary colors that, properly mixed and stabilized in a final step with substances deriving from milk proteins, ensure not only a wide range of colors, but excellent guarantees of solidity with washes, sweat, light and rubbings. The entire dyeing process has a low environmental impact, takes place no more than 30 ° and energy consumption is reduced to a minimum. In the finishing phase, after the dyeing, softening agents based on Aloe Vera are used, giving the treated product a fragrance and lightness that finally translates into a guarantee of healthiness and well-being for the people who work there, for the environment and not last, for final consumers. All four jackets produced are in fact made with yarns and anallergenic colors that do not create any kind of problem in contact with the skin.



[Figure 2] Pure natural pigments of plant origin

### 3. RESULTS

The final result of the analysis conducted among companies operating in Italy for the production of yarns from natural fibers, with a check carried out together with the expert of the Kiton company fabrics, the following fibers were selected for the NEM capsule collection: hemp, bamboo, nettle, and soybeans all with particular characteristics that we will soon describe below and that lend themselves to a sartorial processing for the hand that the fabrics based on these yarns possess. Hemp is resistant and easy to grow, having urticant characteristics does not require the use of pesticides and herbicides. High up to 4 meters, it is a plant with strong roots that reduce soil erosion; alternating it with other crops, it can contribute to rehabilitating polluted land and enriching it naturally by increasing its productivity thanks to a strong contribution of nitrogen. Finally, it is one of the most efficient plants in converting carbon dioxide into oxygen. The range of fabrics obtainable from its fiber is very wide: thanks to the modern processes of maceration and degommaggio, it has been possible to spin titles up to 36,000 metric which is equivalent to the thinner linens used in clothing.

The used hemp fabric is:

- it is highly protective because it filters 95% of ultraviolet rays and shields from electromagnetic fields
- creates, in contact with the skin, a micromassage that promotes blood circulation
- has considerable absorption power and easily disperses body moisture.

Being a hollow fiber, it is characterized by a thermostatic effect that allows to develop a sort of “natural insulation” thanks to which it is possible to perceive a feeling of freshness in summer and warm in winter, creating an optimal body microclimate without causing bacterial proliferation. often causes bad odors. It can be washed in the washing machine and the washings make it more and more soft and pleasant, and also the fabrics made in intimate blend with other fibers like cotton, silk, wool and cashmere are very interesting; it is easily tinged, assuming particular nuances and a high, special shine. The hemp fiber is particularly suitable for use for men's tailoring also due to its characteristic of being both soft and resistant. Despite having a similar appearance to linen, which produces folds at right angles, those of hemp are rounded and tend, if not to disappear, to attenuate significantly, so that the garments can be worn several times, while maintaining a pleasant appearance and without having to be ironed every time, which in the jackets often for linen jackets becomes a major problem. Another fiber used for a jackfruit was bamboo, a pure cellulose fiber and, similar to hemp, can be grown without the use of synthetic chemical fertilizers, pesticides or defoliant. Its rapid growth means that the harvest can take place every 2 or 3 years, avoiding the dev-

astating processes of deforestation. The structure of the bamboo hollow-shaped fiber gives the fabric the property of insulation, that is an excellent effect of perspiration and at the same time the preservation of heat. The fabric is soft and delicate to the touch and, at the same time, resistant to use and washes. It is also a hypoallergenic fiber and an excellent shield against ultra-violet rays.

The nettle is a vegetable fiber obtained from *Urtica dioica* or wild nettle, a perennial herbaceous plant of the Urticaceae. In view of its high resistance to pathogens and stinging properties, its cultivation does not require the use of herbicides and parasiticides. Nothing is lost on the nettle: the textile fiber is obtained from the bark, with the inner part producing cellulose for extremely valuable paper; the fresh ends and leaves provide a highly nutritious product for zootechnical use. The Nettle is a very fine fiber, for some characteristics even more than cotton and hemp: long, shiny, soft, uniform, strong to torsion and elastic is very resistant, because unlike other fibers, its strength increases with the spend some time. The fabric that is obtained is antistatic, hypoallergenic, resistant and has a good absorption capacity and is characterized by an "airy" texture, similar to linen, but with a brilliance similar to silk. The last fiber used for the NEM project but perhaps the most interesting in the prototyping for men's tailoring is soybean which is a recent type of fiber obtained from the by-product of the processing of the soy pod, from which a soft, soft fabric is obtained. above all environmentally friendly, but above all it is a biodegradable fabric, with a minimal or no environmental impact. Nicknamed the vegetable cashmere, it is very easy to treat and has the ability to absorb dyes better than other fabrics, so that they can be saved during use during the coloring process, it also has a remarkable color fastness and is not very flammable. It is a vegetable fiber that has a great capacity for perspiration, air permeability and ability to retain heat; the use is suitable on hot days, where, in the presence of the sun, protects the skin from harmful rays, also has the generous characteristic of protecting the health of the dermis and is resistant to bacteria. Soy, offers all the advantages of natural fibers and in intimate melee, with wool or cashmere, silk, hemp, nettle, linen and cotton, increases its resistance, has an elastic capacity that allows a stretch suitable to follow the fabric the bodily forms favoring visual and tactile elegance to all the garments. Another interesting feature is that it does not even affect ironing and it is still sufficient to do it at low temperatures, without using steam.

Here are the names of the 3 capsule collections that gave life to the Four jackets prototyped according to this zero emission model:

CHROMA from the greek for skin, an experimental project to create a jacket that blends classic men's tailoring and materials leading to beneficial effects. The scope is to solve the most common problems businessmen encounter whilst travelling, using materials - hemp, nettle and soy fabric - that improve thermal-regulation and comfort. Therefore, the jacket, which is softer and lighter, becomes a second skin that adapts every moment of the day.

ETHICS are the moral principles that allows to assigns a person' behaviours: Eco is the interaction between organism and their environments. Ethico is the establishment of the ethic values to positively improve the ecosystem such as the Eco Ethics. With the term Etico the jacket capsule collection completely in bamboo fabric, breathable and reflective UV, antibacterial and with a high potential of thermoligulation.

CHANGE WT is a experimental jacket throught for a meddle-eastern clientele and ii created for its thermal regulation properties. For this reasons KITON textile was combined with the bio-material hemp, inserted into the collar and cuffs.



[Figure 3] Project CROMA o jacket in hemp, nettle and soy fabric.

### 3. CONCLUSION

The NEM project exhibited and presented during the Men's fashion Week 2018 in Milan at the Palazzo Kition was also submitted to the commission of the Italian National Chamber of Fashion evaluating eco-sustainable projects born in Italy in recent years and is being evaluated, and gave as an important output the possibility of integrating young professionals with experience in environmental issues of process and product in a textile company that is working experimentally on this topic thanks to this kind of project.



[Figure 4] Project CHROMA –hemp, soy and nattle fabric  
[Figure 5] Project CHANCE – WT in hemp fabric



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## **NEW SUSTAINABLE COSMETIC PRODUCTS FROM FOOD WASTE: A JOINED-UP APPROACH BETWEEN DESIGN AND FOOD CHEMISTRY**

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### **ABSTRACT**

Through an integrated approach, which combines tools and techniques in design and food chemistry disciplines, new sustainable products have been experimented in cosmetic field.

The design tools, acting in multiple and diversified fields, aim at valuing and increasing capabilities by creative training for generating sustainable and reproducible goods, whereas the investigation of the chemical composition of foods and their by-products is one of the main goals in food chemistry research. In this context, agri-food sector by-products are an inexhaustible source of bioactive, whose re-use, as alternative sources of low-cost and bio-sustainable active ingredients, is desirable in the nutraceutical field. Furthermore, the recycling of waste could reduce its environmental impact and the related disposal costs. The collaborative methodology is prompt to convey a new concept of wellness and body care through a new eco-oriented product production in which food winter-wastes are investigated for their cosmeceutical value for the formulation of green-cosmetic products. The paper reports the experience carried out in the design and food chemistry laboratories.

Key Words: green-cosmetic products, food waste, bio-sustainable active ingredients.

## 1. INTRODUCTION

Recent studies and reports on companies in the cosmetic sector demonstrate a steady growth in turnover both nationally and internationally, with import and export flows extending globally. The constantly growing market trend is due to various causes, which, over time, have generated a consolidated position in the cosmetic sector, whose market has a heterogeneous and geographically diffused dimension, with a very high European share. Made in Italy cosmetic sector is characterized by companies that invest in creativity and innovation, and implement design-oriented strategies (Verganti, 2009). In fact, a positive dynamic record in terms of production and exports seems to be related to creativity, safety and innovation, which are determinants to generate products with a high know-how content and in line with the evolution of consumer demand. In fact, sustainable production, traceability of ingredients, and the ethical code of companies define consumer choices and the growing demand for eco-friendly cosmetics (Cosmetica Italia, Beauty Report 2018). Indeed, cosmetics have a massive environmental impact as their production involves different aspects, among which ingredients choice, which in turn affect the acquisition of resources, and their processing. Suitable packaging and communication, the product distribution and its disposal must not be neglected, as well as the fate after use. Recent studies have correlated the use of sunscreens based on chemical filters in bathing areas near the reef and the progressive whitening of corals, a phenomenon, which risks destroying 10% of coral reefs (Danovaro et al., 2008). Thus, sustainability design requires an accurate analysis of the entire production chain and an input and output evaluation action consistent with the design strategies. The application of sustainable strategies in every phase of the production process - from the acquisition of the resources for the cosmetic formulation to the choice of bottles and packs made of biodegradable, recyclable and eco-compatible materials until the product disposal phase - lead to an overall assessment of the functional units that make up the product and a balance of the impact on the environment in all phases of life.

## 2. ECO-ORIENTED STRATEGIES OF PRODUCTIVE CHAINS

Recently, cosmetics field, commonly considered as hardly unrelated or antithetical to sustainability and environmental protection, broadly have shifted its manufacturing models, favoring sustainable actions. In this context, new brands are founded for which sustainability is a distinctive identity feature. Ingredients, processes, packaging materials, labels printing, distribution, and all strategies, involved in the products life cycle assessment, are defined with a sustainable and ethical approach. The importance of supply chains, from ingredients to chemical formulation, from extraction processes to manufacturing of cosmetic lines, from the distribution strategies to the product dismissal, are the main part of new cosmetics products success. Thus, the role of design is essential like the gradual extension of the eco-oriented criteria to various manufacturing sector. Through the product Life Cycle Design approach (LCD), innovative concepts of life cycle and functional thinking are developed and new way to products production and use are shared (Vezzoli, 2010). "Innovation and the related design process of creative destruction lead to new ideas, new entrepreneurs and new business models, thus contributing to the establishment of new markets and the creation of new jobs in a sustainable way. Sustainable innovation is, therefore, the key to enable green and growth to go hand in hand, and design has gained the multidisciplinary expertise to drive it in the right way" (Gaiardo, Tamborrini, 2016).

Companies' commitment towards environment and the promotion of local producers' communities is conveyed through communication and awareness campaigns headed for sustainable and ethical behaviour. This is the case of multinational brands such as Aveda, the cosmetic company, which was one of the first companies in the world to promote environment safekeeping in its production processes. Another example is the French company World Wild Men cosmetics, Organic & ethical skincare for men, which in addition to the proposal of products following eco-oriented principles in design and production (Vezzoli 2017), transfers, through an ironic communication, a message related to individual choices safeguarding the environment and daily action. The WWM cosmetics select the ingredients and their origins, use eco-oriented packaging and all the labels are printed on recycled paper, issued from sustainable woods, printed with vegetal/ecological ink.

Many Italian companies, e.g. Davines, also follow sustainability proposing an ethical code that can guide consumers and beauty centers towards greater awareness of the impact of wellbeing behaviours on the environment. Since its foundation, Davines has promoted eco-oriented strategies in the processes, in the choice of single-material packaging to be used for different uses at the end of its life and a manifesto of behaviour for beauty centers. Companies that choose to orient themselves towards sustainable production act through a careful ingredients choice, reducing resources use, optimizing packaging by compatible, recyclable eco-materials. Sustainable strategies in formulations are cold process, time and energy saving, ingredients selection from green and local companies and the new concept development of products and formulations able to optimize materials in the process and in the use. It is necessary to evaluate the inputs and the outputs of all stages in the product definition and to use a product life cycle design approach (Vezzoli, Ceschin, Cortesi 2010).

## 3. GREEN-COSMETIC CONCEPT FORMULATING

A multidisciplinary and integrated approach is the driving force of the proposed new development concept in the cosmetics field. According to eco-oriented principles, and based on agri-food sector analysis, bio-sustainable active

ingredients have been used in a new skin care line. Design and Food Chemistry “at a table” to convey a new concept of wellness and body care: kitchen waste recycling reduces new products environmental impact. The collaboration between Food Chemistry laboratory - Department of Environmental Biological and Pharmaceutical Sciences and Technologies - and design laboratory – Department of architecture and industrial design - has experimented, thanks to well-integrated skills and competences, new sustainable and fully natural cosmetic products. The obtainment of new sustainable and fully natural cosmetic products aims to introduce new behaviour in the daily life and to transfer the awareness about environmental effects related to the reduction, repurpose and recycling of the food waste (Wever, 2012). This was from eco-friendly extraction of chosen waste material, the deep chemical characterization of extracts therefrom, and the assessment of their antiradical properties. The exploited approach is an opportunity for influencing user's behaviour and for spreading a new concept of wellness and body care.

“Feed” project takes into account that skin healthy state requires antioxidants' constant supply, as oxidative stress favours skin aging processes and other disorders. Ultraviolet solar radiation and an unhealthy lifestyle are exogenous factors harmful to the skin, which is constantly exposed to changes in connective tissue due to the formation of lipid peroxides and reactive oxygen species (ROS). The topical application of antioxidants is an efficient strategy to enrich the endogenous skin system in the prevention of oxidative stress related diseases. Among natural molecules, phenolic compounds are main actors in preventing free radicals formation (Pacifico & Piccolella, 2015). Thus, their recovery from alternative but rich source as kitchen waste and their employment in antioxidant products for face aim at protecting skin from exogenous radicals (UV rays, pollution, smoke), as well as at preventing and delaying epidermal cells aging. “Feed” is articulated in three main products: 1) a soap-scrub enriched with exhausted coffee powder for a cleansing and exfoliating treatment; 2) a peel off mask with extract obtained from broccoli wastes for revitalizing and soothing treatment; 3) a cream with orange peel extract with moisturizing and elasticizing effects (figure 1). Food Chemistry laboratory of the University of Campania “Luigi Vanvitelli” realised the cosmetic references with the idea to create a kit lasting about a month, in which each product is a phase of reconstituting and protective treatment from UV rays and polluting sources. In addition, the products can also perform an anti-aging action.



[Figure 1] Feed project 2018, Designer Claudia Derrico, final work master degree in Design for Innovation, University of Campania Luigi Vanvitelli

### 3.1. Sustainable formulating: research steps and test

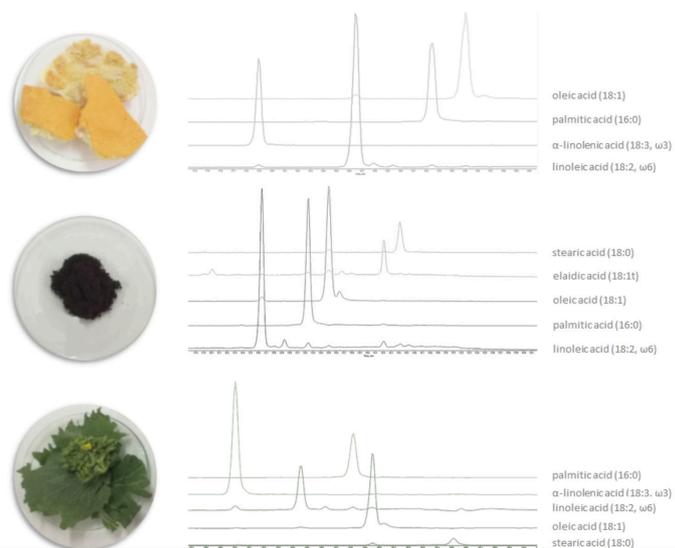
The recovery and re-use of bio-active (poly)phenols from kitchen plant wastes could be pivotal for establishing new cosmetic references, in the awareness that such molecules can exert cosmeceutical action in dermo-cosmetics and are good candidates to replace synthetic compounds, which have demonstrated possible negative effects on health and environment. Indeed, kitchen food plant wastes are very rich in sugars, minerals, organic acids, fibers and bioactive compounds, exactly like their edible counterparts. Herein the potential use of food waste from oranges, broccoli and coffee was evaluated in the formulation of cosmetics commonly used in personal care: an anti-aging face cream, a mask and a scrub, respectively. In the consciousness that the bioactivity of a plant extract is in its chemistry, the alcoholic extracts from orange peels (*Citrus sinensis*), coffee grounds (*Coffea arabica*) and broccoli leaves/stems (*Brassica oleracea* var. *italica*), prepared by ultrasound-accelerated maceration, underwent chemical characterization through the combination of ultra-high-pressure liquid chromatography (UHPLC) and high-resolution tandem mass spectrometry (HRMS) techniques. Extracts from orange, coffee and broccoli wastes were also tested for their scavenging capacity against DPPH (2,2'-diphenyl-1-picrylhydrazyl) radical and ABTS radical cation (2,2'-azinobis-3-ethylbenzothiazolin-6-sulfonic acid).

### 3.2. Extracts' characterization

Orange peels are mainly rich in flavones and glycosylated flavonols, differing in B and C rings oxidation degree and glyconic moiety, its position and the glycosidic bond type (O- or C-glycoside). Rutin appears to be the main component, followed by naringenin 7-O-rutinoside and apigenin 6,8-di-C-glucoside. Minor components include rutinoyl derivatives of luteolin- and myricetin. Glycosylated flavonoids characterized broccoli waste extract. UHPLC-HRMS analyses highlighted the presence of flavonols (kaempferol, quercetin and isorhamnetin) mono- and di-O-glycosylated, in which the saccharide moiety is likely to consist in sophorose or gentiobiose. In addition, the presence of kae-

mpferol and quercetin glycosides differently acylated was evidenced. Coffee grounds' extract chemically differs from the previous ones due to the presence of phenolic acids instead of flavonoids. In particular, chlorogenic acids, and caffeoyl-shikimic acids were identified as constituents of the coffee grounds' extract.

Moreover, besides the presence of the more polar phenols and polyphenols, the content of fatty acids, both saturated and mono- and polyunsaturated, was detected in all the waste extracts. The content of oleic acid (18:1) and linoleic acid (18:2,  $\omega$  6) is almost comparable in the three samples, whereas  $\alpha$ -linolenic acid (18:3,  $\omega$  3), which seems completely absent in coffee grounds, reaches the maximum content in broccoli waste. Palmitic acid, the only saturated fatty acid (16:0) detected in appreciable amounts, is mainly present in the Brassica oleracea extract (figure 2). The presence of fatty acids gives added value to the investigated formulations. In fact, linoleic and  $\alpha$ -linolenic acid have different functions in relation to skin care, such as the ability to influence the metabolic processes of the skin and to promote the activity of vitamins A and E. They are also used in anti-inflammatory cosmetic formulations, against skin lesions of dry skin, in the treatment of dermatitis and psoriasis (Kiezel-Tsugunova et al., 2018).



[Figure 2] Fatty acid occurrence in wastes of *Citrus sinensis*, *Coffea arabica* and *Brassica oleracea*

The three samples exert a dissimilar antiradical effect against the two probes considered, albeit dose- dependent in both cases. Flavonoid extracts from orange and broccoli wastes were not able to fully neutralize DPPH•, whereas coffee extract appears effective. With respect to antiradical activity towards ABTS radical cation, extracts from *Citrus sinensis* and *Brassica oleracea* wastes seem to have comparable reducing capacities, slightly in favour of the latter, as evidenced by their relative ID50 values (extract dose capable of inhibiting 50% of the present radical in the reaction mixture) equal to 47.9 and 32.8  $\mu\text{g}/\text{mL}$ , respectively. Coffee grounds extract scavenges efficaciously both target species, showing an activity comparable to that observed for Trolox®, a synthetic analogue of vitamin E with well-known antioxidant capacity, used as a reference standard. The calculated ID50s are 27.0 (vs. DPPH•) and 11.4  $\mu\text{g}/\text{mL}$  (vs. ABTS•+). The results obtained are in agreement with literature data, according to which the chlorogenic acids present in coffee and its waste, by virtue of their chemical structure containing catechol units, are particularly reactive towards free radicals, which are reduced to harmless species (or at least less reactive) following the donation of available hydrogen atoms (Tajik et al., 2017). The lower activity of the other two samples studied could be explained based on their richness in glycosylated flavonoids.

### 3.3. Extracts' preparation

Kitchen wastes, once collected and cleaned, underwent freeze-drying (FTS-System Flex-Dry, SP Scientific, Stone Ridge, NY, USA). Lyophilized wastes underwent ultrasound assisted maceration. To this purpose, for each sample, three extraction cycles (30 min each) were performed in a 40 kHz ultrasonic bath (Branson M3800, Carouge, Switzerland) with methanol (MeOH). Extracts obtained underwent UHPLC-HRMS- based metabolic profile analyses and antiradical power assessment.

### 3.4. UHPLC-HRMS analyses

Extracts from table wastes (10.0 mg), solubilized in pure methanol (1.0 mL), underwent UHPLC-ESI- QqTOF-MS/MS analysis. To this purpose a Shimadzu NEXERA UHPLC system was used with a Luna® Omega Polar C18 column (1.6  $\mu\text{m}$  particle size, 150  $\times$  2.1 mm i.d., Phenomenex, Torrance, CA, USA).

The mobile phase consisted of a binary solution A: H<sub>2</sub>O (0.1% HCOOH), B: CH<sub>3</sub>CN (0.1% HCOOH). In the extracts of *Citrus sinensis* and *Coffea arabica*, the elution was carried out as detailed below: starting from 5% of B a linear gradient was performed up to 95% B in 15 min, continuing for 1 min before re- equilibrating the system (1 min). For the extract of *Brassica oleracea* var. *italica*, the separation was carried out always starting from 5% B, following an isocratic elution for 15 min, then reaching 40% B in the next 5 min, before re-balancing the system for 2 min. In all the cases, a flow rate of 0.5 mL min<sup>-1</sup> and an injection volume of 2.0  $\mu\text{L}$  were set. The MS analyses

were conducted using the AB SCIEX TripleTOF 4600 system equipped with a DuoSpray™ ion source operating in a negative electrospray ionization mode, with a declustering potential (DP) of 70 V, a collision energy (CE) of 45 V and a CE spread (CES) of  $\pm 25$  V. Data processing was performed using the PeakView® - Analyst® TF 1.7 Software.

### 3.5. Assessment of DPPH radical and ABTS radical cation scavenging ability

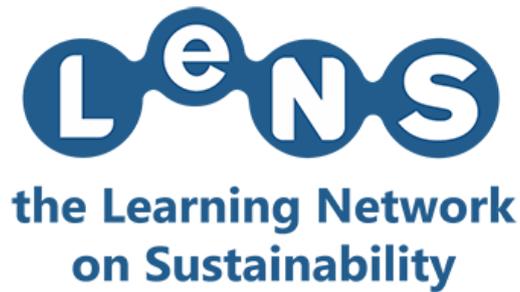
The scavenging capacity of the extracts prepared from the waste of *Citrus sinensis*, *Coffea arabica* and *Brassica oleracea* var. *italica* against DPPH radical and ABTS radical cation was carried according to Pacifico et al. (2019). Trolox®, a synthetic vitamin E analogue with known antioxidant capacity, was used as positive standard. Tests were carried out performing three replicate measurements for three samples ( $n = 3$ ) of the extract (in total,  $3 \times 3$  measurements). Results are the mean  $\pm$  SD values. ID50 values, based on the percentage decrease of the initial probes' absorption by the different concentrations of the test samples (1.56, 3.125, 6.25, 12.50, 25, 50 and 100  $\mu\text{g/mL}$ ) were also calculated.

### 3.6. Cosmetic references

For soap scrub preparation, sodium hydroxide, dissolved in distilled water, and EVO oil were emulsified together with 2.6 grams of coffee grounds. The obtained mixture was poured into the appropriate mold. Face cream preparation was based on almond oil and beeswax, which were dissolved in a bain-marie, and then added to boiled distilled water, together with drops of *Lavandula angustifolia* essential oils and the orange peel extract. Peel off mask preparation was realised using two and a half tablespoons of milk, brought to boil, and mixed to food jelly and broccoli extract.

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## **CHILDREN FURNITURE DESIGN FOR SUSTAINABILITY**

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### **ABSTRACT**

Through analyzing the process of design and research in the children's furniture work, "Accompany", the paper explores the relationship between the behavior of children aged 3-12 and their furnitures, and proposes the concept of "sustainability" in children's furniture design, which is proposed to be "growing up" along with the growth of children. The "Accompany" is assembled by the limited number of standard wooden parts and hardware, and able to be re-assembled to the new furnitures by choosing the different combinations of the standard parts and fittings. This design fits the characteristics and behaviors of children in their fast growing period of time. "Accompany" provides the sustainable usages to meet the demands of rapid growth of children.

Key Words: Children's Furniture, Sustainable Furniture Design, Furniture Design

## 1. INTRODUCTION

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable design is the principle of designing the products and services that meet the needs of the present without compromising the functions and improve the performance of the functions by the process of design to apply with reducing negative impacts on environment and health. Sustainable furniture design must have three characters: the first is the resource saving and environment friendly to protect the Earth; the second is to provide the users with health usage; thirdly, the furniture should be used for long-term. (Hao-ming Zhou, 2011) If the furniture in the materials choosing, producing, packaging, transporting, using, durability, maintenance and recycling etc. meets the above characters, it can be considered as sustainable furniture.

Children's furniture should be designed to meet the needs of children both psychologically and physiologically, be consistent with children's behaviors, and provide a set of the functions such as sitting, lying, and supporting or appliances such as item storing. Without seriously considering the psychological, physiological and behavioral changes in the childhood, the long-term use of an unreasonable sized furniture may lead a child to develop a series of problems such as poor bone development, poor eyesight and etc.

## 2. THE CHARACTERS OF CHILDREN FURNITURE DESIGN FOR SUSTAINABILITY

There are three characters in children furniture design for sustainability.

### 1) Multifunction

Ideal children's furniture should meet the different needs of children in the different situations, so it must be multifunctional. It means that the furniture has many practical functions; on the other hand, it can be realized by the transformation of furniture functions by adjusting and adding parts. Figure 1 shows the furniture "Smart Kid" designed by Adensen Furniture. The multifunctional kit starts out as a crib, but it can easily be disassembled and reassembled as a playpen, a desk, a chalkboard, a book rack, or a junior bed for child age up to 10 years old.

### 2) Transforming

For the purpose of multifunction, children's furniture needs to be transformable. Furniture functions can be changed by the various combination of the structures with adjusting furniture angles or sizes to achieve the new functions of the furniture. The work of the "Smart Kid", known as transforming design, not only saves parents the hassle of arranging furniture in and out of the house to meet their child's evolving demands, but also saves both money and natural resources.

### 3) Growth

Children's furniture under the concept of sustainable development must have the features of extensibility and adjustability. The main performance is that the size of furniture can be extended, the angle of furniture can be adjusted. The adjustments can fully meet the needs of children in the different ages. Figure 2 show Tripp Trapp designed by Peter Opsvik. A children's growth chair, by adjusting the distance between pedal and seat, it can be used in different age groups from infant to adult.



[Figure 1]Smart kid [Figure 2]Tripp Trapp

## 3. THE DESIGN OF "ACCOMPANY"

According to the degree of psychological and physiological changes in the different period of children, children can be divided into four periods: Infant (0-1 years old), toddler (1-3 years old), pre-school age (3-6 years), school age (6-12 years) and teenager (12-18 years old). (Yuan Xu, Lan Shi, 2008) This paper focuses on discussing the desk design for children of aged 3-12 years.

In different age, children have different demands for game, reading and learning for desk, and they should use desks in different sizes and heights for each activity. If every piece of the required furniture is purchased, it not only costs lots of money but also needs some considerable storage spaces for the discarded furniture in the future. The "Accompany" furniture, with the concept of sustainable furniture for children, combines limited parts and components into multiple types of furniture to meet the various needs of children at different ages, and through adjusting the size of desktop and the height of desk to attain the objective of growing up with children. The work extends the life time of the furniture, achieves the goal of the multifunction furniture and reduces the cost in an effective and sustainable way. At the same time, the structure, materials and colour meet the need of growing up children.

### 3.1 Ergonomics

Human factors and ergonomics are the psychological and physiological principles for designing (and engineering) of products, processes, and systems. The goal of human factors is to reduce human error, increase productivity, and enhance safety and comfort with a specific focus on the interaction between the human and the thing of interest. (Wickens, Gordon, Liu, 1997) It provides appropriate human parameters and furniture parameters. In the process of operation or the use of products, human health will not be affected. Children furniture should be designed restrictively according to the children's standards.

In the design of "Accompany", the principles of ergonomics are complied with. By analyzing the relationship between "Accompany" and children's body morphological characteristics, physiological data such as age and body size, the size of furniture is carefully considered. "Accompany" is not only compatible with the human dimension in height, but also fits for the fast growing height of children.

#### 1) Body morphological characteristics of children

The growth and development of children in childhood is rapid, and the various parts of the body change rapidly. The growth of height and weight is faster; the skeleton is soft and elastic, and a child's bone is easy to bend and deform after being compressed. (Yahui Xiao, 2012). At this stage, special attention should be paid to the sitting posture. The ergonomics of children furniture design is particularly important; the muscles of children in early childhood are softer than adults, with more water content, less fat, protein and inorganic substances, and they are easy to fatigue during activities, but it recovers quickly.

#### 2) Height and weight of children

The rapid growth of children aged 3-12 years old is obvious both psychologically and physiologically. The height of children is 90.8-101.8 cm in the age of 3, 110-123 cm in the age of 6. The height of children grows about 20 cm in three years. The weight of a baby is around 12-17 kg at age of 3, 18-25 kg at age of 6. According to the above statistical data, children's desks must be replaced. The consideration of size, stress and other factors must be included in the design process for children.

"Accompany" can be adjusted to different size and height by using hardware and embedded part. The table height is 40cm at age of 3 and grows up to 50 cm at age of 5. The height and size of the table are designed to be adjustable for the changes in height and sitting height at different age.

#### 3) The relationship between desk and stool

According to the National Standards of the People's Republic of China of "Functional sizes and technical requirements of chairs and tables for educational institutions", for every 8 cm increase of children, the desks will be raised by 3 cm, and the chairs will be raised by 2 cm. Children aged 3-4 years are suitable for desks height of 43-46 cm and chairs height of 23-25 cm. For children aged 5-6, desks and chairs are required with height of 49-52 cm and 27-29 cm. Children aged 7-8 years are suitable for desks height of 52-55 cm and chairs height of 29-30 cm. For children aged 9 to 10, desks and chairs with height of 58-61 cm and chairs of 32-34 cm are suitable. For children aged 11 to 12, tables and chairs of 61-64 cm and 34-36 cm are suitable. It is accurate for most children to choose the height of desk and chair according to their age. But for some children, it is more accurate to choose furniture by their height than to choose the height of desk and chair according to their age. The lowest desk height and chair height are set at 37 cm and 19 cm, which are suitable for children in the range of 75-89 cm. The highest height of the desk is set at 79 cm, and the chair height is set at 46 cm. It is suitable for children over 180 cm. This standard desk and chair is suitable for the majority of people, except for special groups.

The furniture can be adjustable by which the size of the children's furniture can be adjusted according to the change in children's height. "Accompany" can be adjusted to different size of desktop and height by hardware of Invis joining system and Clamex P. Considering the stages of children's growth, processing methods and modular design, the desk legs of this scheme are divided into three lengths of 40 cm, 10 cm and 5 cm to meet the needs of children with different height. The height of desk and chair match the height of the form of "Accompany".

### 3.2 Structure

The structure should be reasonable structure and structural safety. Reasonable structure refers to the facts that the rational structure of the furniture is easy to assemble and disassemble according to the structure itself. At the same time it applies in the design process with no harmful substances released during and after the installation. Children have a strong curiosity about external things, but concept of self-protection is weak. The furniture must have the smooth surfaces and high quality parts to achieve the goal of safety to children. With the reasonable strength for children to beat, shake, move and tap, the furniture must be robust enough and without falling off small parts during the installation and the life cycle in use.

"Accompany" is to use the idea that the desktop and legs will grow with the growth of children according to their age. Therefore, the convenient, beautiful and safe way of connecting the desktop and legs is extremely important. The scheme uses Invis joining system and Clamex P which developed by Lamello, Switzerland.

#### 1) Invis joining system

Invis joining system is a magnetically operated screw connection that can joins and releases without physical contact and is completely invisible. Rotary magnet-operated screw connection that are completely embedded in each component, using a special magnetic actuator that operates beside the component. (Figure3) It can be tightened and loosened again, which is the ideal connecting parts for installing leg structure of "Accompany".

## 2) Clamex P

Lamello sets standards with the Clamex P-System that it comes to joining work pieces. It is used to connect the desktop and desktop or stretchers (or protective board), which enables strong connections with the work pieces without the need for tools. The form-locking P-System anchorage Clamex P does not require glue or screws. The furniture fitting is characterized by its small 6 mm tool openings for hex keys. (Figure 4)

“Accompany” requires a small number of parts and is simple to be assembled, so it is easy to be converted between the desk of different sizes and height. The different works can be reciprocally converted in a frequent way. The Invis joining system and Clamex P are hidden in the materials so that no harm for children to use. Over 3 years old children, they can master a variety of more skilled movements. Sports and games can not only enhance children’s physical abilities, but also help children to explore, understand and experience the changes of the world. It makes children exciting in the process of participating in some housework with parents. During the converting furniture process, parents can invite children to join the job. It is just like playing game with parents. The children’s ability is improved. So “Accompany” will bring happiness to children.



[Figure 3] Invis joining system [Figure 4] Clamex P [Figure 5] Color system

### 3.3 Materials

There are two kinds of wood used in “Accompany”. One kind wood is certified by the Forest Stewardship Council (FSC), another kind wood is modified wood.

FSC is an independent, not-for-profit, non-governmental multi-stakeholder organization, established to promote the responsible management of the world’s forests. FSC forest management certification confirms that the forest is being managed in a way that preserves the natural ecosystem and benefits the lives of local people and workers, all while ensuring it sustains economically viability. So the wood on FSC certification is regard as sustainability.

In order to increase the supply of timber resources, the artificial fast-growing forest has vigorously been developed. The fast growing wood of artificial forest has the disadvantages of loose materials, low density, poor dimensional stability and poor resistance to rot, which leads to poor product performance and low added value. In order to efficient use of low-quality fast-growing wood, modified wood is researched. Wood modification is the technologies with which the properties of wood are permanently altered by heating at high temperatures or reacting with low molecular weight monomers or oligomers. The specific properties of wood are consequently improved and certain new characteristics imparted due to the modification. The modified woods can resultantly serve for a longer term compared to the non-modified ones. The tension due to the lack of wood resource can be reduced. (Yanjun Xie, Qiliang Fu, Qingwen Wang, Haigang Wang, 2012) So modified wood is also a sustainable materials.

### 3.4 Finishing

Children’s respiratory tract is short and narrow, respiratory mucosa is tender, respiratory frequency is fast and uneven, alveoli are small and easy to be blocked, vulnerable to dust particles and other harmful substances. At the same time, children’s breathing volume is 50% higher than that of adults in terms of body weight. The air quality of living space is very important for children’s health. Unfriendly furniture will release harmful gases in the air, which will harm children’s living space. In order to protect children’s physical health, furniture should use environmental protection materials. (Erxiang Yan, Dongjiu Yu, 2017)

Wood wax oil is used in the work for furniture surface finishing, which is coating for wood products environmentally. The raw materials are mainly made of refined linseed oil, palm wax and other natural vegetable oils combined with vegetable wax and some other natural ingredients. Therefore, it does not contain toxic components such as triphenyl, formaldehyde and heavy metals, and has no pungent odor. It is a really environmental protection materials.

### 3.5 Color

Children are naive, lively and lovely. They like bright and rich colors. The color design of children’s furniture is moderate, harmonious, high saturation and high brightness. It is not only conducive to children’s healthy emotional development, but also improve children’s color aesthetics.

Because the “Accompany” will accompany children for many years, it will supply three kinds of color scheme: wood color, white color and color system.

Wood color, the selection of beech, ash, pine, which shows pure wood color, brings people fresh and warm effect. For the children in different age, there will be feel comfortable and natural to use. Because it is proved that the wood with high brightness value could produce the elegant, simple, passionate emotional association. The wood with low brightness value made the person produce the traditional, heavy, gorgeous, and distinguished emotional association. The wood with unclear texture produced a simple sense of perception. The texture clear wood could produce the gorgeous, elegant, and natural emotional association. (Tinyu Jia, Xiaoting Niu, 2017)

White is also a very versatile color.

Mental performance such as curiosity, fantasy and bright colors attraction is quite well developed in pre-school age, so the third color scheme is color system to satisfy children's psychology. Color system uses the same hue, but different lightness. They are both united and changed easily. Through different color matching, it can meet the preferences of children in different ages. It is analyzed below the color of pink and blue used in "Accompany".

In Europe and the United States, pink is usually associated with girls, while blue is associated with boys. Colour was first used as a gender marker in World War I; pink was first used as a feminine marker in the 1940s. It was found that the female preferred red-purple color in spectrum, while the male group preferred yellow-green color. So the color system is chose pink and blue(Figure 5).

The furniture designed for girls is pink, which has three degrees of brightness. Customers can customize or choose according to their preferences. It can be monochrome or from top to bottom deep pink to light pink. On the contrary, light pink to deep pink can be assembled. Bright and soft colors make up a very vivid scheme. And blue scheme is designed for boy.

### 3.6 Scheme

The design scheme adopts the structure of detachable components to encourage children to participate in the process of the transformation between different forms and increase parent-child interaction. "Accompany" uses multi-color scheme to meet the preferences of different customers, it meets the needs of children at different stages of growth by changing the size of furniture. The design scheme can stimulate the usage of the product and improve the efficiency of the product.



[Figure 6] Installation diagram [Figure 7] The first type

"Accompany" is the kind of furniture that accompanies children to grow up. The furniture consists of a desk-top of 60×40 cm, several desk legs of 40 cm, several desk legs of 10 cm, several desk legs of 5 cm, the stretchers (or protective board) and hardware of Invis joining system and Clamex P (Figure 6). These simple components can be combined into four different types of desks, stool and storage basket for children in different ages to play, read and study.

"Accompany" is designed into four types to meet the demands of children in four different age groups. By taking consideration of psychological and physiological characteristics of children, "Accompany" is designed to meet the needs of children through a variety of functional changes.

#### 1) Type one: desks for 3-4 years old children

The desks are designed for reading, playing and placing when children are about 3 to 4 years old(Figure 7). There are three kinds of desk in this type. Children begin to develop and exercise the motor function at this age, they can choose the plastic toys to disassemble and assemble. On the desk with protective board (Figure 7a), children can play with small toys such as space sand or Lego without dropping the toys into the ground. The second one (Figure 7b) is also for playing toys such as the block on the desk with extra desk legs of 10 cm and 5 cm attached to the shorter desk. When the customer doesn't use the extra desk legs, the desk legs can be used as toys for building blocks. The desk legs with the installed the wheels is transferred into a small train, and it is one of the favorite toys for children aged 3 to 4. The third one is a normal desk with the small train on the desktop(Figure 7c).

#### 2) Type two: basket and desk

The second type(Figure 8) is basket and desk. The basket is convenient for children to collect toys. If children need to read, the furniture can be installed as a desk, just like Figure 8, the desktop is bigger than the third desk in Figure 7.

#### 3) Type three: desks for 5-6 years old children

The third type is designed for 5 to 6 years old children while children gradually enter the learning stage. Desktop requirements increase, desk height also needs to be increased. At this time, the original two small desktops(in Figure 7 ) are connected together into a desk of 80×60 cm or 120×40 cm. The height can be adjusted according to the height of the child. Another desk(in Figure7) can be installed into a stool in Figure 9.

#### 4) Type four

The fourth type is a standard desk for children over 7 years old (Figure 10). During this period, children's learning content increases, and the required desktop area also increases. The desk size can be adjusted and combined



[Figure 8] The second type [Figure9] The third type [Figure 10] The fourth type [Figure 11] Line type [Figure 12] L type

according to the size and characteristics of room space, such as Line-type(Figure 11), L-type(Figure 12), etc. Height can also continue to increase according to the height of the child. In order to increase the strength of the desktop, the protective board will also be used as stretchers of the desk.

### 3.7 Packaging

“Accompany” extends the principles of sustainable development in the life cycle of children furniture. “Accompany” is a combination of wooden parts and a number of hardware, and therefore the furniture can be flat-packed, which is not only convenient but also reduces the cost of transportation.

## 4. CONCLUSION

The work, “Accompany”, meets the needs of children’s rapid growth, and highlights the design concept of growing up with children together. The furniture is applicable to different age children and so easy to make extensive transformation through the different combinations and updated parts. Thus, the life time of the furniture is naturally extended and the effectiveness of furniture in long term using has been achieved.

The concept of growing up with children in furniture design is an effective solution and an important manifestation for the concept of sustainable design, which leads the development of children’s furniture into a more secure, more practical and more environment friendly direction. In short, The concept of Children Furniture Design for Sustainability reduces family costs, production costs, saves the materials and protects the environment.

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## STUDY ON THE DESIGN OF TENON AND MORTISE JOINTS FOR NEW TYPE SUSTAINABLE EXPRESS PACKAGING BASED ON THE CONCEPT OF INTEGRATED CYCLING

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### 1. INTRODUCTION

With the growing prosperity of e-commerce in China, the logistics industry has made considerable development, especially the express delivery industry has achieved rapid growth. The monitoring data of the E-Commerce Research Center (100EC.CN) shows that in 2017, the business income of China's domestic express was RMB 276 billion yuan, with a year-on-year increase of 35%. With the rapid development of the express delivery industry, express packaging has become an indispensable material carrier in people's consumption process. However, while consumers are enjoying the convenience and excellent shopping experience brought by the express packaging, a surge of garbage appeared due to the large amount of discarded express packaging boxes. According to statistics, the proportion of plastic and paper wastes in domestic garbage has increased significantly in recent years. Based on the calculation by the National Post Office, more than 1.5 billion express parcels were sent during the promotions of "Double 11" period in 2017, and most of these express packages were directly discarded, resulting in tens of thousands of packaging wastes. Even with conservative calculations based on the usual standard of 0.2 kilograms per package in the industry, 1.5 billion express packages produced at least 300,000 tons of garbage. Throughout the whole year of 2017, the amount of garbage generated by express packaging was as high as 8 million tons. [1] The resulting waste of resources and environmental pollution is breathtaking. Under the current situation of thriving supply and demand, how to reduce the pollution of express garbage, improve the recycling rate, and control excessive emissions has become an urgent necessity in China.

## 2. DESIGN STANDARD FOR THE SUSTAINABILITY OF EXPRESS PACKAGING

On February 6, 2018, the General Administration of Quality Supervision, Inspection and Quarantine and the Standardization Administration of China officially issued the National Design Standards for the “Packings for express service”, including three parts: the enveloping, the packaging box and the packaging bag. This standard was implemented on September 1, 2018. The release and implementation of the national design standards for express packaging has brought the express industry into a new stage of development. First, it embodies the idea of sustainable design based on technological development. The relentless pursuit of rationalization, recyclability and greenization of express packaging through minimization has been made to reduce the consumption of packaging materials, thus reducing the comprehensive cost of packaging and transportation. Secondly, an effective system for recyclability has to be established and perfected for recovery and recycle of express packaging materials to improve recycling utilization rate of materials, extending the life cycle of packaging to ensure the recycling of express packaging. Finally, waste of resources and environmental pollution of packaging waste are reduced during production and processing to ensure degradable treatment and achieve environmentally friendly packaging that meets the true standards of sustainable packaging design. [2]

### 2.1. Minimization

Packaging minimization is to facilitate the recycling, that the designer shall adhere to the guidelines of pursuing reasonable and appropriate properties of packing in designing product packaging on the premise that the design can fulfill the basic purpose of packing and functions of protection, operation, delivery and dissemination of information, minimizing the use of various materials to reduce the resource consumption in the manufacturing process and the energy consumption in the logistics process, meanwhile discarding the use of rich colors to achieve a reduction in the weight and volume of the package. For example, when the weight is the only factor to be considered, for packing the plastic bottle of the same volume, the plastic packaging material is calculated as 1, the aluminum is 1.5, the composite board is 2, and the glass is 13.5.[4] The correct selection of packaging materials can achieve the purpose of minimization.

### 2.2. Greenization

Innovative design promotes sustainable transformation of the economy and society, opening up a brand new “deep green” design approach to achieve the transformation of degradable and pollution-free packaging. Specific cases include: SF Express green packaging (green packaging of sticking envelope for secondary use, tape-free carton, and ordinary woven bags replaced with canvas bag in transit depot); paperless system in 1st shop warehouse; logistics box recycling at Suning logistics (supply chain + express delivery, localized distribution of package production).

### 2.3. Recyclability

Recyclability of packaging means that a single packaging material is used for product packaging as much as possible to facilitate sorting and recycling. Without affecting the quality of the packaging, the materials with high recoverability should be selected for packaging and transportation [5]. At its core, whether for use or recycling, what we do at each stage has a positive interaction with the natural environment, and such interaction is beneficial to the Earth’s ecosystem and environment. The most typical is the repeated use of packaging, which means the packaging can be reused many times. It is the most environmentally friendly practice today. [6] The development of new materials continues to change the exterior of the packaging and provides a new way to protect the product. Reuse allows the available resources to be fully utilized, which not only extends the life of the product, but also limits the increase of wastes.

## 3. THE CONCEPT OF INTEGRALLY CYCLED PRODUCT

The realization of the products, especially the integrally cycled restorative products with ecological restoration function, will surely become an important powerhouse for leading a new round of development of human civilization. Judging from the development of packaging in China’s express delivery industry, it obviously followed the pattern of the traditional extensive economy. The traditional extensive economic development mode has caused a series of problems such as resource shortage, environmental pollution and global ecosystem destruction, and the integrally cycled products become the strategic trend of common concern. [7] As shown in Fig. 1, the concept of integrated circulation of sustainable express packaging consists of three cores:

**Materials.** How to select renewable or recyclable materials to ensure efficient economy of raw materials through improving integrated circulation and recovery, reuse and control of biodegradation of target applications is the cornerstone and primary task of the integrated cycle of express packaging, helpful to reducing the demand for non-renewable resources and contributing to environmental protection.

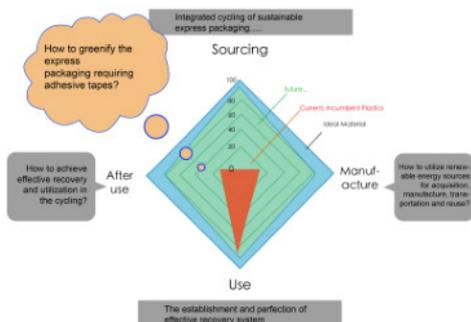
**Manufacturing.** In this process, how to obtain renewable energy for manufacturing, transport and reuse, and use clean production techniques and best practices for manufacturing determines whether the product so manufactured meets market standards for performance and cost, and whether the entire manufacturing cycle is beneficial, safe, healthy, and cyclical to individuals and communities. Green design and manufacturing should further strengthen the ability to deal with complex and systemic problems, especially to further develop common technologies such as methods, tools, software, integration and evaluation of green design. [8]

Recycling and reuse. The questions that designers need to consider include how to effectively recycle and utilize the packaging after it has been used and what happened to the packaging after it was discarded. Material waste degradation and decay, resource recycling, regeneration recycling, and sorted recovery, etc [9] are the first principles of the integrated cycled product, thoroughly improving the economical quality of recycling and reducing circulation loss. The lifecycle of packaging process application is extended by establishing and improving an effective recycling system.

#### 4. PROBLEMS IN THE TRADITIONAL DESIGN OF EXPRESS PACKAGING

The express packaging waste accounted for a considerable proportion in urban domestic waste, which began to impose a heavy burden on the social environment. Taking Beijing as an example, in 2017, China's express delivery industry consumed 9.9 billion packaging boxes, 8.26 billion plastic bags, 16.95 billion meters of adhesive tapes, and 2.97 billion buffering pads, which can wrap the earth 425 rounds, as well as 182,000 tons of corrugated paper, equivalent to felling 1547 hectares of forest. [10] Therefore, the main problems of the domestic traditional express packaging design lie in disposable express packaging, overpacked, low quality packaging, plastic tape is used in large quantities that give rise to concerns such as environmental impact, product safety and so on.

As shown in Fig. 2, the structural strength of the traditional express packaging largely depends on the toughness of the adhesive tapes, and the excessive use of the tapes makes the recycling and reuse of the packaging box of corrugated board difficult, and the tape that is difficult to tear off virtually increases the difficulty and cost of recycling and reusing the corrugated paper. While the excessive use of tapes is related to the violent loading and unloading practice in the express delivery industry, because the seller would rather wrap more tapes and bubble films round the goods than bear additional losses and risks, lest the packaged goods sent by the seller be damaged in the violent loading and unloading by the couriers. However, the excessive use of tapes also adversely affects the consumption experience, although it provides consumers with a sense of security. Sometimes it is not so convenient to take apart the package from the seal as to open a hole in the box with a key to take the goods out, causing heavy pollution to the environment and failure of recycling and reuse.



[Figure 1] Diagram of the concept of integrated cycling economy. [Figure 2] The unpacking and tape issues of traditional express packaging

#### 5. NEW DESIGN OF EXPRESS PACKAGING REQUIRING NO TAPE

##### 5.1. Resolution of the problems by the new express packaging

From the perspective of the integrated recycle, the new sustainable express packaging design vigorously aims at eliminating waste during the design phase and achieving sustainable utilization of resources through the “cycle to cradle” circular economy practice. In addition, consideration must be given to the protection of the goods contained inside packaging, materials, and costs, as well as conditions that consumers are unaware of, such as being transportable, easy to use and recycle, etc. [11]

On the basis of the above conditions being met, the “mortise-and-tenon joint structure” of new sustainable express packaging has a foothold in low carbon and environmental protection. Minimizing the use or abandoning the use of tapes is the best solution to achieve the sustainability of express packaging from the design phase to lengthen the service life of express packaging as much as possible, fully exploit the sustainable value of express packaging; continuously improve the robustness of express packaging and recycle to the greatest extent possible; provide solutions to reduce tape usage and lower down resource waste and environmental pollution of express packaging.

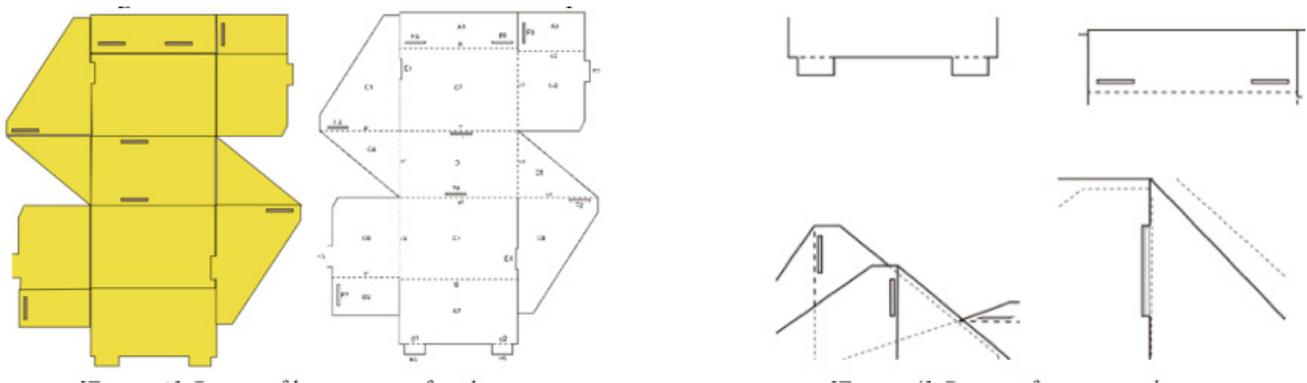
The new express packaging design adopts the concept of avoiding excessive use of tape, exploring the sustainable concept of using mortise-and-tenon joint technology, and promoting the closed loop relationship between input and output of express packaging in future, which is conducive to the cycle of symbiosis of the enterprises and the ecological environment. Firstly, the existing traditional express packaging structure has to be changed: the sides of the package are designed as movable surfaces, and the sides are fixed in a form of rabbit, thereby reducing the surfaces to be sealed from two to one, so that even if one openable surface needs tape sealing, it will save more than half of tapes used in the conventional form, providing a solution to the problem of excessive use of tapes and packaging boxes discarded after being used once in the express delivery industry.

It is found, through research and practice, that the interlocking structure of corrugated paper can achieve the required strength for express packaging and get rid of the use of a large amount of tapes. Such structure not only makes consumers feel safe, but also allows consumers to enjoy a fast unpacking experience. And the structure of the box is not destroyed after the box is opened. The packaging box is only made up of corrugated paper and courier receipt, which is more convenient for recycling of the package, or the package can be directly sent to the paper mill for beating and remaking, reducing the link in the cycle process and the cost of the cycle.

### 5.2. Layout view of the new packaging

The layout of traditional express packaging box is a structure of connected lateral cardboard, with top and bottom sides left open, to be fixed and sealed with tapes. However, such structure makes the tapes a necessity for express packaging, otherwise the bottom side will have no load-bearing capacity, and the excessive use of the tapes increases the difficulty and cost of recycling the packages.

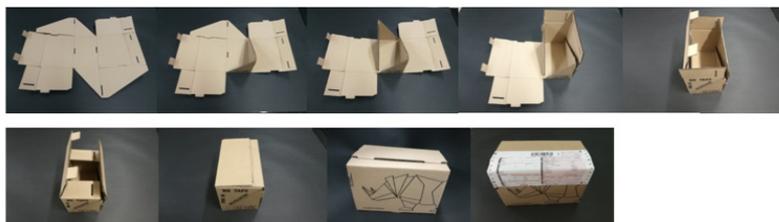
The new-type packaging structure adopts a crisscross structure in which the bottom cardboard is connected to the side cardboard and the side cardboard connected to the cover cardboard. This structure causes the ridges of the two lateral boards to be perpendicular to the main direction of force, leading to the reduction of the load-bearing and impact resistance of the bottom and sides of the entire box. As shown in Fig. 3, the new-type packaging structure consists of two cover boards: A1, A2; two dust-proof folding fins: B1, B2; eight lateral boards: C1, C2, C3, C4, C5, C6, C7, C8; six tenons: E1, E2, E3, E4, E5, E6; eight mortises: F1, F2, F3, F4, F5, F6, F7, F8; and fourteen folding lines: a1, a2, b1, b2, c1, c2, d1, d2, e1, e2, f1, f2, g1, g2. It has a diagonal triangular structure on both sides of the carton, so that each side has two boards and the ridges of the two lateral boards are upward vertical, which can withstand the tensile force and impact force in all directions and reinforce the lateral strength, as the added lateral boards are in within the maximum length and width of the layout plan, with the minimum consumables and without affecting the jointed board, while the utilization rate is improved, thus forming a structure that can greatly reduce the influence on the goods inside even if the box is impacted.



[Figure 3] Design of layout view of packaging [Figure 4] Design of mortise and tenon joint

### 5.3. Design of mortise and tenon jointing

As shown in Fig. 4, the method of rabbeted locking is inspired by the Chinese classical mortise and tenon joint structure. The protruding portion (tenon) at the bottom of the triangular side cardboard is fit into the mortise on the bottom board, so that the side cardboard can keep stable without relying on external force. The mortise on the triangular lateral board can be used to secure the square lateral board. This solves the problem that the crisscross structure is immediately scattered when the external force is lost after being closed, and all the lateral boards are interlocked and mutually fixed. The projection of the lateral board is about 2mm longer than the depth of the mortise, so as to counterbalance the elasticity of corrugated paper by means of folding. The protruding portion of the lateral board results in the notch on the lateral boards, which can make room for the protrusion of lateral boards after boards are jointed, increasing the strength in the middle of the sealing to ensure a firm closure.



[Figure 5] Steps of closing a box

### 5.4. Design of rapid box closing

The new express packaging structure adopts pure jointing structure design and application featuring both lightweight and convenience. As shown in Fig. 5, the folding process of the box is as follows: First, the lateral board is folded along the folding line so as to be perpendicular to the lateral board, and the lateral board is folded along the

folding line so that it is perpendicular to the bottom board, with the tenon inserted into the mortise; then the dust-proof folding fin is folded along the folding line so that it is perpendicular to the lateral board, and the box is closed.

The new express packaging design is intended to realized a mode of fast unpacking, fast taking in and fast taking out, with multiple interlocking rabbets to ensure the stability and supporting strength of the packaging structure, requiring no tape fixing and adhesive sealing, because the strength of this closure comes from the design that the rabbet on the triangular lateral board can fix the square lateral board, making the packaging more stable with higher compressive strength. It features high compression resistance, load-bearing capacity and resistance to heavy impact, in addition to quick unpacking and recyclable and reusable characteristics. What is more, when it comes to the basic role of express packaging, a very important point is to deliver the goods safely. The courier receipt at the seal is glued at the opening to ensure security and anti-theft.

## 5.5. STRUCTURAL STRENGTH TEST

### 5.5.1. Comparison of packaging opening and closing speeds

Traditional express packaging uses corrugated paper as the main material, reinforced with adhesive or metal nails, and sealed only with tapes. There is basically one type of packaging boxes, with upper and lower sides left open to be closed by winding a few turns of tapes. When unpacking, the tapes needs to be removed first. In case of excessive use of tapes, it may take more time. As shown in Fig. 6, the advantage proved in the new express packaging structure design test lies in that the physical performance of the traditional express packaging is guaranteed, while the packaging boxes can be quickly opened and quickly closed, safe in the transportation process and low at manufacturing and transportation costs. With the courier receipt at the seal torn off, the box cover will open. It can be easily opened, reclosed, and packed. The experimental results of the ease of opening of the traditional packaging and the new packaging shows that the unpacking speed of the new packaging is nearly 14 seconds faster than the traditional express packaging calculated from opening the box cover by hand, and the closing of new-type express packaging is 20.15 seconds faster, and different groups of people can easily use and intuitively open the box for a short time.



[Figure 6] Comparison of package closing speed



[Figure 7] Load bearing strength test. [Figure 8] Compression strength test of new express packaging structure

### 5.5.2. Load bearing strength test

The new express packaging is designed for transport packaging and logistics package, specific model is selected according to the weight and strength of the transport to test the load-bearing strength of the carton, containing eight kilograms of sand as a unit and thrown to the ground at a height of about 1 meter. As shown in Fig. 7, the result proves that the new tenon-and-mortise joint structure can withstand the impact during transportation, not easily broken, and can be recycled and reused as a resource.

### 5.5.3. Compression strength test

As shown in Fig. 8, The experimental results show that the tenon-and-mortise joint structure design is tested on the compressive strength of the corrugated packaging material, fully considering the factors of firmness and safe transportation of the express package. In addition, the new express packaging structure is designed like paper folding, which is used to increases the strength to avoid damage in the transportation.

### 5.5.4. Impact strength test

The most important feature of express packaging design, from the point of practicability, is safety, structurally stable, resisting to dropping and throwing force; Figures 9-10 show the different tests from the early development stage to the packaging strength and different damages occur from the same impact test on new and old packaging strength.

In general, express packaging will experience throwing, bumping, clashing, etc. during transportation. The diagonal triangular structure on both sides of the box provides two lateral boards on each side, and the two lateral boards are vertical in texture, which can withstand the tensile and impact forces in all directions and strengthen the lateral strength.



[Figure 9] Impact strength test [Figure 10] Impact strength test of packaging structure of the existing express market of new express packaging structure

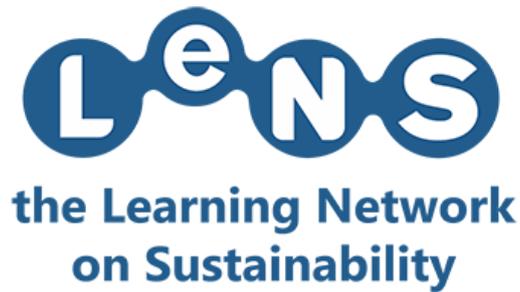
## 6. CONCLUSION

From the perspective of integrated cycle, the new sustainable express packaging design proposes an innovative solution of a new integrated cyclic express packaging design that controls and reduces environmental pollution. Innovative research and development of tenon-and-mortise joint structure design is explored, which is the technique using mutual jointing and interweaving of cardboards by means of tenon and mortise joints according to the physical properties of the corrugated paper. This can ensure the stability of the structure without reliance on tapes, greatly reducing the amount of tapes used, the packaging boxes can be recycled within a limited times, increasing the recycling rate, beneficial to the popularization and realization of social sustainability, thus ushering in a development road to ecological benefits. At the same time, the entire life cycle is beneficial, safe and healthy to individuals and society. In the industrial cycle from cradle to cradle, efficient recycling and utilization can be achieved from the raw materials acquisition, manufacturing, transportation and recycling.

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## **8. DESIGN FOR SUSTAINABLE TECHNOLOGIES AND RESOURCES**



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## **INTERACTIVE DESIGN STRATEGY FOR SUSTAINABLE BEHAVIOR CHANGE BASED ON OPEN SOURCE HARDWARE**

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### **ABSTRACT**

In order to cultivate students' environmental awareness and sustainable design thinking, and try to guide users' sustainable behavior through design. First, typical environmentally friendly interaction design cases are collected and divided into corresponding intervals of behavioral influence based on the product influential types framework. Then, the multi-sensory experience map and user experience five levels are used to explore the relationship between behavior influential types and key interaction design elements. Through case analysis, the design strategies of different types of behavioral impact are summarized. Finally, based on open source hardware Arduino and sensors, intelligent interactive products are designed. The effectiveness of the design strategy is verified and optimized by curriculum design and exhibition. And the feasibility of carrying sustainable education training mode in intelligent interaction design is also verified.

Key Words: Behavior Change, Interactive Strategy, Arduino, Environmental Protection

**1. INTRODUCTION**

Design for sustainable behavior (DfSB) is an important part of sustainable design (De Medeiros, Da Rocha & Ribeiro, 2018). DfSB involves the application of design strategies, which attempt to influence users behavior to achieve more sustainable behavior when the products are used (Lilley 2009). Users play a fundamental role to influence the environment in the process of using products. It can obtain environmental benefits by changing users' behavior and the way they interact with products. And the DfSB strategies can be used by designers to shape personal perception, learning and interaction when applied to the interface between a user and the product. (Tang and Bhamra 2009).

More than 100,000 Chinese design students graduate each year. It is a positive solution to the global problem about climate change and environmental deterioration by cultivating students' environmental awareness and sustainable design thinking, and guiding users' sustainable behavior through design. Especially in the era of intelligence, how to give meaning to the product and how to make the "Product-Human-Environment" harmonious by innovative interaction is the problem that designers must think about. Therefore, based on the relationship and significance between products and people, this study will guide students to collect, classify and analyze environment-friendly interactive design cases, and cultivate their sustainable design thinking. Summarize design strategies that have different impacts on behavior, apply and verify them in design, and try to guide sustainable behavior through design.

**2. BEHAVIORAL CHANGE RESEARCH METHODS IN INRERACTION DESIGN**

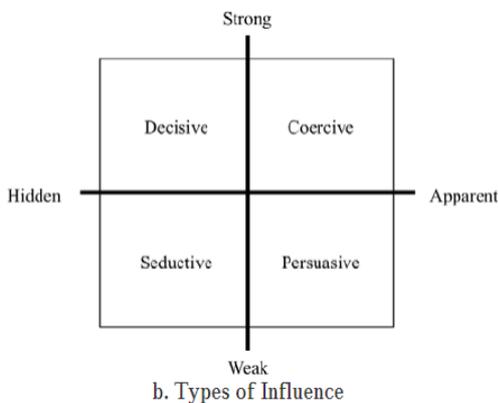
**2.1 The Relationship Between Behavioral Change and Interaction Design Strategy**

Behavior Change is the audience changed in behavior after receiving media information. B.J. Fogg (2002) proposed "persuasive technology" that products can be designed to stimulate people to change their behavior and attitudes. Thaler and Sunstein (2009) believed that such intervention is beneficial to product "nudge" users to make desirable decisions. Therefore, interactive product design plays an important role in user behavior change (Zachrisson & Boks, 2010).

Malaysian scholar Wan Nooraishya (2018) has shown that successful persuasive technology is based on the positive experience of user interaction. Dutch scholar Raub Thomas(2018) believes that good experience and positive feelings of products can affect the user's subconscious and make it more likely to repeat the same behavior. So the user experience of products is an important factor for users to change their behavior motivation. This study uses user experience to judge the short-term persuasive effect of interactive design works. The impact of user experience-centered interaction design strategy on behavior change is the focus of this paper.

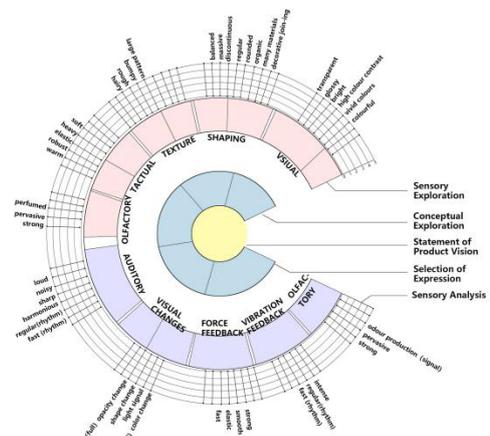
**2.2 The Relationship Between Behavioral Change and Interaction Design Strategy**

Nynke Tromp and Paul Hekkert et al. (2011) divided the degree of influence on behavior using two dimensions of "strong or weak" and "explicit or implicit" according to the expected effect of products on user experience, and Type of Influence framework is proposed (Figure 1). Based on two dimensions of exerting influence, four types of influence on behavior is distinguished: coercive, persuasive, seductive, and decisive influence. Italian scholar Serena Camere et al. (2018) proposed The Experience Map (Exp Map), the structure of the Exp Map is composed by five steps (Figure 2): Statement of Product Vision, Conceptual Exploration, Selection of Expression, Sensory Exploration, Sensory Analysis. The stepwise process assists designers in materializing conceptual ideas. Bernd Schmitt (1999) classifies consumers' experience in purchasing or using products into five categories: Sense, Feel, Think, Act, and Relate. Combining the three theories and methods, we can form a complete research path from "Classification of Behavior influence types - Factor Decomposition of Interactive Design - Behavior Evaluation" in the study of sustainable behavioral change interactive design strategy.



14) Source: Tromp, Hekkert, & Verbeek (2011)

[Figure 1] Type of Influence



[Figure 2] The Experience Map



**3.3 Design Strategy Extraction**

30 design cases with the theme of “garbage collection” are studied as samples, data statistics are conducted on the characteristics of interaction design elements of each product with behavior influence type and the proportion in each level of multi-sensory experience map, forming a general design strategy, as shown in table 1. According to the actual needs, such characteristics can play a guiding role in the design of environmentally friendly interactive products.

[Table 1] Key design characteristics and strategies for four types of behavioral impact

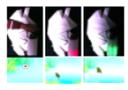
Type of influence	Main Characteristics		Reference Strategy
Coercive	Relate Layer	cultivate the behavior habit of garbage recycling	The product mainly uses the pressure sensor to interact with the user’s delivery behavior, and requires the user to get some reward or avoid punishment by delivering garbage through the change of interface information, so that the user feel excitement.
	Think Layer	require users to deliver garbage	
	Sense Layer	visual interaction (change of interface information)	
	Feel Layer	excitement;	
	Act Layer:	delivery	
Persuasive	Relate Layer	cultivate the behavior habit of garbage recycling; persuade users to deliver garbage	Products usually make infrared, metal, ultrasonic sensors reduce the difficulty of user’s delivery behavior, and through its visual changes, give users a relaxed feeling, persuade them to deliver garbage.
	Think Layer	reduce the difficulty of delivery behavior	
	Sense Layer	visual interaction (light, pattern, shape change)	
	Feel Layer:	relaxation	
	Act Layer	throw; touch; tread; press	
Seductive	Relate Layer	cultivate the behavior habit of garbage recycling; inform the bin sitting position	The products mainly use photosensitive sensors, through visual and olfactory changes and special appearance, attract users’ attention. They are curious and told the location of the dustbin.
	Think Layer	attract the user’s attention	
	Sense Layer	visual and olfactory interactions (light and odor changes)	
	Feel Layer	curiousness	
	Act Layer	delivery; Play	
Decisive	Relate Layer	cultivate the behavior habit of garbage recycling	The products use laser radar, pressure transmission, infrared and other sensors to monitor the specific behaviors of users such as “delivery; pressing; waving” and generate corresponding visual and auditory feedback, which brings a good experience to users and reach the purpose of encouraging users to adhere to the behavior or to persuade users not to litter.
	Think Layer	encourage users to deliver garbage;advise users not to litter	
	Sense Layer	visual and auditory interaction (position, color and sound changes)	
	Feel Layer	pleasure	
	Act Layer	delivery; pressing; waving	

**4. DESIGN PRACTICE**

**4.1 Conceptual Design**

In order to make the design work effectively promote the change of user behavior, the students are guided to use the design strategy of 3.3 to carry out innovative design, investigate the user experience of the design work through the exhibition, and further improve the design strategy. The teacher and the students respectively carried out 4 rounds of design exchanges, completed the design of environmentally friendly interactive products.

Referring to the design strategy, students designed 10 environmentally friendly intelligent interactive products. The typical work “Frog Frell” (Fig.6 ) uses a decisive behavior influential strategy. It is a device design for recycling used batteries. When the user puts the battery for the first time, the light of the recycling box changed, and the electronic display showed that the user was rewarded with a small frog. As users put in more batteries, frogs grow up. Another typical design work, “Wall-E Robot” (Fig.6) uses seductive behavior influential strategy. It is a garbage collection robot. After the robot is powered on, the small arms on both sides are swinging up and down, attracting users to throw garbage.

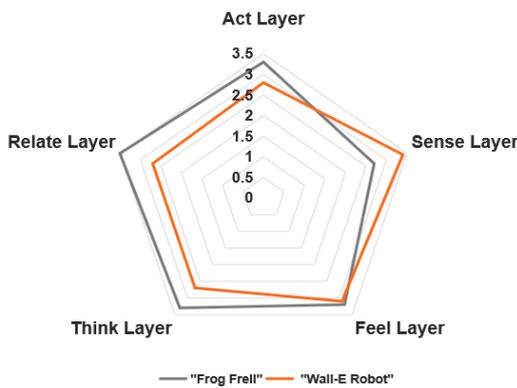
	Relate Layer	Think Layer	Feel Layer	Sense Layer	Act Layer
 "Frog Frell"	To cultivate battery recycling behavior habits	With rewards, encourage continuity	HappyExcitement	 With light signal, color change	Throw
 “Wall-E Robot”	To cultivate the behavior habit of garbage recycling	Attract attention, inform trash bin location	Curious	 Visual Interaction - Position Change (Arm Swing)	Throw

[Figure 6] Design work analysis

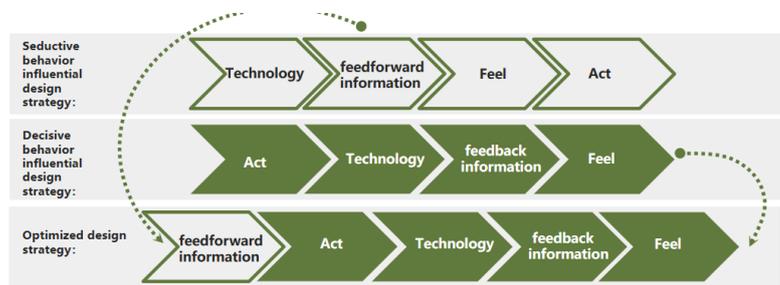
#### 4.2 Design Verification

In order to test the effectiveness of the products designed by the design strategy to guide the behavior change, the design works were displayed on-site, and the short-term persuasion effect of the interactive products was evaluated according to the experience of the audience using environmentally friendly interactive products. Taking “Frog Frell” and “Wall-E Robot” as examples, a total of 20 users (9 males and 11 females) were invited to rate the five experiences of a product from 5 to 1. Finally, the scores of 20 tested users are counted, and the average of the experience level scores from the design cases is obtained. The radar chart is shown in Fig. 7. The area covered by light grey is larger, the integrated user experience for the design work “Frog Frell” is better. The integrated user experience score of the design work “Wall-E Robot” is lower than that of the work “Frog Frell”, but the user experience score at the act layer is higher, the act experience is better.

Based on user interviews and evaluation of interactive devices, the research further compares the use of relevant elements from the seductive and decisive design strategy, and hopes to optimize the design strategy to create a better experience for the user. The sense characteristics of a product with good experience should be attractive in the first place. Then, the operation of the product needs to be intuitive and simple. At the same time, the sensor can monitor the interaction behavior in time. In the process of operation, through sense feedback to give users a pleasant act experience, so that users can emotionally resonate with the product, and finally encourage users to stick to use it.



[Figure 7] Design case scores for each level of experience



[Figure 8] Strategy optimization

Based on the summary of the above characteristics, this study further defines and analyses the design strategy in the time dimension. The information received before user interaction is defined as feedforward information. The information received by the user after completing the interactive action is defined as feedback information. By decomposing the seductive and decisive behavior influential design strategy factors into time dimensions, it is found that the two design strategies differ in the order of using process, and ultimately optimize the interaction behavior influential design strategy, as shown in Figure 8. Optimized design strategy is a relatively standardized and effective interactive product design process based on the change of sustainable behavior, which is modified according to the actual user experience.

In order to investigate the effectiveness of the teaching mode, after the end of the course, a follow-up interview was conducted with the students. 79.63% of the students have improved their environmental awareness. Most of the students expressed that the process of case collection and analysis can effectively guide them to think about environmental issues from personal behavior to social level, and understand the design concept of environmental friendly interaction to promote environmental sustainable development. The experience map is helpful to analyze the user experience of environment-friendly interactive products from the perspective of users and designers, and make the design ideas perfect and concrete. This proves that the feasibility of integrating sustainable education model into intelligent interactive design based on design process and the use of Aduino tools.

#### 5. CONCLUSION

Under the theme of sustainable environmental protection, environment-friendly intelligent product design by using Arduino and other intelligent hardware technologies is an organic integration of behavior change theory and design expertise, which has high teaching significance. Through case analysis, the design strategies of different behavior influential types are summarized. Students refer to the design strategy to complete the prototype production of interactive devices. Through the exhibition, the effectiveness of the design strategy to guide the user’s environmental behavior is verified by comparison, avoiding the traditional theoretical concept design. At the same time, the design strategy is optimized, the feasibility of carrying out sustainable education training mode in intelligent interactive design is verified.

The experience of site design works has a transient effect on the behavior and consciousness of potential users. The formation of behavior habits is a long-term process of behavior change, Through the design work, we will continue to track and compare the changes of user awareness and behavior, and optimize the design strategy, which will be a further research direction in the future.

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## **DESIGN-DRIVEN STRATEGY FOR THE SUSTAINABLE TEXTILE HERITAGE COMMUNITY IN CHINA**

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### **ABSTRACT**

The people who involved in the heritage community can represent the local identity and traditional knowhow is the key element for sustainable development in using the local resources and heritage knowledge (Faro convention, 2005). In this context, the design intervention is considered a strategy to empower the local people innovation processes connecting skills and knowledge and creative resource in order to build a sustainable social innovation and create new values for heritage communities. However, a research opportunity has emerged during the Ph.D. research in the field of Chinses textile heritage: even if people believe innovation is the way to revive traditional textile craftsmanship, there is no systematic activation model that can not only recognize the values of the textile crafts, but also sustain the craft community's capabilities and behaviors. In this scenario, based on design activation methods and a strategy with hypotheses of solutions, this paper describes a new approach applied to the sustainable textile heritage communities.

Key Words: Design activation method, Sustainable community, Textile heritage.

## 1. SUSTAINABLE DEVELOPMENT IN THE TEXTILE/FASHION SECTOR

The topic of sustainable development in the fashion sector has acquired an increasing relevance in the last decade: from one hand, it has become crucial for fashion brands to show a corporate social responsibility. Textile enterprise such as Euro Jersey<sup>1</sup> made lots of efforts on sustainability from environmental point of view to the economic and social responsibility. Luxury fashion brand like Gucci<sup>2</sup> are also following Kering's sustainability strategy<sup>3</sup> for reducing environmental impacts, valuing the people who make products as well as supporting communities, and new solutions by applying technical innovation. In this respect, significant policies are promoted at national level on sustainable development in fashion and textile field for example, 'The Manifesto for the sustainability in Italian Fashion', by Camera Nazionale della Moda Italiana, "aims at designing an Italian way to a responsible and sustainable fashion as well as fostering the adoption of models of responsible management throughout the fashion value chain to the benefit of the economic system of the whole country"<sup>4</sup> and fashion consultancies like Green Strategy are supporting companies with sustainable fashion strategies<sup>5</sup> and talk about circular fashion<sup>6</sup>.

From the other hand, on the academic scientific research side, based on the analysis of Web of Science<sup>7</sup>, in the scientific topic related to "Fashion" and "Sustainability" a considerable increase occurred from 2014 till 2018, and simultaneously, the rate of the topic related to "Textile" and "Sustainability" was also sharply going up from 2014. It is also noticeable that the discussion of fashion and textile sustainability moved from more environmental friendly/eco-friendly production processes to the themes of long-lasting duration, recycling, responsible consumption, and economic growth, that is a cultural and social sustainability too. Therefore, approaches based on fair work, traceability, transparency, community development and so on have been adopted by many fashion brands<sup>8</sup>.

However, for some traditional fashion and textile craftsmanship is hard to survive in contemporary society and face those cultural and social sustainability issues. Given this, the research is concerning how to understand the current situation of textile heritage and practices within Chinese community, thus, towards a sustainable future of long-lasting textile craftsmanship innovative development, and a growing economy.

## 2. A DESIGN-DRIVEN FRAMEWORK OF SUSTAINABLE AND DISTRIBUTED SOCIAL INNOVATION FOR ACTIVATING HERITAGE COMMUNITIES

In order to support a cultural and social sustainable development for craftsmanship and heritage communities, the theoretical background provided by the "Design driven active-action strategies of typical knowledge" developed within the Design and Culture sector of the Design dept. of Politecnico di Milano, offer a sustainable approach that looks promisingly transferable to textile and fashion crafts communities in China. This approach is based on the fact that in order to be preserved, the typical knowledge needs to be continuously practiced, performed, taught and socialized, in other words, "activated" (Lupo, 2011) balancing the conservation of the original cultural values with contemporary interpretations in new design products and processes through identification/acquisition, conservation/documentation, and transmission/fruition (Lupo, 2008). While regarding the environmental impact of traditional textile crafts, most textile craftsmanship is often considered as eco-friendly because of the good use of natural material, the cultural sustainability is sometimes being neglected, because even if some textile heritage community and their traditional production and craftsmanship are the core spirit of a brand, they are not explicitly recognized and empowered by the collaboration. Though, there are some cases trying to empower the artisans' traditional skills and knowledge. For instance, the GuateMaya<sup>9</sup> project launched by Pacunam Foundation recognised that "Preservation of culture is key to Guatemala's sustainable development", and "Artisanal craftsmanship represents one of our key assets, and an incredible development opportunity."

During the research of textile heritage in China, we found that even if from the top-down to the bottom-up, local government, scholars, entrepreneurs, designers, and craftspeople believe that innovation is the way to revive traditional textile craftsmanship, there is no systematic activation model that can not only recognize the values of the textile crafts, but more importantly, can also continue the related community's capabilities and behaviours.

The main purpose of applying this design-driven framework is considering the process of sustainable development of Chinese textile heritage from unveiling to activating. The Identification/Acquisition is the unveiling and visualising procedure for enabling the craftspeople and the masses' awareness of the importance of textile heritage. The conservation/documentation is documenting and re-using the absorbed knowledge from upper step. And final-

<sup>1</sup> <https://www.sensitivefabrics.it/sustainability/>

<sup>2</sup> <https://eco-age.com/news/gucci-president-ceo-marco-bizzarri-unveils-culture-purpose-sustainability-plan>

<sup>3</sup> <https://www.kering.com/en/sustainability/our-strategy/>

<sup>4</sup> [https://www.cameramoda.it/media/pdf/manifesto\\_sostenibilita\\_en.pdf](https://www.cameramoda.it/media/pdf/manifesto_sostenibilita_en.pdf)

<sup>5</sup> <http://www.greenstrategy.se/sustainable-fashion/seven-forms-of-sustainable-fashion/>

<sup>6</sup> <https://circularfashion.com>

<sup>7</sup> "TS=Fashion" AND "TS=Sustainability" and "TS=Textile" AND "TS=Sustainability", [http://apps.webofknowledge.com/CitationReport.do?product=WOS&search\\_mode=CitationReport&SID=C1QbhPSeXRr3kj1PWvf&page=1&cr\\_pqid=1&viewType=summary](http://apps.webofknowledge.com/CitationReport.do?product=WOS&search_mode=CitationReport&SID=C1QbhPSeXRr3kj1PWvf&page=1&cr_pqid=1&viewType=summary) and [http://apps.webofknowledge.com/CitationReport.do?product=WOS&search\\_mode=CitationReport&SID=C1QbhPSeXRr3kj1PWvf&page=1&cr\\_pqid=13&viewType=summary](http://apps.webofknowledge.com/CitationReport.do?product=WOS&search_mode=CitationReport&SID=C1QbhPSeXRr3kj1PWvf&page=1&cr_pqid=13&viewType=summary)

<sup>8</sup> <https://eco-age.com/eco-age-principles>

<sup>9</sup> <https://eco-age.com/news/livia-firth-guatemala>

ly, transmission/fruition is important to create resilience and sustainable collaborative/participatory processes that interact with different stakeholders.

### 3. THE RESEARCH OF CHINESE TEXTILE HERITAGE

Back to the history, China's textile heritage had a flourishing time and impacted also the European textile culture through the old Silk Road. Textile arts and crafts in the past did not only represent the fashion or a typical knowledge in a period of Dynasty, but the aesthetic of textile craft can also picture a group of ethnic people, because it is the result of a specific culture and society. However, like many other traditional craftsmanship, textile heritage is endangered even if there are protection initiatives released by local government and UNESCO. In China, the official recognition of textile heritage starts from 2006, and the study about textile heritage and costume begins even earlier. But these actions cannot stop the situation that the traditional craft is hard inheriting to the young generation and also losing the meaning to crafts community.

An official list provided by China Textile Intangible Cultural Heritage Office illustrates that there are 86 traditional textile arts and crafts recognized as national textile heritage. In order to systematically unveil the situation of Chinese textile heritage and discover some solutions for sustainable development, during the research in the field of Chinese textile heritage we classified the 86 textile heritage:

- Based on four regions (Eastern, Central, Western, and Northeast China) for analysing the similar geographical conditions and cultural impacts.
- Based on textile fibre (Plant-based fibers and Animal-based fibers) for analysing the textile raw material resource based on the natural causes.
- Based on the types of textile heritage: 1) Weaving Technique such as Nanjing Yunjin brocade; 2) Embroidery Skill such as Xiang embroidery; 3) Printing and Dying Skill such as Nantong blue calico; 4) Primary Textile Material Making such as Ramie cloth making technique; and 5) Ethnic Costume such as Li ethnic costume, for analyzing the typical knowledge and skills.

We used eight parameters (Cultural, Social, Geographical, Temporal, Economic, Aesthetic, Technical, and Intellectual<sup>10</sup>) for deeper analysing the certain and uncertain value of the textile heritage.

We also identified stakeholders and innovators (Craftspeople, Government, Institute, Museum, Designer and Artist, Non-government-organization, Studio and Workroom, Industry, Tourism and Handicraft market) for analysing the knowledge owners and active-action participants.

After this phase of unveiling the textile heritage knowledge in China, we can understand which can be the factors supporting sustainable development, and which sustainable innovation strategy can activate the craft heritage and heritage community, from the next two phases of conservation/documentation and transmission/fruition.

#### 3.1. Case study

We selected, from each one of the four areas, two cases that are most representative and/or uncertain.

1. Eastern China<sup>11</sup> is the most developed area in China in the field of textile heritage. This area includes the political centre Beijing and economic centre Shanghai. Most of the regions are the coastal or near coastal area: this localisation brings a massive opportunity for export and import which means an intense development of the textile industry and fashion manufacturing. To this areas belong also some historical skilled and developed textile craftsmanship like Li cotton textile technique and other textile-related crafts. The cases for this region are: Nanjing Yunjin Brocade and Li Textile techniques. Both of the heritage are not only famous in China but also well-known in the world.

- Silk-making has a significant history in Jiangsu and Zhejiang province<sup>12</sup>, and Yunjin Brocade is one of the most brilliant representative form of silk product: it is highly considered by local government, it has been supported and promoted as a symbolic cultural and traditional craftsmanship abroad. Even fashion designers<sup>13</sup> try to transform this heritage into modern form, but aesthetic stereotype still hesitates in an initial innovative step.
- Li textile techniques is defined as intangible cultural heritage by UNESCO<sup>14</sup> and is a positive example of sustainable development by the good use of local natural condition but has been less supported from contemporary design practice. Therefore, even if its knowledge and skills represent Li ethnic group's culture and religion, the textile techniques is facing the issue of lack of inheritor. The main reason is because Li eth-

<sup>10</sup> During the research of the unveiling, the valuing parameters are crucial for studying the challenge and opportunity for sustainable development. Cultural represents the value of the textile heritage's distinct cultural history and traditions; Social represents the specific community of craftspeople and the group of ethnic minority; Geographical represents the typical area, territory resource, and natural environment; Temporal represents the history duration from the origin; Economic represents economic benefit from raw fiber materials to the end market; Aesthetic represents the artistic value such as designs, colours, and compositions of the decorative patterns; Technical represents the technique of handicraft and the use of traditional instrument; Intellectual represents the possibility of applying the machine and digital technology.

<sup>11</sup> Including Beijing, Tianjin, Hebei Province, Shandong Province, Jiangsu Province, Shanghai, Zhejiang Province, Fujian Province, Guangdong Province, and Hainan Province

<sup>12</sup> Sericulture and silk craftsmanship of China, retrieved from <https://ich.unesco.org/en/RL/sericulture-and-silk-craftsmanship-of-china-00197>

<sup>13</sup> 'Yunjin Brocade Fashion Show held in Milan', Retrieved 2015, from [http://njweek.chinadaily.com.cn/2015-07/16/content\\_21311757.htm](http://njweek.chinadaily.com.cn/2015-07/16/content_21311757.htm)

<sup>14</sup> Traditional Li textile techniques: spinning, dyeing, weaving and embroidering inscribed in 2009 (4.COM) on the List of Intangible Cultural Heritage in Need of Urgent Safeguarding, <https://ich.unesco.org/en/USL/traditional-li-textile-techniques-spinning-dyeing-weaving-and-embroidering-00302>

nic minority customs are assimilated by modern lifestyles, and the younger generation is looking for more promising job instead practicing the leftover textile technique (Luo, 2008).

2. Central China<sup>15</sup> is inland plain, the environment condition is good for the textile plant-based fibres such as cotton and ramie. In ancient time, this area was the origin of Chinese civilization and stimulated the textile aesthetic development. The cases are: Xiang embroidery and Ramie cloth.

- Xiang embroidery is a general name for the embroidery products which arise from and are mostly produced at Changsha, Hunan Province, with distinct characteristics of Chu culture. Although it is regarded as one of the four most distinguished embroidery styles in China (together with Suzhou embroidery, Sichuan embroidery, and Cantonese embroidery), similar to Yunjin brocade the innovation level stays in the traditional style without many breakthroughs.
- As a promising ecological fibre, ramie has been grown in China for many centuries, and farmers in ancient China are known to have used the fibre to weave clothing. Now China still leads the production and exports of ramie in the world<sup>16</sup>, and Jiangxi and Hunan Province is one of the four major ramie producing areas in China. Especially the post-processing is mature in this area, but the newest design and making technique are imported from Korea and Japan. And the two countries had already successfully declared the traditional ramie making technique as ICH in the list of UNESCO<sup>17</sup>.

3. Western China<sup>18</sup> is the largest area in China. Even though there are three megacities in this area, due to the big land area, the population density is the lowest compared to the other four areas. Animal husbandry source is rich in Inner Mongolia and Xinjiang, it indicates that this area is rich of animal-based fibres such as wool and cashmere. Except for animal-based fibres, Xinjiang also holds half of the total production of cotton in China. But still, there are many regions that are plateaus, desert, and underdeveloped because of the harsh natural environment. There is the most significant amount of the ethnic minority communities in this area, and it has the largest number of textile heritage with extraordinary textile crafts and ethnic costume arts. The case are: Uyghur textile heritage and Miao textile heritage. This two ethnic minority textile craftsmanship heritage contain several types of textile craftsmanship.

- Uyghur textile heritage includes Uyghur traditional costume, Uyghur embroidery, Uyghur felts, weaving and dyeing technique, Uyghur Etles Silk dyeing technique, and Uyghur Pala Zi weaving technique. All of these traditional crafts are the “fruits” of Xinjiang Uyghur ethnic people’s cultural history, ethnic habit, and use of territorial resource. Thanks to the natural condition, there are many advantages for textile industry and textile heritage’s development. However, lots of the rural districts and undereducated situations also cause these heritage stuck in an urgent protection position. Moreover, as the modernization influence of this area, the traditional craftsmanship is no longer the necessary living skill. Therefore, even there is traditional craftsmanship station<sup>19</sup> towards embroidery, it is not considered by local people.
- Similar to Uyghur textile heritage, Miao textile heritage is also the result of ethnic culture and habit with good use of natural resource. Its contemporary practices are much more developed: not only redesigning the arts and crafts’ elements<sup>20</sup> but also reusing the traditional technique and costume structure principle (He & Li, 2018) bringing them to modern life.

4. Northeast China<sup>21</sup> is a severe cold area especially in winter, and the bad natural condition is constraining the production of textile raw material of plant-based fibres and animal-based fibres. However, there are rich forests and mineral resource, and from ancient time to modern, this area had many immigration flows, and became China’s most significant industrial base after 1949. The cases are: Manchu embroidery and Hezhe traditional fish skin costume.

- Manchu embroidery can indicate the primitive art that retaining the Manchu original thinking structure and the original shape of Manchu culture. Inheritance of Manchu embroidery is mainly inherited within the family, which the elder generation hand-to-hand teach the next generation. It seems like the situation as Li textile heritage, however, the endangered status is much more than that, due to the lack of successors.
- Hezhen traditional fish skin costume is not included in the list of textile heritage but as a type of traditional craftsmanship, it is listed in the first batch of National intangible cultural heritage. Fish skin culture is one of the distinctive cultures within the region above 45 degrees latitude. Because the economy of Hezhe people living there was based on fishing (Jernakov, 1972), in China, only the Hezhe tribe (living in Heilongjiang Province) inherit the fish skin culture. Traditional fish skin craftsmanship includes a complex set of processes that were used by the Hezhe women in the past. Before the 1950s, most of the Hezhe people loved to wear garments made of fish skin. Later, due to the complicated production process, high cost, and other reasons, is gradually being replaced by other materials, and such conventional technology has gradually lost.

<sup>15</sup> Including Shanxi Province, Henan Province, Anhui Province, Hubei Province, Hunan Province, and Jiangxi Province

<sup>16</sup> Ramie, International year of natural fibers, retrieved from <http://www.naturalfibres2009.org/en/fibres/ramie.html>

<sup>17</sup> Weaving of Mosi (fine ramie) in the Hansan region inscribed in 2011 (6.COM) on the Representative List of the Intangible Cultural Heritage of Humanity, <https://ich.unesco.org/en/RL/weaving-of-mosi-fine-ramie-in-the-hansan-region-00453>; and Ojiya-chijimi, Echigo-jofu: techniques of making ramie fabric in Uonuma region, Niigata Prefecture inscribed in 2009 (4.COM) on the Representative List of the Intangible Cultural Heritage of Humanity, retrieved from <https://ich.unesco.org/en/RL/ojiya-chijimi-echigo-jofu-techniques-of-making-ramie-fabric-in-uonuma-region-niigata-prefecture-00266>

<sup>18</sup> Includes Inner Mongolia, Ningxia Hui Autonomous Region, Shaanxi Province, Chongqing, Sichuan Province, Guizhou Province, Guangxi Zhuang Autonomous Region, Yunnan Province, Gansu Province, Qinghai Province, Xinjiang Uygur Autonomous Region, and Tibet

<sup>19</sup> The first traditional craftsmanship station launched in Hami, Xinjiang: <http://www.ihchina.cn/11/18669.html>

<sup>20</sup> ‘Miao’s creativity inspired haute couture designers’, <http://thefashionabletruth.com/miaos-creativity-inspired-haute-couture-designers/#.XGWL1s9KhPM>

<sup>21</sup> This area is sometimes taking account the east part of Inner Mongolia due to the geographical location, but, in order to classify the textile heritage distribution based on similar living habits and natural conditions, here, Northeast China includes only the province of Heilongjiang, Jilin, and Liaoning.

#### 4. THE SPECIFIC FRAMEWORK FOR ACTIVATING THE TEXTILE HERITAGE

Based on the area analysis and case study, the influencing factors that control Chinese textile heritage's development from ancient time to the present are: Cultural history; Living habit and ethnic characteristics; Geographical circumstances and resources; Economic basis; and Political policies and initiatives. All of these factors have a mutual influence and impact in a distinct textile heritage. These factors can also restrain the sustainable development of each textile heritage in the contemporary context, especially when considering the changing of the social and natural environment and the limit of the creative resource.

Hereby, by applying the design-driven framework, the research can answer the questions: How to keep the textile heritage alive when the knowledge is far away from the masses; How to empower the capability of craftspeople when traditional crafts are no longer the survival skills; and How to stimulate the heritage community when crafts and ethnic groups are losing inheritor.

##### 4.1. The role of stakeholders and innovators

The stakeholders and innovators play different roles in each of the phases of the a sustainable innovation framework of unveiling-activating Chinese textile heritage (from identification/acquisition, conservation/documentation, to transmission/fruition).

In China, 'Revive the Traditional Craftsmanship' has been announced as a governmental initiative in 2017<sup>22</sup>, and the establishment of the official office of textile heritage and textile heritage station started two years before. But despite of the coordination of the whole textile heritage system, there are still many issues to be improved. The information of each heritage is not always easy to find online or even in the field.

Since there are the museums, design institutes, textile industries, and NGO research groups focusing on single textile heritage and/or textile-related craftsmanship, a digital archiving platform could be supported and co-created by several stakeholders and actors as the first step of identification/acquisition and second step conservation/documentation, in order to introduce each heritage as an open-end resource for public. A good example is KOGEI JAPAN<sup>23</sup> website provided by Japanese Ministry of Economy. The purpose of this website does not only identifies the authentic Japanese traditional craftsmanship but also provides a platform for contacting and collaborating opportunity for the crafts' communities.

In the step of transmission/fruition there is no doubt that designer plays an essential role in intermediate the craftspeople's know-how and his knowledge with innovative approaches to crafts through design practice in various aspects, for example by using the alternative materials and appropriate technologies or the definition of new product lines (Sethi, Duque, & Vencatachellum, 2005). However, the reduction of the craftspeople's role to that of a mere producer subservient to the designer's influence, won't be sustainable for the development of the crafts community. Therefore, designer and design practice should pay attention to empowering the craftspeople and related heritage community. A sustainable vision is craftsmen themselves designers and designers themselves craftsmen. In order to achieve this status of craftsman-designer and designer-craftsman, the design and art institute and design industry can communicate and co-design with textile craftspeople through craft learning in the workplace and collaborate workshop in design institute. For instance, Paola Besana<sup>24</sup> (an Italian weaver, designer and textile artist) is working on textile weaving technique's practice, research, and innovation (her studio can provide a system knowledge and skill learning from library collection, loom technique support, to design practice). Through workshop in the design school and co-design activation with museum and even industry, she presented the traditional weaving technique as a contemporary design activity that allows the craftsmanship to apply in a wider range of practices.

#### 5. CONCLUSION

This paper presents the preliminary results of a research on analysing the sustainable development factors of textile heritage in China and proposing the design-driven framework for unveiling and activating the traditional knowledge and craftspeople's capability. The main contribution of this paper are: re-organize the research of Chinese textile heritage by the phase identification/acquisition; illustrate the role of related stakeholders in the activation procedure; and proposing the proper innovation actions example. The research expects that the active-action framework could be applied and impact on the sustainable development of textile heritage community in China. However, at this stage of the research, due to the limits of some of the case studies' desk and field analysis, the knowledge about design activation method for sustainable development might be not totally sufficient or adapt for all cases, and the future study should also structures life-long learning system for craftspeople by co-design methods. Therefore, other example and strategy of design intervention will be explored and tested in the field in further research.

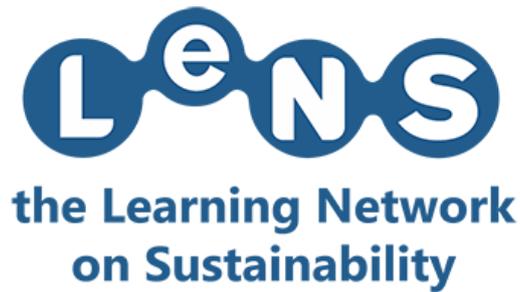
<sup>22</sup> Notice of the General Office of the State Council on Forwarding the Chinese Traditional Crafts Revitalization Plan of the Ministry of Culture and Other Departments, [http://www.gov.cn/zhengce/content/2017-03/24/content\\_5180388.htm?gs\\_ws=weixin\\_636259716732157481&from=groupmessage&isappinstalled=0](http://www.gov.cn/zhengce/content/2017-03/24/content_5180388.htm?gs_ws=weixin_636259716732157481&from=groupmessage&isappinstalled=0)

<sup>23</sup> <https://kogeijapan.com>

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## **EXPLORING THE DESIGN ETHICS OF THE FUTURE INFORMATION SOCIETY: A BRIEF DESIGN ETHICS STUDY OF “DIDI GLOBAL” AS A SOCIALITY INTERNET PRODUCT**

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### **ABSTRACT**

Because of the rapid increase in Internet products, such as smartphone applications, numerous innovative business models have been created, along with some typical, attendant social problems. This is an ethics study and risk assessment of design. “SIP” is an acronym for “Sociality Internet Products.” It was created in this study to explore a new design epistemology point of view. The study shows analysis models of legal research first. Then it provides analysis diagrams and statements of design, including how more indirect stakeholders are related to the system, and it proposes several pieces of supplementary advice to help the future design of business models. Throughout this study, it is important to understand that the sustainability of a commercial product relates not only to capitals and occupancy, but also to a healthy and balanced relationship between citizens, society, and the environment.

Key Words: Design ethics, Sociality Internet Products, sustainable business models, risk assessment of design

## 1. INTRODUCTION

Mobile Internet Products (MIPs) in China have seen a growing number of developments related to Internet finance, and this has quickly resulted in a new, fast-growing, and rapidly-changing industry of service: the mobile Internet products industry. On the other hand, there is not enough productive knowledge or common business principles to help maintain the healthy and sustainable development of these new enterprises. Under the pressure of investments and competitors, many enterprises declare bankruptcy or go offline after a short time, leaving behind a series of problems such as product hoarding, delays in returning deposits, and unemployed workers. Thus, design researchers studying the topic independently and critically can help address the problem, but, more importantly, also increase their influences so that their voices are heard.

## 2. SOCIAL IMPACT OF INTERNET PRODUCTS AND DISCUSSION OF “SIP”

By March 2018, the number of China’s mobile phone users had reached 750 billion. Mobile Internet Products (MIPs) now come in the form of many different applications, or apps. From web pages to mobile devices, Internet products have increasingly gained more direct access to our daily lives. In terms of their basic functions, MIPs can be classified as news, food, shopping, tools, health, education, travel, business, social networks, cameras and photos, games, music, and so on.

### 2.1 Sociality or Social Products?

The concept of “sociality” mainly comes from the fields of philosophy and social science. The research on sociality is mainly focused on the fields of law, sociology, business administration, and accounting. The concept of sociality “is opposite to nature and biology, which is the feature of things developed after participating in social conditions and social relations” and includes features of things formed “in the trend of social development and promoting social progress under the rule of social movement” (Rong Zheng, 2012:33). On the other hand, “social design” is related to social public services. Often regarded as public design, social design “aims at solving social needs,” including environmental and resource protection, food and clothing requirements, and social development issues, as well as solving the needs of the old, the weak, the disabled, and other special groups in various countries (Yu Wu, 2009:17-18). The main purpose of setting up the idea of “social” design is to fill the gap created by the commercial-dominated design markets during the 1970s. However, a MIP is usually a commercial product aiming at making more profits by providing better services and more value to customers. Furthermore, the word “social” often relates to social Internet sites or social Internet services, but the “social influences” discussed in this study (including food, transportation, travel, and residences) are more than social activities and are more closely related to the activities of daily life.

Therefore, Sociality Internet Products (SIPs) are an explorative idea presented by this study to distinguish them from social network applications. SIPs refer to commercial service products that provide solutions to meet demands based on (mobile) Internet technology and have significant shaping ability on society, as well as culture, laws, regulations, the natural environment, and public lifestyles. SIPs are created to illustrate and emphasize the strong and growing power of social influences within some commercial products. It is not created to specify a certain scope or range of things. The sociality, a strong power of shaping society, is a new trend and characteristic that is gradually formed after the birth of a product. This tension between the public and commerce is pretty unique and is very worthy of study.

### 2.2 Features of Sociality Internet Products

The contents or functions of SIPs involve many social aspects: (1) SIPs are widely distributed in both urban and rural areas. (2) SIPs have wide social influences, such as the ability to shape users’ lifestyles and impacts on public transportation, change their ways of consumption, and influence the natural and social environment. (3) SIPs are involved with many industries and organizations, such as enterprises, associations, government departments, schools, and research institutions. SIP industries are related closely to employment, research, technology, and manufacturing. (4) The success of SIPs reflects innovation and development, including technology, science, business, research, and the service industry.

## 3. BACKGROUND OF DESIGN ETHICS STUDIES

### 3.1. Overview of the Development of Design Ethics Studies

The research and study of design ethics is a profound and evolving topic, which includes sociology, ethics, design history, and the philosophy of science and technology. Design ethics is more than a moral code or the ethical principles underlying actions; it is a continuous reflection on design concepts and principles. The literature shows that relevant studies include the reflection or rethinking of theories, the research and study of methodology, and effective knowledge learned through design practice. At every period of a typical social stage, great designers or design thinkers, such as William Morris and Victor Papanek, have put forward design theories in order to face certain social problems, promoting design to meet the demands of more people. For instance, “design for the real world” and design for special groups have been encouraged within the context of market-dominated design strategies, and green and sustainable design theory was formed after severe environmental problems were caused by the domination of traditional industrial production.

Traditional design ethics include kindness, honesty, rationality, equality, safeguarding public interests, respecting individual rights, protecting the ecological environment, and having credibility. In the 21st century, the rise of environmental awareness has meant that designers pay more attention to environmental-friendly principles, regarding human productive activity as a part of the whole system of nature. With the advent of the experience economy and information technology, designers have begun to pay attention to experiences, human-machine relationships, people's values, and the social effects of design. The categories of design studies have expanded to the dimensions of economics, sociology, technology, cognition, and psychology. Overall, more consideration and attention are shifting from the real, physical world to the immaterial, invisible world, consisting of relationships, regulations, and the strength of influences.

### 3.2. Meaning of Design Ethics Study

To study the ethics of design means much more than applying some principles or ideas of what designers should do or follow. Studying the ethics of design involves the continuous exploration and innovation of ideology, which is relevant to designers, scholars, design directors, and even company board members. It is to ensure the sustainable innovation of design value and ensure that sustainable business models are developed. Keenly observing the pain points or providing forward-looking insights will help a product evolve timely and appropriately, avoiding disorientation or blind development.

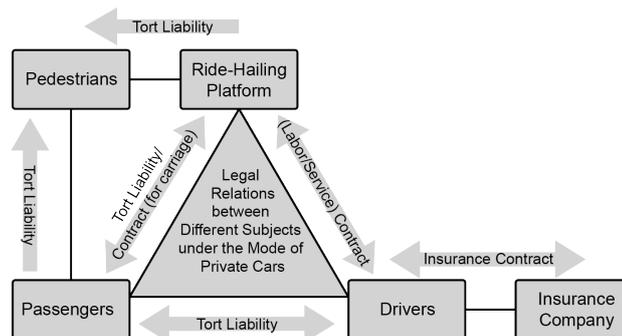
It is essential to study the ethics and values of design because they relate to its voice and influence. In order to continuously expand the influence of designers and the importance of design, people other than designers and scholars should understand the meaning and capability of design. The significance of William Morris's influence is that a profound idea of design can help shape the society, changing the public's perception of design. Meanwhile, studies of principles can provide design practice with clear directions, the red lines that should not be crossed, and the solid ground that one should remain on.

## 4. RISK ASSESSMENT AND DESIGN PROBLEMS OF DIDI

DiDi is similar to Uber, and it is the largest and one of the most important Internet companies providing ride-sharing services. Once a good example of the "Internet +" model, DiDi built up a platform for both private car drivers and passengers, providing them with different ways of sharing unoccupied traffic capacity. However, during the last two years, the innovative business model has encountered severe social problems, such as unemployment, traffic jams, robberies, and murders. After gaining significant growth in terms of market share, DiDi developed a poor reputation due to its neglect of regulations and the inadequate service it was providing.

### 4.1. Stakeholders and Relevant People

From a legal perspective, DiDi as a ride-sharing platform involves many legal subjects, including "passengers, drivers, ride-hailing platforms, insurance companies, pedestrians." Keren Deng's study (Keren Deng, 2018) provides a relational chart of different legal subjects within DiDi's system under the mode of private cars [Figure 1].

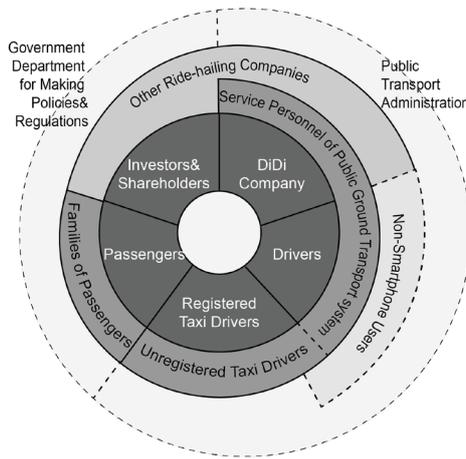


[Figure 1] Legal relations between DiDi's different subjects in Keren Deng's study

On the other hand, from the perspective of creating a decent, responsible service, this study brings more stakeholders and relevant people into the system. Passengers, who are the direct users of DiDi, feel unsafe and anxious when they are inside cars, and this has already led to some social panic. For drivers, who are also direct users, the financial arrangement is not advantageous as DiDi takes a large percentage of their incomes as service fees and provides them with an unsatisfactory service appeal.

Outside the system, different groups of people have been affected as well. It has shaken the traditional taxi industry by causing a large amount of unemployment, and it has also brought a huge extra burden to cities' traffic systems. It has also upset the benign competition of all sharing-rides platforms by attracting millions of drivers into its system with a low entry bar or inadequate checks. Personnel who work within public transportation systems, such as bus drivers and traffic wardens, are facing poorer traffic efficiency and more congestion because DiDi has attracted millions of private car drivers into traffic systems. DiDi's business has also made it more difficult for non-smartphone users to get out and about [Figure 2].

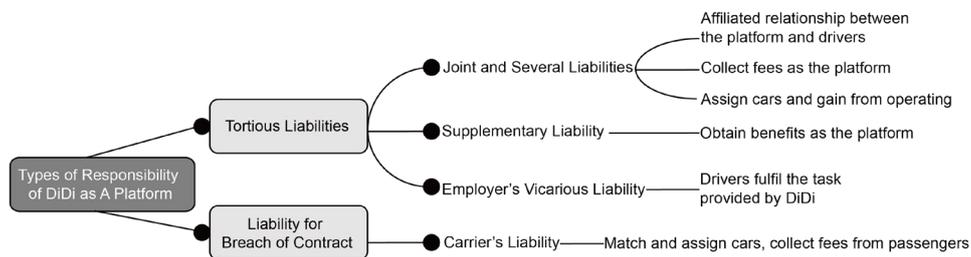
[Figure 2] Stakeholders and relevant people within DiDi's service system according to this study



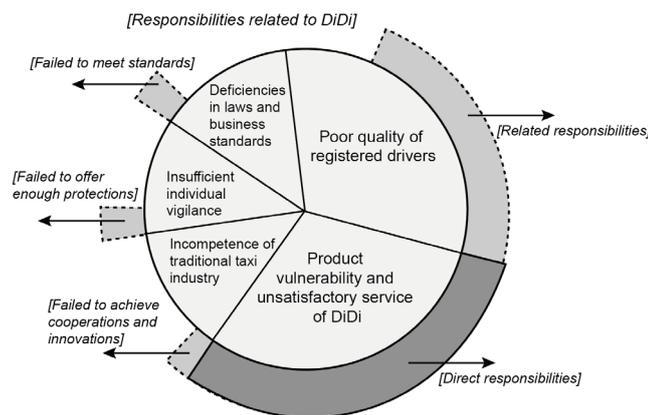
**4.2. Direct and Indirect Responsibilities of DiDi Global**

In Keren Deng’s study, the responsibilities of DiDi as a ride-hailing platform consist of tortious liabilities and liability for breach of contract, which are both presented and sub-classified in the line chart [Figure 3].

[Figure 3] DiDi’s different responsibilities as an online ride-hailing platform



Clearly, DiDi cannot be responsible for all the different types of issues that can arise: some of them come from insufficient individual vigilance and some arise from the deficiencies of traditional taxi industry. Some deficiencies in laws and business standards have led to the current situation as well [Figure 4]. Although the legal liability of DiDi can be described and clarified clearly, the authors believe that there are more responsibilities that DiDi should take on. It has been reported that, in order to expand its market share, DiDi attracted millions of private drivers by conducting few background checks and amidst lax regulations. Research and news reports indicate that people with convictions for burglary and violent behavior, who are not appropriate for working as personal drivers, passed DiDi’s security checks easily. This kind of fast development in “numbers” is attractive to investors, but it will bring more related responsibilities to DiDi, especially when DiDi is so intimate to the daily lives of the public [Figure 4].



[Figure 4] DiDi’s direct and indirect responsibilities

**4.3. Possible Reasons for DiDi’s Issues**

It is not difficult to conclude that the success of the interfacial design of DiDi is qualified. However, most of its problems have not been caused by the shortcomings of its front-line designers. The authors believe that the main reason is the drive for capital and the skewed preferences of DiDi’s decision-makers, especially when they are choosing the strategy for their interface design. Meanwhile, the authors believe that there is a big possibility that DiDi has been confronted with problems and difficulties that its decision-makers never expected (or even thought about) at the early stage of its planning. As a product acquiring growing social influence, DiDi, like many other Sociality

Internet Products, has failed to meet the unexpected and various demands placed on it from different relationships. With the development of modern business models, it is highly likely that one product system will be involved and interact with another system, taking in more direct stakeholders and more indirect social groups, creating new bonds of relationships and breaking down others.

## 5. NEW SUPPLEMENTARY ADVICE AND SUSTAINABILITY OF BUSINESS MODELS

### 5.1. Supplementary Advice for DiDi

On the basis of the analysis, the authors believe that previous and current design principles that mostly depend on material industry production are not sufficient for tackling modern, intractable problems. Whether the conclusions of this study are productive or not, it is necessary and urgent that some new design strategies are discussed. The authors believe that a social public service product that may or will have a significant impact on society should undergo ethics analysis constantly. In addition to the profit strategy that one company should naturally pursue, these strategies and principles arising from design ethics study would focus on ensuring the personal safety of vulnerable groups, the justice of the market competition, the sustainable development of products, and the stability of society. In DiDi's case, some supplementary suggestions are proposed as follows.

- 1). Principles of "focused equality": This refers to ensuring that every user of a product has equal opportunity and an equal outcome in terms of personal and property safety. Some people are vulnerable because of their gender, age, or disability, while some ordinary people may be forced into an environment that is not favorable to them, and thus they are made to feel vulnerable. This means that in the early stage of design planning, potential vulnerable groups and possible urgent situations should be taken into account, using emergency buttons, quick-response interfaces, a timely and effective response service, and so on. This also means that drivers and passengers would have different interfaces or appeal systems: Drivers are in favor of phone calls while passengers are more protected by using a mute interface.
- 2). There should always be room for sustainable structural adjustment: During the pursuit of financing and listing, having the possibility of a business model transformation (or optimization) is vital, especially for the decision-makers. An unhealthy business model may be attractive for some quick investment in the short term, but it will reveal its problems and lose public favor in the long term, causing a bigger investment failure for stakeholders as well as some unsettling environmental problems.
- 3). Have timely corrections to adjust to the limitations caused by technical rationality: Science and technology are objective and impersonal; however, the way they are used shows the attitudes, responsibilities, and wisdom of design. Internet of Things technology may be a touchstone for mankind to take the next step toward a future intelligent society. Thus, private companies which have strong connections with the public's daily lives should be more dedicated to ensuring that care for the individual and social equity are listed among the core concepts of their design principles.
- 4). Undertaking social responsibilities and exploring new models for the future: Under the premise of globalization, it is clear that the social functions and the public characteristics of future commercial products will become even more significant. In the future, private companies like DiDi should also share the necessary obligation of providing safe public services. A designed business model like DiDi will be able to provide the public with more powers and abilities to shape society from the bottom to the top. Only by taking on corporate social obligations and sustainable strategies of design can private enterprises undergo long-term and healthy development and thus provide wisdom for the future of globalization.

### 5.2. More discussions of the sustainability of business models

This study has revealed the emergence of some new trends within recent design strategies. First, strategies and principles may or will focus on immaterial factors more than on physical material factors. The formation of new relationships and the re-organization of existing relationships are valuable and profitable with the help of the Internet of Things. Second, the design process of a SIP is not only a job for an individual product manager or a group of designers. It is a responsibility shared by all stakeholders, decision-makers, board members, researchers, and designers. Within a company, a vertical design consulting mechanism should be established, extending from top managers to practical designers, in order to allow the value of design ethics to be embedded.

In the discussion of sustainability, more elements and factors such as environmental influences should be included. As a matter of fact, other SIP business models, such as OFO, a bike-sharing software, have already resulted in huge waste in terms of occupying public spaces. Although Internet products belong to a new industry, their operations are, and very likely will be, dependent on one or several other substantial economies. Thus, previous concepts and principles, such as green design and sustainable design, are useful and promising. It is inevitable that automation and artificial intelligence will partially replace some of the work of human labor. The task of design is to lead traditional industries to new spaces of value. Otherwise, if design only protects traditional industry blindly, it will create a wider gap when traditional industry has to meet the challenge of future technology.

## CONCLUSIONS

The sustainability of a business model can be discussed in many ways; this study mainly took the perspective of design ethics and presented a case for why it is important, especially when addressing problems of a Sociality Internet Product. Meanwhile, the authors present a point of view on design ideology by providing the idea of “SIP.” They believe that a SIP’s design relates not only to designers but also to stakeholders, decision-makers, and relevant social groups, all of which share the equal right of receiving a safe public service. By discussing some solutions, this study sought to include the discussion of the sustainable, evolving innovation of design values as well.

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## **GLEBANITE® FOR MODELS AND MOULDS IN SHIPYARDS APPLICATIONS RATHER RESORTING TO MONOMATERIC SOLUTIONS**

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### **ABSTRACT**

Despite the recovery of the boating industry today, the crisis in the field sector has brought with it a great amount of boats and related obsolete production equipment (Marsh, 2013). The Glebanite® project aims to create a possibility for all these products considered waste, giving a clear answer to the problem of their disposal, with particular attention to fiber-reinforced composite materials. The project presented aims to trigger a Circular Economy process for the generation of a new recycled and re-processable materials and for a new economy to support recreational boating.

The project has as its starting point the engineering and systemization of the Glebanite material (secondary raw material derived from GRPs waste) for an innovative production strategy of nautical shipbuilding equipment through the use of CNC machine. The project thus straddles the main areas of Eco-Industry, Advanced Manufacturing and Sustainable Mobility.

Keywords: Composite Materials, Eco-industry, Circular Economy, Marine field.

## 1. INTRODUCTION AND LITERATURE REVIEW

The project starts working in the yachts field with the aim of improving the environmental performance of boats and their production tools, reducing the use of resources and emissions throughout the entire life cycle and generating a Circular Economy system that cuts down the costs for boats disposal and of all end-of-life GRP products (Marsh, 2013).

The project thus straddles the main areas of specialization Eco-Industry, Advanced Manufacturing and Sustainable Mobility. The project envisages as a starting point the use of Glebanite® material for the definition of a strategy for the production of molding tools for composite products. Glebanite® is the second raw material deriving from the recovery of fiberglass products. The use of this material for the creation of production tools of the same composite materials aims to close the circle of industrial production with a view to a continuous Circular Economy (Bonaiti, 2017). Currently, the molds for composite material are created from raw materials and assembled with the aid of metallic frames. The use of panels in Glebanite® positioned and assembled using nesting solutions would allow complete recyclability of the tool at the end of its life cycle (E. Luttersa et al., 2012). To date, Glebanite® is obtained by grinding the production waste and/or fiberglass manufactured articles at the end of their life. The obtained inert, of different granulometry, is loaded with polyester resin, vinylester or epoxy, depending on the derivation of the inert material, and then passed through a rolling mill or a mold under press or an extruder. Through these three production processes, panels of the desired dimensions are obtained with a recycled filler charge equal to 60%; the remaining 40% is a resin of current production (polyester, vinylester or epoxy).

## 2. FIELD OF APPLICATION

The objective of the Glemould project is the generation of innovative solutions in the use of composite materials for boating through the validation, technology transfer and up-scaling of advanced techniques and materials already subject to research and applications in other production sectors (Summerscales et al., 2016).

With the Glemould project it is therefore intended to demonstrate that the decommissioned vessels, but more generally the molds in GRPs at the end of their life cycle, can be re-introduced into the nautical production chain. By that, it's possible to generate a virtuous Circular Economy which will not only tend to eliminate the molds and boats being divested, but will create a new microeconomics to support recreational boating (Bonaiti, 2017).

## 3. LIFE CYCLE ASSESSMENT & LIFE CYCLE DESIGN

Specifically, the methodologies applied were those of Life Cycle Assessment for the assessment and quantification of environmental benefits and Life Cycle Design for the design and continuous improvement part. Concerning to the state of the art in the maritime field, it is worth highlighting the current lack of an optimized end-of-life management system for abandoned marine products and waste materials generated along the supply chain. The causes of this criticality are different and can be traced back to various factors. Among these factors, the lack of valorization of the second raw material has a significant weight. To date, also due to the intrinsic complexity of the characteristics of the composite materials, knowledge is lacking for the launch of an efficient recycling chain.

Through the Glemould project, a circular economy model for FRP materials will be experimented and tested on several levels, technological, design, and production. This study was made not only with the aim of obtaining a second raw material, but also and above all to provide for efficient exploitation and application.

## 4. IMPACT OF THE PROJECT

Glemould has identified in the field of molds for composite materials a receptive sector for a substance obtained from fiberglass recycling that can, when fully operational, feed itself with material derived from the molds themselves at the end of their life, in a virtuous circular cycle that will become an example for others industrial sectors.

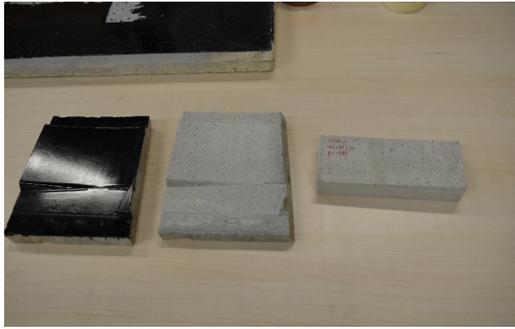
Glemould offers new-design approaches and a software platform to support producer-designer-customer interactions along the main product design process phases (Valle, 2012).

Thanks to specific project actions, the research team aims to bring the percentage of recycled material around 80 - 85% (Grandi, 2018) (Maggiulli, 2018).

### 4.1 PANELS PRODUCTION

From the technological point of view, the Glebanite panels were produced either by a vacuum extrusion process or by using a hot plate press. The production of the vacuum material, although promising in terms of surface quality after processing and contained porosity, has been set aside to pursue the aim of having a content of recycled material equal to 80% of the total.

The production of the material by pressing has been concentrated on two main aspects, the first being that of the composition, working on the chopped particle size, the second most on a technological level, focusing on the operating parameters of the production cycle.



[Figure 1] Sample tests obtained by extrusion



[Figure 2] Panels obtained by press



[Figure 3] Blend of resin and fibres



[Figure 4] Panels obtained by pressing

The result of these tests leads to a composition of the material with a content of 80% recycled with a fiber composition of about 2/3 of big fiber and 1/3 of thin fibre. From the operational point of view the material was compacted with a specific pressure of 20kg / cm<sup>2</sup> and a post-curing for one hour at 90 ° C. Although the manufactured articles had a superficial porosity, it was considered a satisfactory result to produce the material necessary for making the mold.



[Figure 5] Porosity check on samples



[Figure 6] Mould prototype

In order to refine the process and obtain better quality results in the numerical control machining phase, different molds and models have been realized to optimize the working parameters and to define the optimal solution in terms of choice of tools. These models and molds were then used to refine the post-processing suitable for vacuum molding.

## 5. RESULTS & DISCUSSION

The Glemould® project, through the transfer and optimization of technologies for the valorization of recycled fiberglass, has demonstrated the possibility of spreading a solution to the problem of the decommissioning of boats and fiberglass in more general terms. The project, in all its actions, applies a model in which the abandonment of the linear economy is expected and the approach to the circular economy, passing through new business models and transformation of waste into high added value resources.

In this scenario, the contribution of research and eco-innovation envisaged in the project strengthens the competitiveness of our industry in terms of sustainability. Using (and re-using) internally generated recycled material allows us to be less dependent on foreign procurement, with lesser vulnerability to price volatility, especially at a time of significant instability in countries that have the highest endowments of these resources. A key role in the project is related to the development of products and solutions that reflect the principles of the circular economy and can

enhance the characteristics of the material derived from fiberglass recycling. In fact, during the design and development phase, decisions are taken that can significantly affect the sustainability or otherwise of the product during its life cycle (Valle, 2012).

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## **PROJECT REMA: THE REGIONAL ECO-MATERIALS ARCHIVE**

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### **ABSTRACT**

This paper argues the emerging needs of incorporating regional eco-material archive in design education from the perspective of the constructivist point of view and active learning approaches. It is a critical reflection on the pedagogical development on sustainable product design education in School of Design, The Hong Kong Polytechnic University since the 90's. Action research method is carried out into the longitudinal reflective study in which the continuous refinement of the educational approaches will be reviewed with the illustration of different types of cases and initiatives of the teaching activities. The summary includes the recommendations of a framework to support active learning with physical eco-materials archive and cases to enable the design exploration about the cycle of local resources, local production, local consumption, and local recycling.

Key Words: Regional Eco-materials Archive, Active Learning, Material-driven Approach

## 1. INTRODUCTION

Design studio training, design thinking methods, and tools within the conventional pedagogy are not capable enough to facilitate the exploration of a creative and viable sustainable product design solution. We have explored various pedagogical strategies in environmental consciousness design (Leong & Manzini, 2006) into the curriculum of design school for almost three decades ago. Sharing the same vision of other design schools, upcycling design, product and service system approach, and design for behavioural change are also the meaningful attempts that we find it relevant. (Leong, 2002; Leong & Lee, 2014). In the last couple of years, we further push forward the momentum of the development of a sustainable society through exploring the people-centric design, participatory design, revitalization of local assets, and social innovation (Lee, 2008; Leong & Lee, 2011; Turner, 2013). Unfortunately, experienced design educators are not satisfied with those approaches because of the limited teaching resources such as the limited subject's credits and contact hours with students. In particular, we identified that lacking the understanding on diversified people's consumption behaviour, material cultural background, and the knowledge in material properties and environmental impacts as well as choices of applicable eco-materials in our city or region may hinder the development of real impactful projects. Thus, we carried out a few unique educational and research initiatives to address those enquiries (Leong & Lee, 2016).

In the discussion of facilitating active or self-directed learning for the sustainable design education, we realized that the ordinary student project in sustainable design in one semester term (around thirteen to fourteen classes within three months) usually encounters learning difficulties in the activities of (i) identifying substantial local up-cycled resources with proper categorization to address life cycle and material's properties, (ii) understanding the mechanical and emotional qualities of eco-materials exploratively and systematically, (iii) prototyping innovative concepts with eco-materials scientifically, (iv) implementing sustainable service model to facilitate participatory design and service addressing the four Ls (local resource, local production, local consumption and local recycling), and (v) critically evaluating the solutions and making modification. In particular, the tacit knowledge (the know-how and hands-on experience) acquired by the students cannot be transferred and further developed effectively in next year. Adopting previous learning experience in other design projects cannot be ensured. One of the reason is that a design project is unique and situated in different contexts. In most cases, students start over the above learning processes from scratch, uncertainties or the limited and unstructured previous works. Continuous knowledge building (student-wise and school-wise) is one of our goals.

The conventional teaching platform for sustainable product design is facilitated by three learning components (as stated in figure 3), including (a) the scenarios of real design practice, (b) the hands-on prototyping experience, (c) the coded knowledge resources/ archive. For instance, upcycling is one of the popular teaching approaches. As mentioned earlier, we cannot ensure the effective active learning and knowledge internalization of the students as the knowledge construction or transfer (including commercialisation) cannot be sustained. This paper will describe our reflective analysis of our actions in design education and research (Swann, 2002) to approaching the continuous improvement of the sustainable product design education in our school. The next sessions of the paper will elaborate our proposal of a 'knowhow' resources archive which is expected to bridge the coded knowledge (e.g. theories on sustainability), hands-on experience training about tacit know-how, and the experimental material-driven practices in real-world settings.

## 2. THE NEEDS OF PEDAGOGICAL REFINEMENT

We commenced on building the local material archive to support student's learning from 2000 to 2010. Afterward, we covered both consumer practices and physical materials for the inspiration of sustainable production. The Sustainable Make, Act, Do (SMAD) platform<sup>1</sup> is an online platform that we launched in 2011. This online platform aligns the current favourable blended learning called flipped (or inverted) classroom approach (Strayer, 2012) on the demand to promote active learning in the university. SMAD showcases an open source research platform through co-creating the archive on the indigenous environmental problems and sustainable practices in different cities in China. It can inspire the students the awareness and reflection of specific sustainable related practices of different people and cultural background.

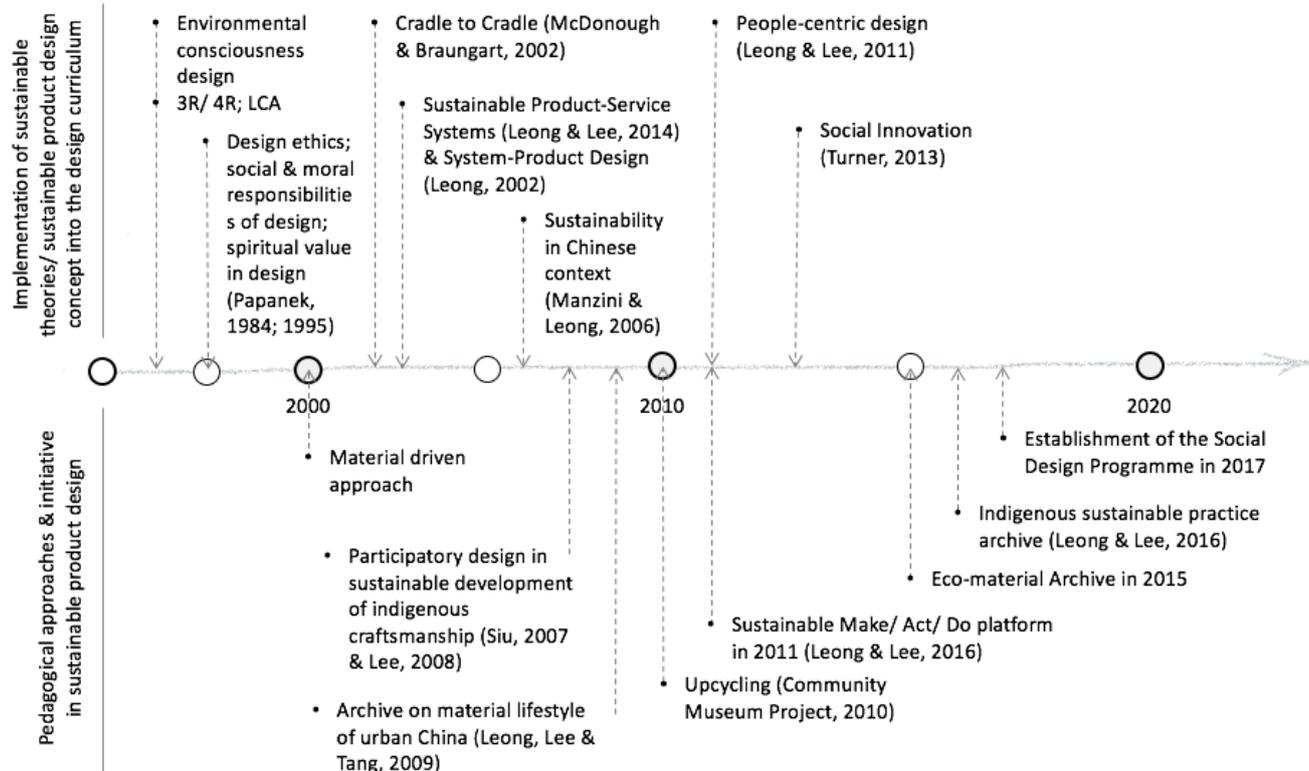
In the review of school-led community projects on the promotion of design for sustainability, projects initiated by NGOs and local designers, there is a need to bridge the learning gap between the design process and material science. Regional (or local) materials and samples can support and inform the student's curiosity, appreciation as well as creative confidence in the design process. It is a good foundation for undergraduate design training. Thus, our team conducted a case study called Regional Eco-materials Archive (REMA) on identifying and mapping the existing eco-materials in Hong Kong and Pearl River Delta area in 2013 to 2015. The collections of eco-materials with the assessment factors to indicate the carbon footprint (material's sources and location of production), renewability, and recyclability are showcased. We proposed an integrated labelling system to facilitate easy and quick understanding of the eco-material's properties and the impact on carbon footprint. The label system is used to code the collected eco-material, and a handbook on defining eco-materials are prepared as an educational tool to support teaching.

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<sup>1</sup> Website of SMAD- [www.sd.polyu.edu.hk/sldi/](http://www.sd.polyu.edu.hk/sldi/)

Almost within the same period, our school establishes the Material Resources Centre (MRC) since the end of 2014 to enable students and researchers who can get in touch with innovative physical materials. The centre showcases more than 1,000 material samples collected by a global materials consultancy with the world's most extensive library of innovative materials and processing methods. The samples cover fabrics, upholstery, furniture and construction materials for the interior, product, and industrial design, and other materials related to communication, digital media and interaction design as well. Nearly all samples are acquired from overseas such as America and Europe. The collection only includes a small portion of eco-materials, and there is no local sample. Thus, we expanded the REMA to around sixty samples and displayed all samples in MRC since 2015. In the last couple of years, there are more local design firms and design graduates develop the small start-up businesses based on the exploration of new eco-materials which sheds light to new possibilities and feasible solutions. It is important to note that there are not many cases can meet all the criteria of our proposed eco-materials criteria as indicated on the label. Surprisingly, more students and practitioners go to visit the MRC and review the material's samples.

To conclude the pedagogical development of product design discipline in School of Design, The Hong Kong Polytechnic University (HKPolyU) in the past two decades, we recalled and illustrated the major theories and concepts being incorporated to facilitate sustainable product design education (Figure 1). The below diagram indicates that we spent more than fifteen years on developing and articulating the material-driven approach in product design education.



[Figure 1] Timeline on the implementation of theories and concepts for pedagogical development in sustainable product design in the product design discipline of School of Design, The Hong Kong Polytechnic University

### 3. ACTIVE LEARNING THROUGH MATERIAL-DRIVEN APPROACH

Curriculum design never meets the latest, complex, and fast-changing scenarios. In HKPolyU, the development of active learning platforms such as massive open online courses (MOOCs), small private online courses (SPOCs), and flipped classroom is the emerging pedagogical direction in the coming years. Though active learning is essential to the quality of education, we have a reservation to the support of merely the intangible (online) interaction and resources.

In the movement of designing for social and moral responsibilities (Papanek, 1995), design educators and designers asked about the 'what if' the creative 'form-giving' may scrutinize the appropriateness in the process of sustainable production and consumption. The teaching team in School of Design, for instance, Philine Bracht and Benny Leong, had incorporated material-driven approach as a teaching method to promote understanding and appreciation of material's properties, and identification and exploration of potential product concept out of the characteristics (essence) of the materials in the middle of 1990's. One of the attempts was framed in a theme called 'design alchemy' in which the students explored and transformed the urban waste. The essence refers to the advocacy of forging the spiritual value of a designed object. This inspiration, as argued by Victor Papanek (1995, p.53), remains valid nowadays that yielding spiritual value in an artefact is both the intention of designer and user.

The material-driven approach is not a new practice. In the review of the approach in design arena, it embraces different dimensions of designer's intention. First, there was emphasis on the expressive or sensory identity of materials such as the exploration during the Italian design movement in 1970s (Ferrara & Lucibello, 2012). Second, the Material Driven Design method proposed by Karana et al. (2015) aims to facilitate designers to explore materials in the perspective of user experience. Third, there is an approach to materials and fabrication processes that focusing local and cultural resources (Souza et al., 2017). We identified that the material-driven approach receives constructive and stable quality assurance from both teachers and students. It is usually being implemented into project-based learning subjects. We had explored teaching instructions with minor changes. Throughout years of iterative modifications, there are two different instructions at the beginning of the project. Approach one is to limit the choice of reusable material such as all students explore PET water bottles as the key material for further study. The tutor can plan the preparation of lecture notes (e.g. specific theories and cases on PET or synthetic materials) and uses of equipment. Approach two is to encourage the students to search and explore reusable materials in the city. This approach usually more time consuming however some students may identify meaningful resources.

#### 4. THE ARCHIVE TO SUSTAIN THE INTELLECTUAL OUTPUTS

We have collected eco-material samples for years. In early 2013, they received a teaching grant to build the Regional Eco-materials Archive (REMA) (figure 2) and improve two major learning problems identified in teaching activities. The students are expected to focus on learning identification of problems and solutions, and integration and justification for proposal formulation. In practice, there is limited information about local and regional resources of eco-materials and real design exemplars in particular the lack of physical samples and real cases in Hong Kong and Pearl River Delta area which the scanty first-hand learning experience weakens student's learning actively. Students rely on online resources and books to understand the eco-materials. REMA is a source of inspiration rather than a source of reassurance (e.g. technical knowledge on lifecycle analysis). It aims to inspire designers who can actively and painlessly to i) acquire visual and tactile experience on the tangible materials which provides physical and aesthetic properties; ii) understand basic characteristics of sustainable materials with lower hurdle on professional knowledge of material science through referring to the label system on the material board; iii) appreciate the source, production and consumption of materials simply through the perspective of the transportation distance of the materials that induce emission of carbon footprint; iv) recognise the types, chemical properties, and general sustainable characteristics (recyclable, reusable, ...) of the materials quickly; v) co-create the regional eco-materials archive and share the exploration with other stakeholders. In short, the archive is expected to enhance the prototyping process of the designer and to co-construct the learning experience with others.



[Figure 2] The image at left showcases part of the Regional Eco-materials Archive displaying at Material Resources Centre in School of Design, The Hong Kong Polytechnic University<sup>2</sup>; the image at right shows the samples done by a team of product design students and the label system showing the material's characteristics.

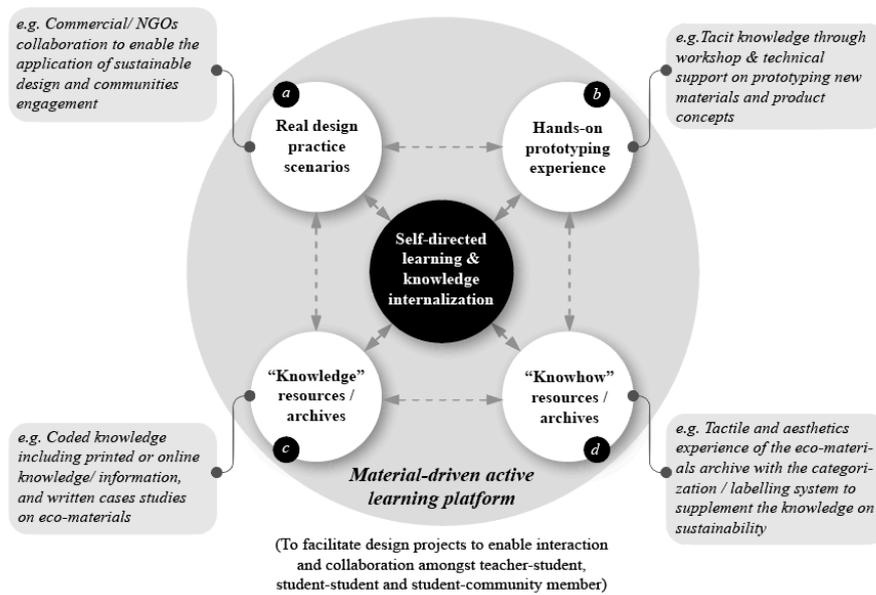
#### 5. CONCLUSION

In terms of Piaget's constructivist learning, the material-driven approach in education is essential to the learning and prototyping such as the discussion in the maker movement (Halverson & Sheridan, 2014). REMA is a "knowhow" resources/ archives (area 'd' at below) to support student's learning at the subject level, programme level, and even cross-disciplinary collaboration.

As indicated above (figure 3), REMA can supplement the other three sources of knowing/ learning experience (indicated in areas a, b & c). We concluded with illustrating this material-driven active learning platform/ model to suggest the way to facilitating the holistic active learning. The eco-materials archive provides two dimensions of experience. The physical experience enables the students to understand the mechanical properties of the materials through tactile interaction. Through visual and tactile (texture) interaction, this mental understanding can inform

<sup>2</sup>The website describes the project REMA- <http://www.polyu.edu.hk/greencampus/GreenNet/issue/6/>.

and enhance the appreciation of the aesthetic qualities of the elements. Besides, it is also effective to encourage the students to explore their unique materials with the application of the visual driven labelling system. On the other hand, this co-created archive can contribute to active learning, ownership, updating and sustaining the archive continuously. As an open learning resource, it also enables collaborative learning out of the classroom and solving

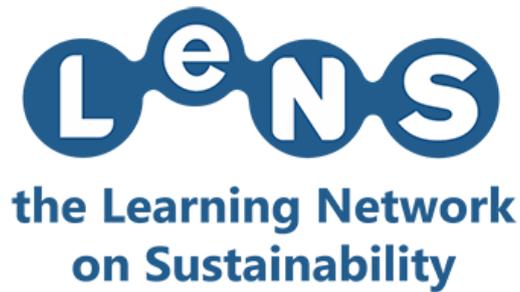


[Figure 3] Material-driven active learning and knowledge construction platform for product design training

problems to address the local system. The major limitation of the REMA is the difficulty in investigating the exact origins of materials (in particular multiple compounds), proportion of different elements, any catalysts being used, and energy consumption efficiency in the production process, etc. Not all producers of the materials can distinguish or expose all information to us. In the perspective of providing an overall picture and concern of sustainable materials with less environmental impact, the current archive can satisfy the needs of the early phase of design practice. In the long run, we anticipate that different regions or cities can build their REMA which can share and benefit both the local design practitioners and overseas partners to adopt the regional eco-materials to deliver local resources for local production.

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## **MATERIALS CLASSIFICATION IN FURNITURE DESIGN – FOCUS ON SUSTAINABILITY**

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### **ABSTRACT**

The materials classification increases in complexity as new materials are constantly released on the market. The furniture designer, usually a designer or architect, needs to stay current with the emergence of new wood panels, new composites, new metal alloys, and so on. The choice of materials is a crucial moment in the project, as it marks the transition between the conceptual design for the actual project. The currently available classifications are generalist and, strictly speaking, fit for any product. However, the practice shows a difficulty in selecting the most appropriate materials considering the specific area of each project. The present article initially demonstrates the difficulty of the available tables, shows case studies in furniture projects and finally presents a classification proposal focused on furniture design.

Key Words: Sustainability; Materials; Classification; Design

## 1. INTRODUCTION

Authors like Callister Junior and Rethwisch (2016) present a detailed and complete overview of materials that are used in almost all engineering courses, design and architecture in the country. For the authors, the traditional classification begins by grouping the materials into three large groups: metals, ceramics and polymers. This initial way is based mainly on the chemical composition and the atomic structure of the base materials. In the part referring to polymers, the authors divide into synthetic and natural, including in this second subgroup those derived from plants or animals such as wood, bamboo, rubber, cotton, leather, silk, wool, natural fibers of ramie, hemp, coconut, etc. .

The new materials arising from contemporary technologies are placed in three separate groups: composites, semiconductors and biomaterials. Of these, the group of composites presents a subdivision with already well-known materials such as the various types of concrete and mixed fibers, such as glass, carbon and kevlar, among others. According to Manzini (1993), the constant emergence of new materials forces a continuous reorganization of their classification. Attempts of classification seek to organize properties, strengths, limitations and use examples, seeking to ease the process of material selection.

The periodic table currently has 118 elements, many known and used for centuries for material obtaining. The difficulty of the material classification can be exemplified with the steel element. Being a binary alloy of Iron and Carbon, itself is divided into several types according to the quantity of iron and carbon, with different characteristics of hardness, mechanical strength, malleability and ductility, among others. By adding other elements to the steel, the alloy steels originate. Among these are stainless steel, quick-machining and deep-drawing. It is estimated that in 2017, more than 300 new types of steel were tested, of which only a small portion is likely to be available for industrial uses.

Ferrolí et al. (2017) present a classificatory table of materials (table 1), in order to facilitate the selection process. It serves as the basis for the beginning of the process, whose method is demonstrated in the website: Sustainable Materioteca of UFSC that is in constant adaptation. Establishing a relationship with the systematics used in design projects (pre-conception, design and post-conception), the tables are more suitable for the methodological stages of conception.

[Table 1] Classification of materials based on FEM - Material Choice Tool. Source: Ferrolí and others (2017)

Table 1	Natural, processed and coated woods	Table 2	Paper, cardboard and cardboard
Table 3	Ferrous metals (cast iron and steel)	Table 4	Non-ferrous metals (alloys )
Table 5	Sintered materials - Powder metallurgy	Table 6	Polymers - plastics (commodities, engineering, high-performance)
Table 7	Polymers - blends	Table 8	Polymers - adhesives
Table 9	Cement, concrete and aggregates	Table 10	Ceramics (common) and Glass
Table 11	Natural materials (gemstones, stones, leather, wool, and others)	Table 12	Natural fibers (rami, sisal, jute, coconut, etc.) and artificial fibers
Table 13	Rubber and plastic - processing	Table 14	Oils and greases
Table 15	Paints and varnishes	Table 16	Nano technology materials
Table 17	Advanced composites	Table 18	Other materials not included in the previous tables

The tables are complemented by physical samples, which allow the user to a tactile experimentation and data sheets of each material that present a brief introduction of the material, focusing on the Life Cycle Analysis (LCA). They follow basic concepts, properties, characteristics, a brief history of the material and main types, classified according to national and international standards (SAE, ASTM, DIN, NM, ISO, etc.)

In the area of furniture design, designers such as Philippe Stark, Fernando e Humberto Campana, Enzo Mari, Alvar Aalto, Tom Dixon and others use very different materials in their projects. The simplistic view of the use of traditional materials such as wood for the body of furniture, fabric for the upholstery and metals in hardware, commonly used in the design descriptions of the catalogs, is no longer accepted, a more detailed specification is needed. Especially nowadays, with an increasing alert of the environmental questions, a description of the origin and artificiality of the materials used can be decisive in the purchase process.

Aware of this, current designers are increasingly seeking to use natural materials and with less impact to the environment. The constant releases of materials called alternative materials further increase the field of study. Materials such as bamboo, coconut fiber, sisal, hemp, etc. are increasingly present in the furniture. Most of these materials still lack accurate and reliable information. While research on traditional materials requires state-of-the-art laboratories, the controlled environment and skilled labor, and high investment values, this is not necessarily the case when it comes to alternative materials whose “case studies” are often described on blogs or unspecialized websites.

This paper discusses the problem of the complexity of the general classification tables of materials, discusses their inadequacy for the specific area of furniture, demonstrates some case studies with furniture designs and the choice of materials and finally proposes a specific classification of materials for furniture.

## 2. MATERIALS IN DESIGN

In the past years has increased the importance of the materials within the design. Only in the last three years have been published by the main Brazilian publishers 23 books whose theme is materials and processes, related to design,

architecture or engineering, in addition to the large number of scientific articles published in annals of events and periodicals.

The group of so-called traditional materials, which independently of authorship usually includes woods, metals, plastics and ceramics continues to have priority, although not as much as in older publications. It should be noted that the priority is more pronounced in books than in articles, considering the focus of each publication and the average time elapsed in the editing of the original manuscripts.

In the section on ferrous metals, Chiaverini (2012) presents in detail the influence of the chemical elements added to the Fe-C base alloy, in addition to thermal and surface treatments. Unlike the first editions, where the focus was steel and cast iron, in the latest versions non-ferrous metals are increasingly present. However, there is still a very great emphasis on mechanical building materials, and designers seeking information on light alloys involving copper, tin and noble metals, for example, is not the source of most appropriate consultation. Barbosa (2014) meets the need in most non-ferrous metals, covering aluminum alloys, copper, nickel, titanium, magnesium, tin, lead, zinc, cobalt, zirconium and niobium.

When the subject is plastic, the works of Eloisa Mano are references used in all the university courses in the country (Mano and Mendes, 1999, 2000, Mano, 1991, among others), besides Albuquerque (2001) and the titles provided by the Advanced Plastic Institute, which offers a vast collection of technical works, addressing plastic commodities, industrial, high performance polymers, additives, blends and polymer composites. Most publications, however, are too focused on chemical engineering, materials or industrial chemistry, and the designer does not find what really interests him for the project.

The wood is also contemplated in many publications, and in design the most used are Pereira (2013), which presents a general overview with technical and aesthetic characteristics of Brazilian trees and SENAI (2014), whose emphasis on furniture design makes it an important query source. There are still authors such as Ashby and Johnson (2014), who in addition to the comprehensive book with all material groups, have developed in partnership with other researchers the Granta Design software, which among other things allows the designer a comparative visual analysis between quantitative and qualitative attributes of different materials (non-ferrous metals, ferrous, polymers, fibers, ceramics, etc.).

Scientific journals and annals of events present the main innovations of the sector, with the constant inclusion of new chemical elements in the search of metallic alloys and polymeric of high durability and resistance, preferably with low cost and weight. Engineers and designers who graduated in the 1990s or less need to be aware of changes in the materials. In the same way, the scientific innovations in the field of plastics are documented in high quantity. Technical publications of industries and universities, such as the monthly plastic magazine *Industrial*, among others, regularly present novelties of new polymer formulations, blends, composites, co-polymers and additives. Since products made from non-biodegradable polymeric materials are currently undergoing a series of environmental restrictions, biopolymers, biodegradable polymers and “green polymers” have become a booming market. The same goes for advanced ceramics, cermets and composites. Manufactured from oxides, carbides, nitrides, etc., the techniques of powder metallurgy have raised these materials to a level of utilization that have led to a cheaper and consequently increase in the supply of manufactured products.

The need of Laboratory or factory manipulation of chemical elements added in steel, aluminum alloys, polymeric or ceramic alloys inhibits amateur attempts. This does not occur in the manipulation of materials such as tree bark, knuckle, coconut fiber, sugar cane, horsehair and even bamboo. The ease of processing and obtaining the material, possibility of using common workshop machinery, lack of ABNT standardization processes and access to the material in nature facilitate free trial. Another aspect to be observed concerns the time of research and development to which the material is submitted. While traditional materials have a history of more than 200 years of research, many of the alternative materials surveys count for a few years, at most a few decades.

## **2. 1 Furniture Design - Designers, Projects and Materials**

Traditionally furniture refers to woods. This popular view is directly related to the historical use of wood in furniture. From the earliest records of the history of furniture, with few exceptions, furniture from ancient Egypt, Roman Empire, Renaissance, European classics (France, England and Portugal among others) going through the twentieth century movements (Arts and Crafts, Art Nouveau, Bauhaus, etc.) has the wood as its main material. It is also influenced by the fact that only the furniture in the residential furniture group is considered as mobile. Only later came the inclusion of other types of furniture, especially the urban. Firstly it is necessary to separate the groups of furniture that will be considered here. These groups were defined mainly considering the aspects of use of the furniture:

- 1). Residential furniture: designed for indoor use, with few users (usually family nucleus and guests), with a non-aggressive environment and little exposure to inclement weather.
- 2). Internal condominium furniture: designed for indoors, but with many users (inns, schools, restaurants, etc.). The environment is not so aggressive, not subject to weather, but the material is more subject to wear by shared and more intense use.
- 3). External condominium furniture: outdoor use, with many users, controlled public environment (balconies, decks, etc.). With aggressive environment, subject to weather, wear by shared and intense use.

- 4). Street furniture: designed for outdoor use, with many users, in open-access public spaces (squares, walkways, bridges, parking lots, etc.). Aggressive environment, subject to inclement weather and possibility of vandalism, with heavy use.

The study of furniture through projects of recognized designers can demonstrate the evolution and use of certain materials according to the time in which they were designed. Enzo Mari designed in 1971 a series of furniture such as the Day Night sofa bed and Sof Sof armchair, both with metallic structure (medium carbon steel). This trend remained unchanged throughout the 1970s, when the designer basically used metals and wood. In 1980, the Zanotta project was produced with PA (Polyamide - nylon) seat. Enzo Mari did not venture into the universe of alternative materials, as illustrated by his famous series of Bamboo Vessels, launched in 1969, which were actually made of Vinyl Polyvinyl chloride. (Giorgi, 2012).

Philippe Starck belongs to the group of contemporary designers that usually uses modern materials. Examples of this are the chair Louis Ghost, 1999, Mr. Impossibile chair, 2007 and chair Mi Ming, 2008. All in transparent or pigmented polycarbonate (PC) with variations in PETG. The designer used alternative materials, especially in the Lou Read chair, 2011, whose resin structure is covered by rawhide and mainly in the 2011 Zartan chair, all built with bamboo and covered with linen and hemp. (Morozzi, 2012).

In Brazil, Perrone (2012) presents the main works of Fernando and Humberto Campana. The designers began their work in the furniture sector around 1988 with the “positive and negative” chairs, both cast iron, which gave rise to the so-called “uncomfortable” series, all made of the same material, without concern for the finish. In 1991, they released the chair Favela, made with pieces of pine. The Campana brothers are examples of designers who use abundant alternative materials, as can be seen in the projects Red Chair (1993), Armchair Plastic Bubble (1995), Table Tatto (1999), whose lid is constructed with PVC drain covers, Poltrona Jacaré (2002), Célia Chair (2004) made of OSB and the Wicker Bank, 2008.

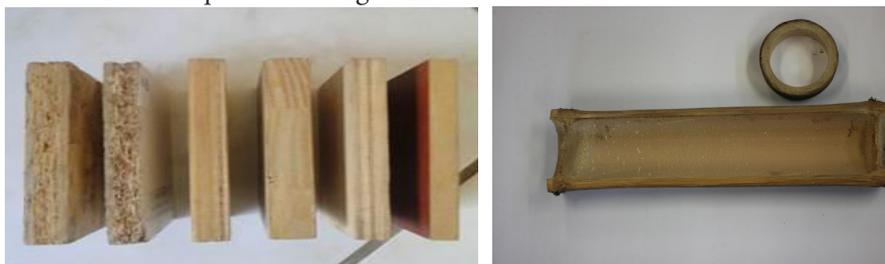
Designers born in the 1950s and 1960s had a beginning of sustainable education. As Ramalho and Santos (2015) explain, at the time of World War I (1914-1918) the first political actions of protection to the environment arose. In 1948 was founded the first world organization of protection to the nature, IUCN (International Union for Conservation of Nature). But it was only in 1972 that UNCHE took place in Stockholm, the first world environmental conference, where the United Nations Environment Program (UNEP) was established. The concepts and discussions of this conference led in 1984 to the spread of the concept of “ecologically sustainable development” at the time these designers were graduating. In 1992, RIO-92 was held in Rio de Janeiro, which established clear guidelines and goals for sustainable development, with concrete objectives, limits and deadlines for actions in all spheres of society. Agenda 21 was written during the Conference. However, the analysis of designers’ designs born between 1950 and 1960 shows that the environmental issue had little impact on material choices. This reality is a bit different in designers born in the 1970s onwards.

After several projects using different materials, Michele De Lucchi (Biamonti and Corradi, 2012) launched in 2005 the collection The Design of Madeira. According to the designer, the goal would be to salvage the wood as the classic material for furnishing, by valuing it. After years of being replaced by metal alloys, composites and fibers, or even being covered by plastic films, the wood returns, according to De Lucchi, to its original place as the main material of the furniture industry.

### 3. PROPOSAL FOR CLASSIFICATION OF MATERIALS FOR FURNITURE

Considering the above, it is verified that the way the materials are classified does not meet the expectations and needs of the furniture designers. The classification tables are, in general, very complex and approach materials that are not used for the specific purpose studied here. The first moment for the proposal of the classification was the division between the furniture categories previously described: residential, condominial internal, condominial external and urban. Some subcategories found in the bibliography, such as the so-called nomadic furniture (Souza, 2016), are included in one of these groups.

For the classification of materials were studied properties, general characteristics, strengths, limitations and everyday examples of use of each material. As far as possible, physical samples of the materials were analysed whenever possible to verify subjective characteristics such as tactile issues (softness, roughness, thermal sensation on the touch), beauty, smell, etc. Figure 1 shows a set of top view samples for visual comparison. This type of analysis allows, for example, the need for subsequent finishing.



[Figure 1] Samples for analysis of subjective questions. Source: prepared by the authors.

For the final composition of the tables, after the initial separation into groups of furniture, the next step was a survey of the materials supply market, considering factors such as ease of manufacturing, the degree of specialization of labour, machinery, direct acquisition costs and transport, indirect costs, quantity of suppliers, supply, demand, environmental legislation, recycling factor, life cycle analysis, aesthetic issues (texture, gloss, etc.), and comfort and safety in use (ergonomic aspects). The tables shown in table 1 of this article were used as a starting point for the preparation of the proposal. The primary analysis reduced from 18 to 7 tables. After this first step, the materials were classified according to the suggested group and subjective criteria were adopted to determine the factors. The factors originated from the FEM tool: Auxiliary Tool for Material Selection, by Ferroli and Librelotto (2012), which are: manufacturing and productive; marketing and social services; economic and financial, aesthetic and product presentation, ergonomic and safety and ecological (environmental). Table 2 shows the results of the applied research in group 1 - natural and processed woods for residential furniture. Due to space constraints, this article will present only that group. The other tables are available in the Sustainable Materioteca site of UFSC.

[Table 2] Classification of materials for furniture - natural and processed woods - part 1 - residential furniture. Source: prepared by the authors.

Natural and transformed wood							
Residential furniture							
Determinant factors			Marketing	Economic	Aesthetics	Ergonomic and safety	
Natural Conífera	Pinus	*****	*****	*****	**	***	***
	Cipreste	****	****	****	***	***	***
	Cedrinho	****	****	****	***	***	***
	Zimbros	**	**	**	****	**	**
Natural frondosas	Pau-marfim	*****	****	***	***	***	***
	Peroba-rosa	****	***	***	****	****	**
	Canela	***	***	****	***	***	***
	Amendoim	***	***	***	***	***	***
	Cedro	**	***	***	****	****	***
	Cerejeira	****	*	*	****	****	*
	Uva do Japão	****	***	***	****	***	****
Transformada Compensada	Compensado laminado	****	****	****	***	***	***
	Compensado sarrafiado	*****	****	****	**	***	***
	MDP	**	*****	*****	****	***	***
Reconstituída inflada	Sofboard núcleo de PU	***	**	****	***	****	**
	Sofboard de EPE	***	**	***	***	***	***
Madeira aglomerada	Aglomerado BP	***	****	*****	**	**	**
	Aglomerado especial	***	****	****	***	***	**
Aglomerado de média densidade	MDF ST	*****	*****	****	****	***	***
	MDF MR (umidade)	*****	****	***	****	****	***
	MDF FR (contra chama)	*****	****	***	****	***	***
	MDF HD (resistência)	*****	****	****	****	****	***
OSB	OSB3	***	***	****	**	***	***

## FINAL CONSIDERATIONS

The purpose of this article was to show the development of tables to choose materials with a focus on furniture design, considering four types: residential, condominium internal, condominium external and urban. It initially demonstrated a history of the use of traditional materials in furniture design, gradually being replaced or supplemented by alternative materials. This created a problem for material selection because of the difference in relevant and reliable informational data between the various material groups.

Based on previous applications, the authors developed seven practical tables that seek to guide the designer in the choice of materials, establishing correlations with factors of fabrication, productivity, aesthetics, market, society, environment, ergonomics, safety and costs. Preliminary application studies conducted to date indicate the need to test the tables in the four furniture groups in at least three to five different project design situations. These tests have already been started with the application of university product design classes.

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## **THE SUSTAINABILITY OF BIOMIMETIC SYSTEM DESIGN: FROM ORGANISM TO ECOLOGY**

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### **ABSTRACT**

As a design method inspired by nature, biomimicry plays a significant role in the design process and production activities.

Using existing research in biomimetic design, this thesis divides the Biomimetic System Design (BSD) into three levels: organisms, small-scale systems and ecosystems. BSD integrates of the material and information exchange between organisms and the environment rather than focusing on a single individual or structure, thus taking the biomimicry from an isolated state to a connected state. The system we have designed will have a positive interaction with the natural environment and give feedback to the environment. Biomimicry under the guidance of BSD is more integrated with the environment. The aim and outcome of this thesis is to explore the significance of BSD for sustainable development.

Keywords: Biomimicry; Biomimetic System Design; Ecological Design; Sustainability

## 1. INTRODUCTION

Historically, people have been inspired by nature when practicing various mechanical design and technical inventions. Past researchers have received some design guidance and inspiration from nature, so that the product has certain characteristics related to nature (Fremerey, Fischheiter, Mämpel, & Witte, 2010; Shu, Ueda, Chiu, & Cheong, 2011). The process of finding design inspiration from organisms in nature is biomimicry design (Ying Wang, 2012). BSD provides a new direction for human beings. While nature's biology and various mechanisms form a relatively stable state in the long-term evolution process, BSD is very efficient and reasonable for designers.

In the general sense, biomimicry design uses existing technology and materials to achieve a particular feature and function of an organism. BSD can be divided into three independent and complementary levels: structure, function and form (Xuan, 2012). Structure may contribute to function, and form is also a manifestation of a structure (Chang et al., 2016; Yuan et al., 2017).

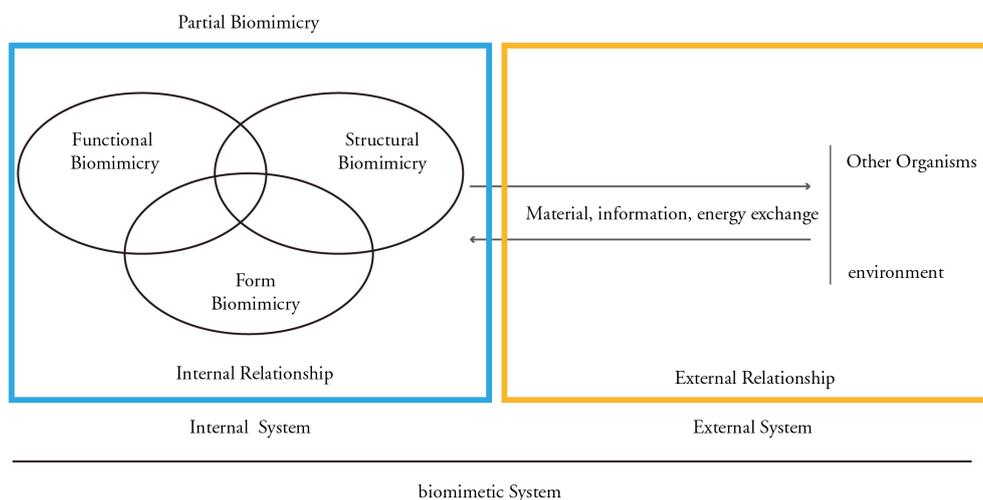
The imitation of functional mechanisms of biological parts has accelerated the progress of human science and technology. However, if we think from a systemic point of view, the biomimicry design for a certain individual organism may only realize one of the functions. The realization of this function may not form a unified whole with the external environment. BSD is a complete ecological bionic. Considering the overall coordination effect with the environment or the relationship with the environment when implementing biomimicry design, this coordination is an environmentally friendly embodiment that rises to a sustainable concept.

## 2. BIOMIMETIC SYSTEM DESIGN

### 2.1 BSD RELATED CONCEPTS

BSD uses a systematic perspective to rethink the scale of biomimicry design. When we were experimenting with biomimicry design in the past, we were more concerned with the realization of a certain mechanism and function of the organism, or simply an imitation of the shape (Junior & Guanabara, 2005). It is a one-sided perspective if we evaluate the relationship with the environment or the impact on the environment. Internal and external systems are the two dimensions of a whole system (Figure 1). The internal system focuses on how the individual is governed and coordinated to maintain a good operating state from the inside. For example, plants and cells have their own set of regulatory mechanisms, like signal transmission and protein production. Each organism is an independent system.

If we put a biological individual into the environment, then it has a background. It needs to communicate and exchange with the environment at physical and information levels. It is not an independent system anymore and starts to have a connection with the outside system. This connection can be made with other organisms or the ecological environment.



[Figure 1] biomimetic System (credit: Author)

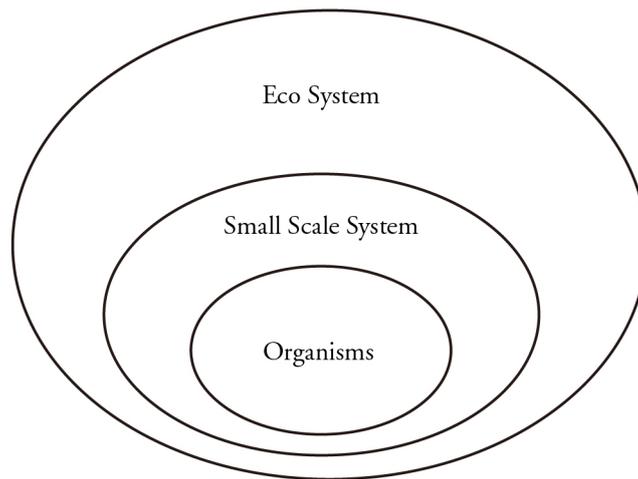
### 2.2 THREE LEVELS OF BSD

This paper divides BSD into three different levels by evaluating the focus of biomimicry design and the relationship with the environment. They are biological individual systems, small-scale systems and ecosystems. The basis of the division is through the object of imitation and the organism's relationship with the environment. For a biological individual system, the object of imitation is how the internal system of an organism operates and regulates. The small-scale system integrates the relationship between the individual and the individual's surroundings. The main focus of BSD is still on the biological individual. The ecosystem level is a more complex system that takes into account the complex relationship between organisms and the environment within an ecological region which is designed for an ecosystem (Gamage & Hyde, 2012). (Table 1)

System Level	Imitation Object	Relationship with Environment
Organisms System	Function (single function or multifunction)	Weak
Small Scale System	Systematic functions coordinated by biology and the environment	Strong (Partial Environment)
Eco System	A wide range of systemic functions of the environment and other organisms	Strong (Overall Environment)

[Table 1] *Three different systems*

These three biomimetic systems are not in an independent condition. There is a progressive and inclusive relationship between them (Figure 2). From the biological individual system to the ecosystem, they are gradually expanding, which means the large scale system contains a smaller scale system. For an ecosystem, the ingredients it contains are not single, but are composed of many biological individual systems and inorganic environments.



[Figure 2] *The relationship between three levels (credit: Author)*

**2.3 RESEARCH ON THE SUSTAINABILITY OF BSD**

The sustainability to be explored in the paper is mainly concentrated on ecological sustainability. As a natural design approach biomimicry design may make researchers instinctively think that biomimicry design is strongly related to sustainability (Baoshan, 2004; Lotfabadi, Alibaba, & Arfaei, 2016). Organisms existed in nature and the environment can be coordinated and coexisted, so they are more sustainable in people’s impressions than what humans create (Haidamous, 2017). But for most biomimicry designs, the extracted functions are often separated from the environment. When discussing this issue, it is especially important to combine biomimicry design with the environment.

In addition to the scale of biological individual systems, small-scale systems and ecosystems combine biomimicry design with the environment in order to achieve a harmonious coexistence state. These two scales are more environmentally friendly than a single biological system (Blizzard & Klotz, 2012). Organisms can exist in the long-term evolution process because of adaptation to the environment. At the same time, this adaptation is a two-way model. On the one hand, the organism adapts to the existing environment. On the other hand, activities of the organism will not make a huge change to the existing environment. The lack of adaptation and environment will make it difficult for organisms to survive for a long time. Therefore, on the issue of sustainability, BSD has a greater advantage than the traditional biomimicry design.

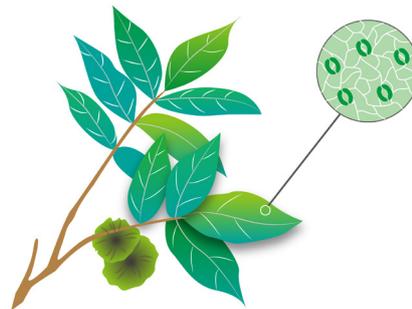
**3. CASE STUDY: SMALL SCALE SYSTEM AND ECOSYSTEM**

Given the isolation of biological individual systems, in this section we focus on the sustainability of small-scale biomimetic systems and biomimetic ecosystem design.

**3.1 SMALL SCALE SYSTEM DESIGN STUDY**

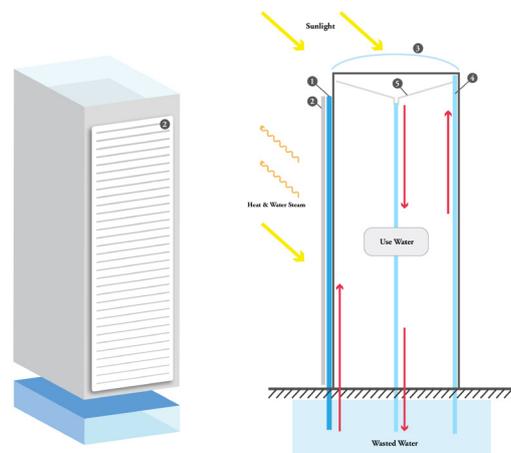
This section is about building biomimetic systems of mimicking the systematic functions of plants And creating a sustainable, systematic internal and external circulation system.

As an important mechanism of plants, transpiration has the functions of transporting nutrients and cooling plants (Leuning, Kelliher, Pury, & Schulze, 2010). Plants adjust the evaporation of water by controlling the opening and closing of the stomata on the leaves (Figure 3). The water absorbs nutrients from the roots of the plants to various parts while evaporating. The heat taken away by evaporation can also help the plants to cool down. This design (Figure 4) uses this mechanism to achieve the corresponding functionality. In this case, we can see whether the plant absorbs nutrients or dissipates heat, it is an interaction with the external environment.



[Figure 3] plant and the stomata on the leaves (credit: Author)

The system consists of a wastewater collection system, a water purification system inside the building, a water storage board and artificial “stomata” outside the building. The internal wastewater collection system primarily disposes of low-pollution domestic water. By simple filtration, wastewater that meets emission standards is collected in a reservoir below the building. The water purification system takes a portion of the wastewater to the top of the floor conducting it under evaporation. The vaporized water condenses at the top of the floor and is collected. The collected water can be used as a new round of domestic water and can be processed to meet drinking standards. A circular effect can be achieved inside the building, thereby reducing or eliminating external intake of water.



[Figure 4] concept diagram 1. Water storage board 2. Artificial “stomata” 3. Heat absorbing cover  
 4. Water absorb pipe 5. Water collector (credit: Author)

For the level of biological individuals and the external environment, the heat exchange and transfer between the building and the outside are mainly considered in the construction. As mentioned, part of the internal wastewater is stored in the collection tank, and some of the wastewater is washed through the building’s external wall water-absorbing material (water storage board) covering the building’s outer wall with a water film. The water storage board can serve two purposes. When the outside temperature is cold, this layer of water can provide insulation. The specific heat capacity of water is larger, so the temperature change will not be particularly obvious. When the outside temperature is high, water begins to evaporate, thereby cooling the building. The outer layer of the water storage board is covered with artificial “stomata”, and its opening and closing are controlled by a voltage sensing material, so that the amount of evaporation can be controlled by the intensity of the light. The design imagines the building as a plant system. Inside the plant, there are conduits and screens which mimic the function of transporting water and nutrients. The implementation of this function is inseparable from the process of external transpiration. Through the constant evaporation of water, the nutrient-rich water is continuously raised to the top of the plant. This process is a systematic process of internal and external coordination.

### 3.2 BIOMIMETIC SYSTEM AT THE ECOSYSTEM LEVEL

The definition of an ecosystem can be divided into three levels: the complete natural ecosystem, the natural and artificial ecosystem, and the fully artificial ecosystem. Three different levels of ecosystems have certain reference significance in the design of biomimetic systems. The premise is that the ecosystem can prove to exist for a long time under a long time span, and it is inclusive with the surrounding environment (Saunders & Hobbs, 1992). There will be no violent conflicts between organisms and environment.

Here, an ecological system transformed by human activities in Azheke Village is taken as an example to explore the possible direction of BSD at the ecosystem level. The Hani Terrace is located between the mountains of the southern part of the Laoshan Mountain in the Red River State of Yunnan Province at an altitude of 700-1800 m. It has a history of more than 1,300 years and is a typical representation of Chinese terraces (Z. Wang, Song, Wu, & Zhang, 2016). The Yuanyang terraced field (Figure 5) in the core distribution area of Hani Terrace is distributed on a slope with a slope of 15-75°, and the upper part is a forest with important hydrological functions (Yan Wang, Zhang, Song, He, & Zhang, 2013).

The special climate and special location give the Aztec village aborigines a unique way of life. After a long-term transformation of the local residents, a stable ecosystem of artificial transformation has formed (Table 2). Folk houses (mushrooms) are built from stone, wood and straw on the spot. is the houses are divided into upper and lower layers; the lower layer raises livestock, and the upper layer serves as a place for life. Another important feature of Azheke Village is the canal that is spread over each ridge and next to each dwelling. The canal draws water from the stone mountain and bares the domestic water of the residents. This huge water network also performs the function of irrigation. As a major source of food, terraces are responsible for the production of food crops and fish ponds for local residents. Because rice grows in a special environment, fish can coexist with rice for a certain period of time. The overall life style of Azheke is coordinated with the local environment, biology, climate and other conditions. Every living facility has its underlying causes of existence, rather than being designed at will.

[Table 2] Features of Azheke Village

Features	Description
Terrain	Stone Mountains, Water storage capacity is strong Terraced Field
Climate	High Humidity
Vegetation	Dry Winter Melon Water Hyacinth Subtropical Secondary Forest
Building	Mushroom House Structure
Crop	Rice, Corn
Daily life	Hookah, Dance, Brazier



[Figure 5] Mushroom House and Terraced field (credit: Author)

Therefore, Azheke Village has formed a mixed re-engineering environment from the entire natural environment in addition to the transformation of humans for many years. Apart from some unsustainable links, the sustainable part of the whole ecosystem is a valuable reference. At the same time, it can be modified and upgraded accordingly in order to make the system more efficient and sustainable.

Here we will talk about the design direction of the biomimetic system for the ecosystem: transformation and reconstruction. The design of the modified biomimicry system is aimed at the unique ecological environment of a certain region. We chose the long-term, human-reformed and sustainable ecological environment to study and use as a model to transform another unsustainable human community. Once we find the place to be transformed, we will carry out localization designs to complete the transformation. The reconstruction of BSD means that we will technically reproduce and reorganized a sustainable ecology to form a new sustainable community in other regions.

#### 4. REFLECTIONS

The development of biomimicry design to the present has produced enormous benefits for the development of human society. But if we are still concerned about one feature or one problem, the design will not be related to the current sustainable development context. The concept of bionic design itself will always come to a halt. This thesis proposes a new understanding of bionic design, namely BSD. It is divided by different levels to explore some possible design directions. The key point is whether the system contains the interaction and mutual constraints between biology and the environment. Because as a sustainable natural system, there is an inextricable link between organisms and the environment. This connection also allows a variety of organisms and environments to survive for a long time in this stable ecosystem. Knowing this key point, the next step is understanding how to create or port this connection that keeps the entire system stable. This will be a question worthy of further discussion.

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## **SUSTAINABILITY DESIGNED WITH(OUT) PEOPLE? UNDERSTANDING FOR WHAT ENERGY IS (OVER-)USED BY TENANTS IN AN ENERGY EFFICIENT PUBLIC HOUSING IN MILAN**

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### **ABSTRACT**

Techno-centric approaches to sustainability and energy optimization are not sufficient to achieve the international targets for CO<sub>2</sub> emissions reduction. This applies to our case study, engaging 500+ tenants of a public housing in Milan, deeply renovated in 2014. The 14mln euros invested in technical implementations risk to be vanished by tenant's ways of living which are not consistent with expected or optimal uses of the building infrastructure and devices.

This study frames changes towards more sustainable patterns of energy use by analysing how people carry on conventional practices and for which energy is required.

The study is based on a multi-disciplinary methodology pairing quantitative data from energy monitoring with qualitative understandings of tenants' practices through ethnographic and participatory methods. This paper presents interim findings drawn from a first set of semi-structured interviews to tenants in order to unpack people's understandings of technical implementations, ways of doing for reaching thermal comfort and personal satisfaction, leverage of personal skills and aspirations to implement change in practice.

Key Words: energy use; public housing; case study; design for sustainable consumption.

## 1. INTRODUCTION

In 2011, the European Commission's Communication 'Roadmap to a low carbon economy in 2050' established that greenhouse gas (GHG) emissions should be cut down by at least 80% by 2050 from their 1990 levels (ECC 2011). The domestic sector accounts for about a third of total energy used in Italy (ENEA 2016), where this study operates, and with similar figures in other European countries, including Sweden (Swedish Energy Agency, in Palm and Reindl 2015) and the UK (DECC 2018). More specifically, buildings construction and operations (especially for residential purposes) accounted for 36% of global final energy use and nearly 40% of energy-related carbon dioxide (CO<sub>2</sub>) emissions in 2017 (IEA 2018). Global buildings sector energy use continues to grow since 2010 (IEA 2018). The majority of domestic energy is used for space and water heating, which account for up to 80% in the UK for instance (DECC 2018), although these building end uses are the most improved over time (IEA 2018).

Retrofitting buildings to increase their energy efficiency in use and expectedly reduce the final demand of energy results in a main strategy to achieve the GHG emissions cut target through major investments and plans of funding across European countries.

In Italy, the adopted measures included fiscal deductions for implementing domestic energy efficiency in multiple ways, most notably by improving building insulation and increasing the energy efficiency of their appliances (ENEA 2016). Such measures have been implemented also in public and social housing to unleash the potential of relatively inefficient conditions.

Although interventions aimed to increase the efficiency are relevant, techno-centric strategies for energy optimization are not sufficient to achieve the CO<sub>2</sub> emissions reduction target (Allwood et al 2012). Technical innovations alone may even lead to unintended consequences and increase energy use (Alcot 2005).

Such rebound effects are reported also in the case study of the project here presented, EnerPOP, which aims (also) to identify the factors of the gap between the expected (calculated) energy savings and the actual (measured) ones, and to propose actions to reduce this and inform prospective plans of retrofit intervention at least in Milan.

Multiple factors contribute to the gap, including variations of actual climate with respect to the one adopted in the simulations (Erba et al., 2017), differences between the designed comfort conditions and those set in practice by the building manager and/or by the tenants (Sfakianaki et al., 2011), inappropriate management by users of active and passive systems and their controls (El-sharkawy et al., 2015). Such factors are not accounted for the calculation and certification of the energy efficiency of the buildings as per European Commission instructions (e.g. European Parliament 2010). Negotiations of relevant matters for the definition of energy measures in the procurement document is often black-boxed (Palm and Reindl 2015). As clearly inferred by Guerra-Santin et al (2017:165) in their Dutch social housing study, "actual occupancy patterns and their effect on energy use are currently not reflected in the 'standard' occupancy patterns defined in norms and simulation tools." More analytical understanding of tenants' ways of living may generate more accurate energy assessment during design phase (Becchio et al 2016:1035).

Few scholars have been encouraging a renovated understanding of energy use and renovation from a social science perspective (e.g. Palm and Reindl 2015; Moezzi and Janda 2014), encouraging a reconceptualization of the relationship between buildings and people as mutually constitutive and co-evolving (Chiu et al 2014).

Our study aims at contributing towards this direction, by pursuing a multi-disciplinary approach which merges quantitative data deriving from energy use monitoring with qualitative understandings of tenants' everyday practices, shared norms and aspirations. In this paper, the focus is on the identification of energy using factors for being comfortable in winter time, i.e. heating and hot water, where major inconsistencies between expected and actual consumption rates are reported. The supporting data derive mainly from a first set of interviews with tenants of a large public housing in Milan, complemented with indoor measured parameters and on-site observations. The Municipality of Milan counts a total of about 66 thousand public houses, of which 28 thousand are owned by the Municipality itself and managed by Metropolitana Milanese SpA (MM) (investee company of the Municipality of Milan), including the one of our case study. About 25 thousand families live in public housing in Milan, for a total of about 51 thousand tenants (MM SpA, 2017), 17% of which are foreigners and 33% are over 65 years old. Between 2015 and 2017, the Municipality of Milan invested about 180 million euros for ordinary and extraordinary maintenance of public residential buildings, of which approximately 50 million euros specifically dedicated to energy efficiency implementations. Nevertheless, preliminary findings report inconsistencies between the potential efficiency to be reached through such interventions and the actual ones. A main result of this investigation informs about how energy use for keeping the house comfortably warm is the result of concurrent, sometimes interconnected factors. Beyond the expected factors affecting domestic fuel consumption, such as the number of households, efficiency measures ... (DECC 2018), some other less tangible, quantifiable yet significant elements emerged. These are presented in the following pages.

## 2. METHODOLOGY AND CASE STUDY

The findings of this paper are based on a case study, a methodology which enables to deal with the specific connotations of a phenomenon in relation to peculiar conditions. Necessarily, a single case study is not sufficient to provide descriptors of more generic situations, including those addressing social dynamics in energy efficiency (Belafi et al. 2018). In fact, we do not aim at generalising, but rather scoping, identifying and analysing limitedly explored dy-

namics through complementary disciplines and their methods. The main result of the project is an assessment of the validity of the approach to unpack underexplored dynamics leading to inefficient consumptions. Therefore, this case study may represent the source for a methodological approach to be implemented in similar contexts.

Our case study is a retrofitted public housing building located in the southern-east periphery Milan, with evidences of substantially inconsistent (even doubled) rates of energy use with respect to estimated ones at the design stage (i.e. 34 kWh/m<sup>2</sup>\*yr); more specifically, in the two preceding heating seasons, a reduction of the outdoor temperature was accompanied by an increase in energy use, unexpectedly (Sangalli et al. 2019). The building consists of five floors above ground, with 154 apartments, about half of which are small two-room apartments (ca. 40 m<sup>2</sup>), and the rest four-room apartments (ca. 65 m<sup>2</sup> to 85 m<sup>2</sup>).

Since 2013, the building has undergone a major energy refurbishment for improving thermal comfort and air quality, in addition to the removal of asbestos. The retrofitting consisted in the installation of a) external thermal insulation coating system and new windows; b) novel heating system, also for hot water production, connected to the district heating network; c) programmable thermostats in every apartment; d) centralized mechanical ventilation system; e) air-to-water heat pump, which allows recovery of heat from the air extracted from the rooms and eventually preheats the domestic hot water; f) photovoltaic panels providing electrical energy to the heat pump and the common parts. Additional sensors were installed in the apartment in order to monitor the performance of the building, which included g) thermal energy meters (in each apartment), to measure the thermal energy required to reach and maintain the value of air temperature set on the programmable thermostats; h) temperature, humidity and CO<sub>2</sub> sensors installed in the corridor(s) of 17 apartments. The environmental data are recorded hourly and can be accessed remotely and exclusively by the Municipality and Politecnico di Milano through access to an online platform, protected by a password.

Since 2014, the apartments were assigned to (new) tenants, progressively reaching a nearly full occupancy of about 500 people mainly represented by elderly Italians (single or couple) and families of first-generation immigrants with children. Specifically, about 30% of the inhabitants are under the age of 15, and 60% of the families are foreign, including more than 30 different nationalities. In all families, at least the head of the family is able to speak Italian.

Data are collected and analysed with an STS perspective, according to which “buildings’ energy systems are situated in sociomaterial practices involving knowledge, institutions, technology, and methods.” (Palm and Rindl 2015:249)

A mixed-methods approach is used in this study, confronting quantitative data on the local conditions of the apartments (through the thermal and environmental sensors) with qualitative data from the interaction with the tenants and also with stakeholders. In this paper, interim findings are drawn mainly from the first set of activities for the ethnographic investigation, mainly consisting of semi-structured interviews to tenants, as well as conversations at different levels of formalization (e.g. scheduled meetings, unscheduled visits) and occasional observations with different levels of participation by the researchers. This paper includes the insights gained through the first set of interviews: specifically, with fourteen tenants residing in 10 family units, five of which were selected among those living in the 17 apartments equipped with environmental sensors and who expressed availability to collaborate with the researchers. The sampling operation was initially aiming to an equitable representation for the placement of the apartment (floor, exposure), size of the family (single, couple, family with children), nationality. The selected interviewees were asked to participate to an interview lasting about 60 to 90 minutes in their home, on a voluntary basis (without reimbursement) and according to their time preferences (date and hour). Several ones have declined the invitation to be interviewed, especially among families of foreign origin. In order to avoid over-representation of domestic habits and practices by the same type of families that agreed to be interviewed (typically small families of Italian origin), the sample has been expanded to include families of foreign origin, although residing in apartments which were not equipped with the aforementioned environmental sensors.

Interviews were audio-recorded with the interviewees’ consent (except for two), paired with notes which were (not fully verbatim) transcribed and analysed through NVivo software.

The semi-structured interviews covered not only practices and routines closely related to thermal comfort both in summer and winter season (e.g. use of radiators or aircon, clothes), but also questions regarding the way of living both inside and outside the building (e.g. relationship with other tenants, personal interests and skills) in order to identify additional factors to frame energy use and potential interventions to encourage its optimisation.

### 3. INTERIM FINDINGS

A preliminary analysis of the interviews reflects a wide variability of social practices and standards of thermal comfort, as it might be expected. The difficulty in understanding how the building infrastructures work and how to maintain the ideal temperature in the home is common, and it influences the interaction with programmable thermostats, thermostatic radiator valves, windows and accessory devices to achieve the ideal temperature, both in summer and in winter. A selection of main factors determining practices for regulating comfort indoor is presented below.

#### **Thermal comfort, ideal temperature, fresh air and cultural background**

Interviewees tend to agree on the building capability to maintain warm temperatures indoor, which is particularly valued by those families who lived in under-heated public housing formerly. Higher temperatures are appreciated in winter time, yet these are perceived as uncomfortable in summer season, possibly because of inadequate use of

solar protections and natural ventilation strategies, coupled with high insulation of the building envelope. The ideal temperature varies with tenants. An older tenant confessed to easily feel cold (e.g. she wears light pullovers even in summer mornings). Observations, anecdotes and environmental sensors prove that up to 30 °C are set and reached in some households, against the upper limit of 20 °C set by regional law during the heating season.

Cultural aspects necessarily play their role. Researchers' informal encounters with tenants and preliminary data analysis highlight the possibility for a handful of households coming from countries where the climate is warmer than Italy to prefer higher indoor temperatures. Also, even if tenants are aware that mechanical ventilation system is installed to grant healthy indoor conditions, they may keep the windows open to let (additional) fresh air come in.

#### **Adaptation to routines and circumstances**

The temperature is set or adjusted according to the needs and timing of the householders, as it may be expected. For instance, the heating system may be set to turn on before getting up in the morning and to turn off when out for work. However, punctual regulation is not always the case for all the interviewees. As witnessed also with the analysis of the environmental sensors data, high temperatures are captured even when householders are absent. This may be due also to the possible annoyance deriving from the regulation of the programmable thermostat and thermostatic radiator valves installed in each apartment as addressed below.

Higher energy demand may be due also to extensive stays at home, typical of older tenants, who may feel colder and at the same time having fewer chances, occasion and abilities to stay out of home.

#### **Familiarity, skills and preferences with the thermo-regulating devices**

Interviewees report diverse approaches to thermo-regulating devices installed in their flats. An interviewee declared (and provided evidence) to fully respect the regulation and precisely set the programmable thermostat within the limits. A couple of other households had the programmable thermostat set with the help of the former household and do not fully manage this for occasional adjustments. Another household instead keeps adjusting temperature through the thermostatic radiator valves, thus skipping the programmable thermostats. Programmable thermostats are reported to be hardly comprehensible, at least without dedicating sufficient attention to the instruction booklet, as the interface is counterintuitive and even confusing. For instance, icons of a sun, moon and ice flake indicate comfort, energy-saving and non-icing temperature respectively – rather than daytime, night-time and cooling as some may interpret. If present, only one person in the family is capable of effectively setting or adjusting the programmable thermostats, which may turn out to be an occasion of tensions too. The constant use of thermostatic radiator valves is reported to let them break more easily and being rarely replaced for their relatively high cost. In such case, the temperature of the radiator is set as per last adjustment.

#### **Expenses and value attribution**

Financial aspects were covered during the interviews to understand how expenses impact on personal balance and if savings may be a lever for changing patterns of consumption. The types of expenses covered included both rent and utilities. The sum of the rent varies with the financial situation of the tenants. They report to pay advantageous fares ranging from 50 to less than 200 euros per month for their apartments, the market value of which is estimated at about 700 euros per month by one of the interviewees. The rent is paired with the cost for heating and public utilities, both proportional to the surface of the apartment (rather than per actual consumption). Heating accrues to about 30 to 60 euros per month according to some.

The individual utilities for consumed gas (almost exclusively for cooking) and electricity accrue to about 15 to 40 euros per month per apartment. When prompted about the impact of such expenses on their financial stability, the interviewees tend to consider these amounts as reasonable or even cheap, especially utilities possibly because also of the advantageous fares that some of them benefit from. Likewise, the cost of the rent tends to be considered appropriate, although not affordable for everyone. In fact, at least a third of the tenants accumulated a debt with the managing company.

## **4. CONCLUSIONS AND OUTLOOKS**

The preliminary insights gained through the first set of semi-structured interviews confirm that people – rather than buildings – use energy, to satisfy needs and accomplish practices, especially related to thermal comfort. Setting and adjusting ideal temperature within each household are entangled in webs of practices and factors determining the final demand of energy. Deeper understanding of what energy is used for results of fundamental importance for effective modelling, design and interventions intended to increase energy efficiency and reduce GHGs.

This may sound obvious, yet analytical investigations unveil how these are entangled with multiple practices and daily routines (e.g. working, entertaining), understandings of technical devices and skills for their use (e.g. programmable thermostat, building infrastructures), cultural background and rooted beliefs (e.g. need for fresh air). These are not necessarily tangible, measurable, rational elements, which effect consistently on building energy use. Therefore, the development of interventions with tenants aiming at the reduction of energy use are challenging and tricky. Most notably, monetary savings on bills result in a limitedly appealing option to the interviewees, although potentially vulnerable conditions apply to them. Therefore, incentives and interventions leveraging on reducing expenses may not result as effective as per researchers' former hypothesis. Environmentally beneficial practices may

clash with routinized actions and cultural elements, such as opening the windows when the heating system is on for the need of let fresh air come in, although the mechanical ventilation is active.

Effective communication is occasionally suggested in literature to encourage tenants in adopting low energy practices or more sustainable behaviours (e.g. Becchio et al 2016). Although reasonable, how an effective or strong communication may be arranged is a highly variable and hardly verifiable. In our case study, former uses of notice boards for encouraging respectful habits and practices towards other tenants or the building have been repeatedly reported as ineffective, possibly because these are not captivating, understandable or relevant for them. Social practice theory helps in framing how routines and practices in general are in competition for time. Therefore, the strategy we intend to pursue is to promote the transition towards less energy-intensive practices by leveraging on shared interests, such as improved health and wellbeing, higher comfort, less stressful setting and adjusting of indoor thermal conditions, enjoyable and effective use of common areas, preserving the positive elements of the building, feeling part of a community.

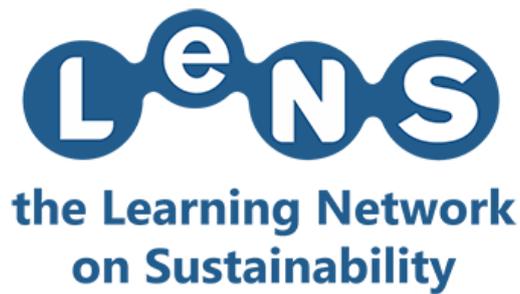
The researchers will proceed with additional interviews, onsite participatory and co-design activities with tenants and stakeholders, and more analytical comparative data analysis to further unpack what energy is used for in order to identify potentially relevant elements to be connected to energy saving interventions. The ultimate outcome of the project consists of a document pairing building retrofit interventions with actions for tenants' engagement in sustainable practices, ranging from effective energy provision to initiating communities of practice which may catalyse the potential of the local assets. Designer play a fundamental role in delivering tools, methods and approaches which pair the two – technical and social oriented – components in a synergetic fashion.

## ACKNOWLEDGMENTS

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## RESEARCH ON BIOMASS ENERGY UTILIZATION IN RURAL AREAS BASED ON SUSTAINABLE DESIGN CONCEPT

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### ABSTRACT

Due to the low grade and dispersion of biomass energy resources, a large amount of rural biomass energy has not been effectively utilized. Instead, it has been landfilled and incinerated at will, becoming a waste. How to make efficient use of agricultural derivatives and human and animal waste treatment and become a clean energy becomes crucial. Through combing and summarizing the literature research on rural biomass energy development, the results and shortcomings of existing research are summarized. Through the basic concept of S.PSS and the treatment of existing agricultural by-products and the treatment of manure in livestock and septic tanks. This paper proposed an overall design scheme based on the agricultural by-products and human and animal manure convenience of ordinary farmers in North China, based on the theoretical requirements of sustainable design, proposed agricultural by-products and humans and animals in the homes of ordinary farmers in North China.

Key Words: Rural Areas, S.PSS, Sustainable, Manure composting

## 1. INTRODUCTION

Traditional fossil energy, as the main energy source consumed by China for a long time, has supported China's rapid economic development for decades and brought serious pollution problems. With the energy shortage crisis and environmental pollution problems becoming more and more serious, the development of new energy with the concept of clean and renewable as the core has received global attention. [1]

### 1.1. Biomass energy utilization

Biomass energy broadly refers to the energy that solar energy stores in the form of chemical energy in biomass, using biomass as a carrier. The rural biomass resources with development value under the current technical level generally include crop straw, forest biomass residues, livestock manure and energy crops. Cai Yaqing used the grass-grain ratio method to calculate the provincial straw resource density and energy potential in China.[2]

The theoretical resource of China's straw in 2009 is about  $7.48 \times 10^8$ t, and the energy potential is  $1.52 \times 10^8$ t. Liu Zhibin [3] combined the grass-grain parameter and energy ratio of crop straw and estimated that the power generation potential of China's major agricultural biomass resources in 2011 was  $6.833 \times 10^4$  MW, which is considered to be rich in China's agricultural biomass resources and corresponding to the biomass power generation industry. Development helps to address energy shortages and environmental pollution.

Biomass energy has become an increasingly important position in advanced countries such as Europe and the United States. However, in developing countries such as China, the backwardness of technology and development concepts has led to slow development, but at the same time, the demand for energy in development is relatively high. Large, so in the future, China's abundant resource reserves contain huge potential for sustainable development.

### 1.2. Current treatment methods in rural North China

The traditional fossil energy industry has matured, and there are still many imperfections in the development and utilization of biomass, resulting in limited economic efficiency of biomass utilization projects. At the same time, the high technical cost of biomass energy and the constraints of the previous capital flow barriers also hinder the development of its industry. On the other hand, fluctuations in fossil energy prices directly affect the economic efficiency of biomass energy. When fossil energy prices are low, biomass energy projects are difficult to reach reasonable income boundaries, resulting in enterprises lacking incentives to enter the biomass industry. The economic benefits of physical energy development are key factors that constrain its development.

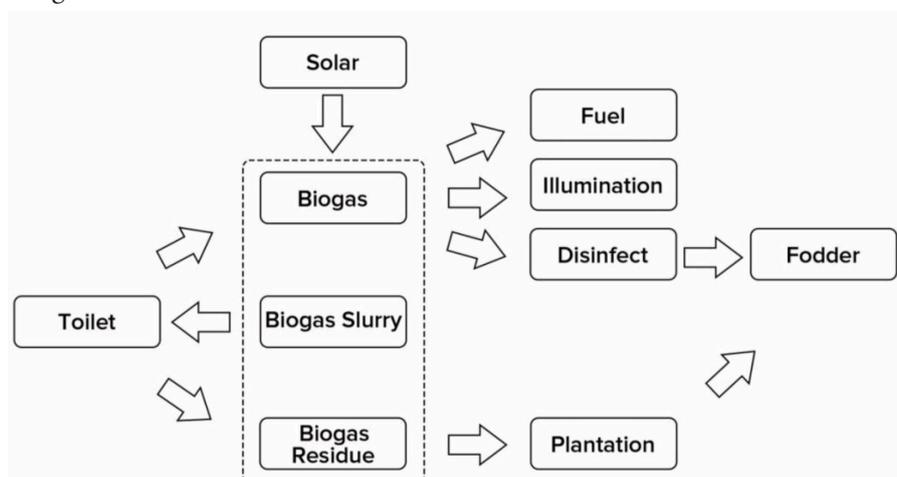
## 2. PRINCIPLE AND DESIGN PRACTICE

### 2.1 Principle

Through combing and summarizing the literature research on rural biomass energy development, the results and shortcomings of existing research are summarized. Through the basic concept of S.PSS, through the treatment of existing agricultural by-products and the treatment of manure in livestock and septic tanks. The method of field research proposed an overall design plan based on the agricultural by-products and the convenience of human and animal manure in the homes of ordinary farmers in North China.

The sustainable housing energy design plan is carried out by the ordinary farmers in North China, and the home is divided into animal husbandry, residential, composting and planting areas according to functions.

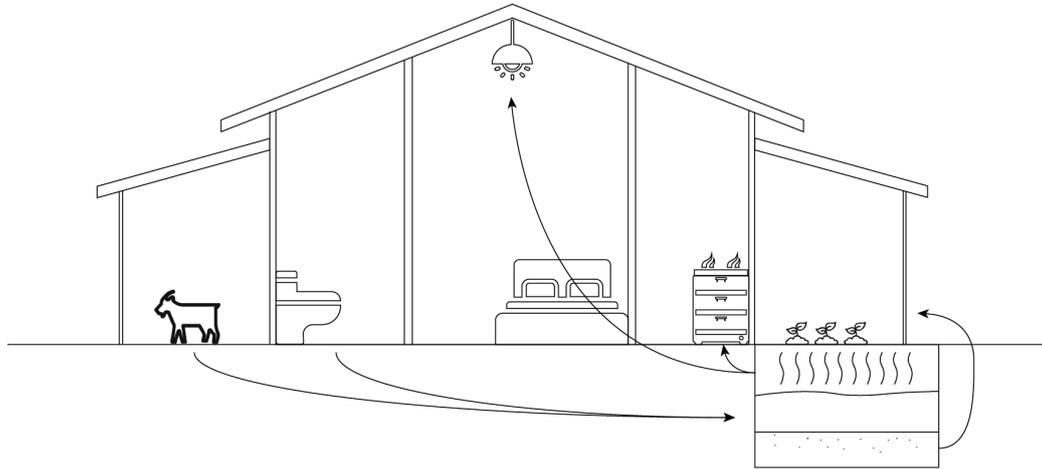
The human and animal feces are separated and processed by solar energy, and separated into biogas slurry, biogas residue, and biogas. Among them, biogas provides fuel, lighting, and disinfection for shed sheds; biogas slurry is treated, odorless can flush toilets, save water resources; biogas residue is fed back to the planting area to provide feed for livestock, and human and animal feces are returned to the treatment system. Separation of biogas slurry, biogas residue, and biogas. Figure 1.



[Figure 1] Rural Family Sustainable Ecological Schematic

## 2.2 Design Practice

Taking a rural household in North China as an example, this paper divides the courtyard into four functional areas and redesigns its daily energy use by using renewable energy. According to the survey, the survey was conducted with the investigation of Taixi Village, Licheng District, Shijiazhuang City, Hebei Province, China, and combined with the daily household consumption such as electricity and domestic water in Xiangcheng District, to calculate the cost of living, which is about 1,200 yuan. Households have their own septic tanks, which are regularly cleaned by the local government every month, resulting in waste of public resources. According to the basic concept of sustainable design, combined with the utilization of biomass energy, it is first divided into four functional areas: animal husbandry area, residential area, composting area and planting area. Through redesign, it can help farmers' daily operating costs by 30%. Figure 2.



[Figure 2] Farmer family sustainable system design

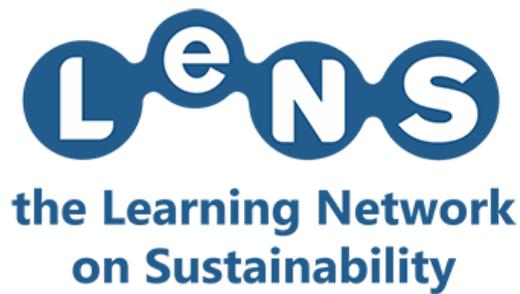
## 3. CONCLUSION AND DISCUSSION

Based on the theoretical requirements of sustainable design, a systematic design scheme for agricultural by-products and human and animal manure convenience in the homes of ordinary farmers in North China was proposed. Finally, the efficiency of the use of agricultural by-products has been improved, the expenditure on energy costs of households has been reduced, and the environment has been friendly. The biogas produced by the treatment of human and animal manure: biogas; biogas slurry has reduced the collective supply of water and fuel. The proportion of resources has achieved a certain degree of self-sufficiency. It provides a reference for the establishment of ecological applications of energy in rural areas.

This design practice has certain deficiencies, such as low biomass energy and low conversion efficiency, which cannot meet the total power supply requirements of the family. At the same time, the solid liquid separation of the faces also brings certain difficulties, resulting in a decrease in utilization rate. In the latter study, we will focus on solving the energy conversion efficiency and solving the problem of solid-liquid separation.

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## **LIFE THE TOUGH GET GOING PROJECT: IMPROVING THE EFFICIENCY OF THE PDO CHEESE PRODUCTION CHAINS BY A DEDICATED SOFTWARE**

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### **ABSTRACT**

The paper describes the state of progress of the LIFE The Tough Get Going (LIFE TTGG) project (funded by the European Union). The authors aim to improve the entire life cycle efficiency of European Protected Designation of Origin (PDO) cheeses by designing and developing software, that will work as Environmental Decision Support System for the environmental footprint assessment (in compliance with PEF methodology promoted by European Commission) and its reduction. The software has been calibrating and validating on the companies of the Grana Padano and Comté cheese supply chains (100 farms, 34 dairies, and 19 packers).

In this article, the environmental impact of 10g dry matter of Grana Padano PDO cheese was evaluated, through 3 different impact categories: Climate Change, Acidification, and Mineral Fossil & Ren Resource Depletion. Two emission mitigation scenarios were considered: reduction of energy consumption in the dairy processing phase and environmental packaging optimization.

Key Words: Life Cycle Assessment, Dairy Products, Software, PDO

## 1. INTRODUCTION

Farming activities are considered to play an important role in depleting the Earth's resources and contributing significantly to Greenhouse Gas (GHG) emissions, to soil fertility, to water scarcity and to the release of pollutants that affect ecosystem quality (McMichael et al., 2007) but its acquisition requires energy expenditure. In post-hunter-gatherer societies, extra-somatic energy has greatly expanded and intensified the catching, gathering, and production of food. Modern relations between energy, food, and health are very complex, raising serious, high-level policy challenges. Together with persistent widespread under-nutrition, over-nutrition (and sedentarism).

Life cycle assessment (LCA) represents a reference method that helps in analyzing supply chains with the aim of achieving environmental sustainability objectives (Sala et al., 2017). The LCA methodology, integrated with the Life Cycle Design (LCD) methodology, allows the development of products with a low environmental impact (Vezoli, 2018). Previous works have been already done in developing operational methods for the assessment of the environmental impacts of dairy activities: EDEN-E tool (van der Werf et al., 2009) an operational method for the environmental evaluation of dairy farms based on the life cycle assessment (LCA), the LatteGHG tool (Pirlo and Carè, 2013), PMT\_01 tool (Famiglietti et al., 2019). Based on our knowledge, a model for assessing and reducing the environmental impacts of dairy products in a full life-cycle perspective has not yet been developed. The present study reported the application of the LIFE TTGG in the assessment of the environmental impacts of 10 g of dry matter of Grana Padano PDO cheese. Two "Scenario analyses" were performed to compare different energy management practices for dairy plants and for packaging solutions.

## 2. MATERIAL AND METHODS

### 2.1. Goal

The objective of this study was to present the LIFE TTGG software prototype, a comprehensive LCA instrument that aims to: a) analyze the environmental impacts of EU PDO hard and semi-hard cheeses according to PEF methodology; b) assess three different impact categories and determine the contribution of each production stage; c) support technicians and researchers in the evaluation of an environmental load of EU PDO cheeses.

The software has been developing by the LIFE Programme funded by the European Commission. The project duration is from July 2017 to June 2021.

### 2.2. Scope

#### 2.2.1. System boundaries

The entire life cycle is assessed, including the following life cycle stages: raw milk supply, dairy processing, non-dairy ingredients supply, packaging, distribution, use, end-of-life. Company-specific data are required for raw milk supply, dairy processing, and packaging. While secondary datasets are used for the other stages. A specific average database has been implemented for Grana Padano and Comté PDO cheeses. This database will be used to reduce data collection effort and will increase the reliability of European PDO LCA analyses.

The temporal coverage for data collection is one year. The model of LCA analysis is descriptive (attributorial) (European Commission, 2013).

#### 2.2.2. Allocation

The environmental impacts of processes that involve multiple co-products, were allocated following the IDF rules (IDF, 2015; The European Dairy Association, 2018): biophysical allocation was used for the production of raw milk and meat at the farm gate and dry mass content allocation was used for the processing of the finished dairy products and by-products.

#### 2.2.3. Functional unit and reference flow

The functional unit (FU) and reference flow used in the software was: 10 g dry matter of cheese, consumed at home as a final product without cooking or further transformation.

### 2.3. Inventory analysis

The average inventory included in the software was developed based on information collected directly on farms and dairy plants with dedicated check-lists.

The information needed for raw milk production phase are: a) herd management (n° of lactating cows, dry cows and replacing animals); b) feed composition; c) livestock management (housing and bedding system); d) manure management (storage systems including anaerobic digestion); e) crops yield and fields management; f) energy consumption (electricity and fuel).

Direct emissions in air, water, and soil are estimated following EEA (2016) and IPCC (2006). The information needed for the dairy and packaging phase are listed in Table 21. The secondary dataset used in the software are: Eco-invent 3.4, Agri-footprint, ELCD, Swiss Input-Output database, Industry data 2.0, and USLCI.

### 2.4. Emission estimation and impact assessment

The final environmental impact is expressed on 16 impact categories, following the ILCD 2011 Midpoint + (version 1.0.9, May 2016) – normalization/ weighting set EU27 2010 per person, equal weighting (European Commission and Joint Research Centre, 2012).

**2.5.Scenario analyses**

Two scenario analyses were performed to test software taking into account some technical options on the dairy processing and packaging phases. In this specific case, we focused on heat recovery from whey and packaging optimization. Inputs and outputs of the analyzed supply chain are reported in Table 21.

Table 21. Data refer to 1 kg Grana Padano PDO

Group	Characteristic		Units	Dairy
Main ingredients	Raw milk		kg per kg of cheese	13.83
	Salt		kg per kg of cheese	0.05
	Rennet		g per kg of cheese	0.28
	Lysozyme		g per kg of cheese	0.10
Cleaning agents	Cleaning agents		kg per kg of cheese	0.02
Packaging	Electricity – portioning and packaging		MJ per kg of cheese	0.54
	Primary packaging – polymer bag		g per kg of cheese	37.00
	Secondary packaging – Corrugated board		g per kg of cheese	51.00
	Tertiary packaging – LDPE film		g per kg of cheese	3.00
	Tertiary packaging – EUR flat pallet		g per kg of cheese	5.00
Energy consumption	Electricity		MJ per kg of cheese	2.40
	Heat from boiler (natural gas)		MJ per kg of cheese	6.72
	Transport inputs materials		tkm per kg of cheese	0.07
Refrigerant gases	Refrigerant gas		g per kg of cheese	0.02
Other inputs/outputs	Underground water		kg per kg of cheese	30.30
	Wastewater		m <sup>3</sup> per kg of cheese	0.02
Dairy outputs	Grana Padano PDO	DM 67.5%	kg per kg of cheese	1.00
	Whey	DM 6.4%	kg per kg of cheese	11.64
	Cream	DM 26.0%	kg per kg of cheese	0.99
Distribution	Transport to the logistics center		tkm per kg of cheese	0.32
	Electricity for distribution center and retail		MJ per kg of cheese	0.02
	Food loss		%	5.00
Use phase	Electricity for domestic refrigeration		MJ per kg of cheese	0.36
	Food waste		%	7.00
End-of-life of packaging	Recycling paper		g per kg of cheese	29.75
	Recycling plastic		g per kg of cheese	17.09
	Incineration		g per kg of cheese	7.08
	Landfill		g per kg of cheese	42.08

**3.RESULTS AND DISCUSSION**

**3.1.Environmental impacts**

Characterization, normalization and weighting results of 10 g of DM of Grana Padano PDO are shown in Table 22. Three different impact categories out of sixteen: Climate Change (CC), Acidification (A), and Mineral Fossil & Ren Resource Depletion (MF&RRD) were reported.

The main contribution to CC and A impact categories was related to raw milk production (81% and 87% respectively). Dairy processing is the most significant phase for MF&RRD (42%).

In Figure 1 are reported the characterization results of the different compartments for the selected functional unit.

Table 22. Impact assessment results per 10g of DM of Grana Padano PDO

Potential impact	Units	Characterization	Units	Normalization	Units	Weighted
CC	kgCO <sub>2</sub> eq.	1.54E-1	-	1.67E-5	μPt	1.12 E+0
A	molc H <sup>+</sup> -eq.	3.64E-3	-	8.33E-5	μPt	5.56E+0
MF&RRD	kgSb-eq.	3.48E-7	-	3.45E-6	μPt	2.30E-1

**3.2.Scenario analysis**

Using a heat exchanger to preheat the inlet milk before the curding/cooking phase with hot whey outlet is a common solution that can be implemented in the dairy processing phase. The intervention reduces both thermal (approx. 10% of the energy need) and electrical consumption (linked to the whey cooling system – approx. 5%). For packaging was reduced the weight of primary and secondary packaging (from 37 g to 19 g and from 51 g to 30 g respectively).

The dematerialization of the packaging also corresponds to an optimization of the volumes, that lead to a reduction in the impact of refrigeration and transport in the subsequent phases of the life cycle. Table 23 shows the results achieved after the proposed solution implementation.

Table 2-3. Results concerning the effective solutions proposed (from cradle to grave approach)

Potential impact	Characterization				Weighted			
	Units	Pre-value	Post-value	Delta	Units	Pre-value	Post-value	Delta
CC	kgCO <sub>2</sub> eq.	1.55E-1	1.52E-1	1.6%	μPt	1.12E+0	1.10E+0	1.6%
A	molc H <sub>2</sub> eq.	3.64E-3	3.63E-3	0.3%	μPt	5.56E+0	5.55E+0	0.3%
MF&RRD	kgSb-eq.	3.56E-7	3.28E-7	7.8%	μPt	2.35E-1	2.17E-1	7.8%
				Total	μPt	6.90E+0	6.86E+0	0.8%

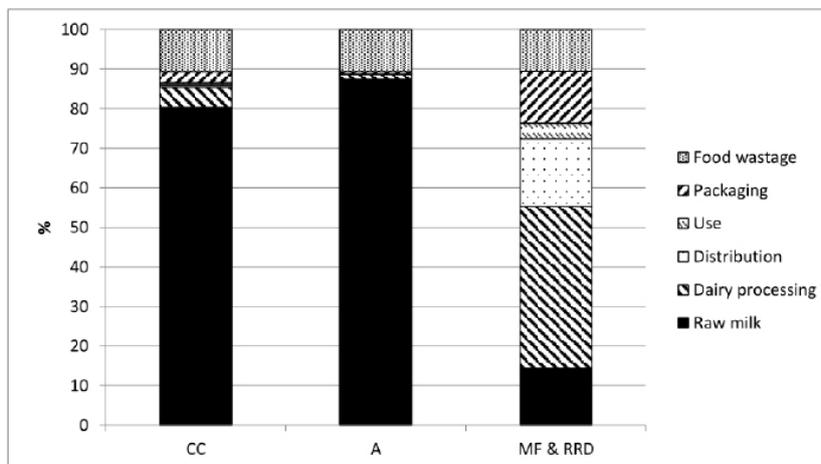


Figure 1. Characterization results of the different compartments per 10 g of DM of Grana Padano PDO

The benefit obtained by the two solutions showed (equal to 0.8%) are split as follows: 0.1% thanks to the heat recovery of whey (approx. 4% considering only the dairy processing phase) and 0.7% thanks to the packaging optimization (approx. 33% considering only the packaging phase: material productions and end-of-life).

#### 4. CONCLUSIONS

The results obtained agree with previous studies (Bava et al., 2018; Famiglietti et al., 2019). The raw milk production represents the main contribution (considering weighted results). The mitigation solutions proposed achieved good reductions in the specific phases (dairy and packer) but have a low benefit (equal to 0.8%) when compared to the life cycle of the product. Further improvements in the LIFE TTGG software development will lead to the involvement of raw milk production phase (approx. 80% of the total impact) and food wastage reduction (approx. 10% of the total impact).

The LIFE TTGG software development has just begun. The target of the software is to compare different mitigation solutions in each production phases. It is a key indicator to improve the EU PDO supply chain, especially for those not shown in this paper (raw milk production and food wastage reduction).

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## **RETHINKING AND RECONSTITUTED MATERIALS FOR A SUSTAINABLE FUTURE — “RECONSTITUTING-PLAN” PROJECT AS AN EXAMPLE**

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### **ABSTRACT**

Over the past two hundred years of the human industrial revolution, we have created an unimaginable material world and have achieved a brilliant success. But at the same time, we are consuming the resources of the earth. Because of the wide use of plastic materials since the 1950s, man-made and synthetic materials occupy a dominant position in the design and product areas. The continuous development and use of materials is like a double-edged sword, which leads us to prosperity and destruction.

Take “Reconstituting-Plan” project of the team as an example to discuss the reorganization and redesign of materials. Rethink people’s habits of creating and using materials and try to turn existing waste into raw materials. On the one hand, this project actively turn rubbish into new products; on the other hand, it try to make Bio Plastic using new formula and kitchen waste. The overall method and model are introduced, compare the performance characteristics of new materials and traditional materials through material recombination, remade, analysis and comparison designing experiments.

Materials are the foundation of design creation and the key to achieve ecological product design. Ecological and sustainable product design is inseparable from the design of ecological materials and interdisciplinary cooperation.

Key Words: Materials, Ecological, sustainable, Product design

## 1. INTRODUCTION

The human history development has the inseparable relation with the material history, material is the substance for human to use and make useful components, device or articles. The material development marks the society progress, for example, the wide use of stone implement is named as “the Stone Age”, similar as that, there are “the Bronze Age” and “the Iron Age”. It can be said that the human development process is accompanied with the whole process of material understanding, production and use.

The material universe and brilliant achievements are created in more than 200 years of Industrial Revolution, which is never imagined by predecessors, however, at the same time, we also consume resources on the earth violently, with the wide application of plastic material since 1950s, the artificial and synthetic materials occupy the leading role in the design and product industries. The constant material development and use by human is like a double-edged sword, which makes us move towards prosperity, meanwhile, also makes us move towards ruins. About sustainability, the definition generally accepted by people which is proposed in “Brundtland Report” in 1987 is that “it can not only meet our current demands, but also can not harm descendants and can meet their required development pattern”. In short, that is “not to do the thing which is harmful to the future at present”. It is required that we shall own the systematic perspective, which is also the only effective method of achieving sustainability. Due to the interconnection of most objects, we must consider these connects during the effective design.

Exactly as human’s rethinking to material after the 21st century, as the biological materials and ecological materials appear successively, the material sustainability becomes the critical study method in the material science, the sustainable materials are not only those which exist in the nature originally, as well as those which do not need to be machined and can be used directly, the sustainable material is also an interdisciplinary new field. At the same time, the sustainable material is the effective method for human to protect the survival environment and achieve the sustainable development of material industry, which has been the hot spot studied at home and abroad at present.

## 2. QUESTION

“There are professions more harmful than industrial design, but only a very few ... by creating whole new species of permanent garbage to clutter up the landscape, and by choosing materials and processes the pollute the air we breath, designers have become a dangerous breed ... In this age of mass production when everything must be planned and designed, design has become the most powerful tool with which man shapes his tools and environments (and, by extension, society himself). This demands high social and moral responsibility from the designer.”—Victor Papanek (p.ix, Papanek, 1985)

Such as Papanek’s worry, the raw materials are not only used up, it will also go with the pollution, rubbish and waste issues. In fact, all the evidence indicates that if we continue to develop in the current speed, we will need a second earth rapidly. How to proceed the sustainable development and how to balance the contradiction between development and pollution become the problem which has to be thought about. He re-thinks people’s habits to produce and use materials, discusses about the possibility of material recombination and redesign, which can make for finding the sustainable development direction in the future.

## 3. RUBBISH AND WASTES ARE TRANSFERRED TO RAW MATERIALS - “RECONSTITUTING-PLAN” DESIGN PROJECT

In the sixties of the last century, the U.S. Urban sociologist Jane · Jacobs put forward the urban assumption as the future mine, he thought that resources can be extracted from the limited natural resources, lots of required raw materials can be exploited from the urban rubbish. Rubbish and waste are the knotty problem for specialists and us, but it may be a “treasure” for designers. Designers collect alternative raw materials of products from industries, life rubbish and wastes, compared with the limited and expensive traditional raw materials, the wastes and rubbish are abundant and cheap. Therefore, brands and manufacturers also district their eyes to the family rubbishes and industrial wastes, and study how to transform their innovation to new raw materials, the measure is guiding us towards the future. “waste should simply not exist... waste is a resource.”

Based on that the concept derives the design practice project of “Reconstituting-Plan”, they hope to recognize and understand the household garbage and wastes again by the project, excavate the recycling potential of “rubbish and waste”, the project follows the principle of “from cradle to cradle”, tries to explore a systematic resolution which transfers rubbish and wastes to raw materials and products by simple processing and material recombination methods.

### 3.1. RePlastic

“Reconstituting-Plan” is the design practice project formed by RePlastic and BioPlastic, on the one hand, it recombines new products by the household wastes, on the other hand, it tries to produce the organic bioplastic by new formula and food wastes.

Plastic is a kind of valuable resource, however, the identity of plastic is very contradictive in the real life: we covet its convenience; but hate its pollution. In theory, every plastic product can be recycled and reused, RePlastic project pays attention to the waste plastic rubbishes in life, and transfers them to “new raw materials” by recycling,

then it plays the secondary value of “waste plastics”. The project mainly pays attention to the disposable plastic rubbish in life, such as PET bottle (PE), express package (PE), tubularis (PP), it looks for the processing methods of every kind of rubbish and wastes by the material recombination experiment, and designs and produces the materials and products with aesthetic value, such as bulk materials, sheet materials and products without visual sense and tactile sense effects.

In recent years, with the flourishing development of Internet economy, on-line shopping replaces with the traditional shopping form gradually, and becomes the main form of domestic shopping, which causes that the domestic express and logistic industries develop rapidly, and with it come the pollution issues of express plastic package and express accessories. The RePlastic project also put forward the feasible scheme to the express plastic package (main ingredient is PE). It fulfills to recycle the waste express plastic, endows a brand new life for it after the material recombination experiment.

Exactly as “urban mine” theory, it is a brand new resource, which can be transferred to a new product by simple processing, and it can be reused after the product cycle ends. RePlastic is a part of “Reconstituting-Plan”, which tries to establish a complete system, including material recombination, test analysis, productization and re-waste.



[Figure 1] RePlastic—“Express packaging bag” after material recombination comes out product

### 3.2. BioPlastic

Common plastics, like fossil fuel plastic is refined from petroleum, these plastics mainly depend on fossil fuel and generate greenhouse gas. But there is an important operation principle in the natural ecology -- the diversity principle, that is to say, in an ecosystem, the more diverse the elements are, the more complex the energy and material flow methods are, the more intricate the food cycle composition is, the stronger the automatic adjustment and stability ability of the ecosystem will be; on the contrary, the duller the elements is, the simpler the structure is, the lower the resistance ability to cope with environment changes will be. The principle is not only that operated in the natural ecosystem, it is also applied in the designs of sustainable material and products. Diversity is a kind of elastic strategy, when solving the same challenge or facing with the same problem, response in various of solutions and methods to reach the preset target. Exactly as the design practice project “Reconstituting-Plan”, prepare the material with the same property as the traditional plastics by the material recombination experiment, petrochemical materials are not the only scheme to meet people’s use demand, several different food waste materials can be transferred at present through BioPlastic project practice and constant attempt, then the alternative material like the traditional “plastic” property is obtained in many kinds of different preparation methods and ways.

Organic bioplastic is the alternative plastic material from the regenerative biomass resource, it is not the actual plastic, but a material which has the plastic property, such as from vegetable oil, starch or microbiota, the production methods of bioplastic are various, BioPlastic part of the practice project is trying to produce organic bioplastic by food wastes actively, it can produce the alternative material for the fossil plastic currently and put forward the more and possible resolution and design practice.

BioPlastic project mainly pay attention to the edible wastes and scrap materials in life, such as nut shell, all kinds of egg shell and garden stuff, it is enlightened by the molecule cuisine, looks for feasible preparation methods by the different prescriptions and proportion of material recombination experiment, finally the organic bioplastic with the fossil plastic characteristic can be obtained. And it designs to produce the bulk materials, sheet materials and products with the aesthetic value but without visual sense and tactile sense effect.

BioPlastic is another component in the “Reconstituting-Plan”, it obtains raw materials from food wastes, tries no waste from raw materials to processing production to finished product materials and product stage, raw materials is obtained from food wastes, and produced to materials or products, which can be corrupted or decomposed nat-

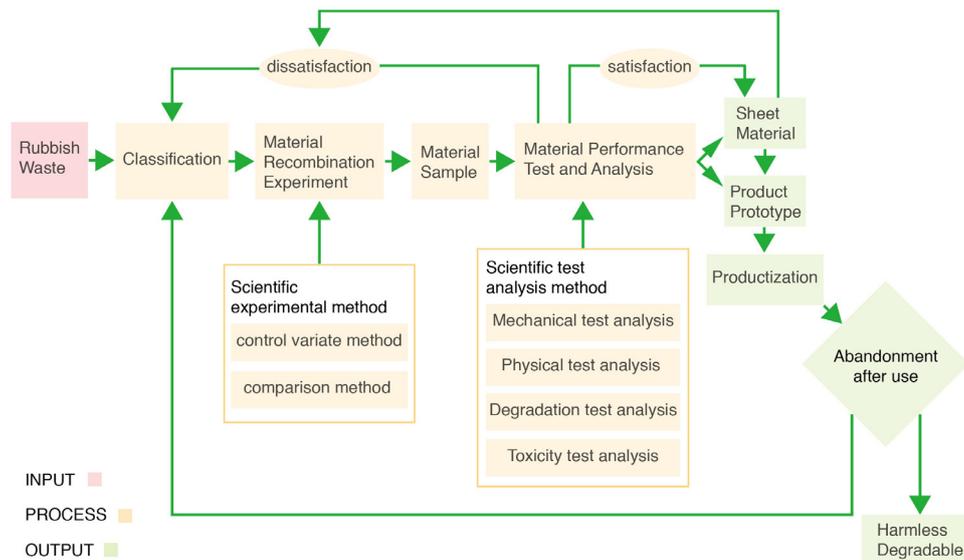


[Figure 2] BioPlastic—“Egg Shells” after material recombination comes out product

urally in the aerobic or oxygen-free environment after using. At the same time, these products can be recycled and entered the later life cycle of product after completing the life cycle due to the special natural components, which achieves the process from cradle to cradle indeed. The following application and development of BioPlastic materials have advantages and potentials in the fields of household products, bags and suitcases and building materials. The material hardness, abrasability and the surface natural pattern, texture and color are suitable for the household products or bags and suitcases; by exploring and studying food waste materials to excavate potential value, not only the waste egg shell, to look for more common materials which can be replaced by the recycling materials or wastes, it is the original intention of design of the whole “Reconstituting-Plan” -- to collect the alternative product raw materials from industrial, life wastes and waste yard, “waste should simply not exist... waste is a resource.”

#### 4. METHOD

The overall method model of “Reconstituting-Plan” project, as is shown in Figure 3: it is mainly composed of three main processes, rubbish and waste input stage, material recombination and recycling stage, and new material and product output stage. The research core of “Reconstituting-Plan” project is the material recombination and recycling stage and new material and product output stage, no further discussion on the front-end resource input stage of rubbish and waste is included in the project.



[Figure3] material recombination method

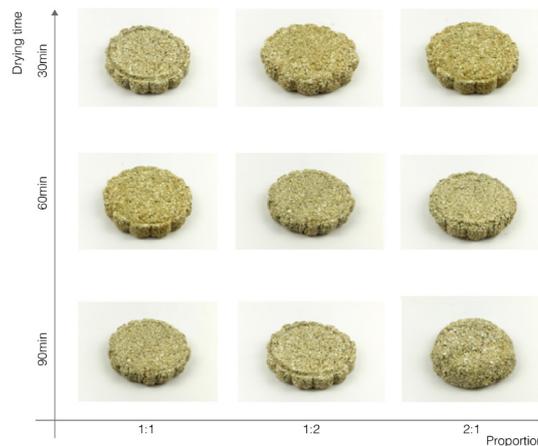
The material recombination and remake stage is the second stage in the whole model, which is the core method of “Reconstituting-Plan” project. Including four main parts, classification, material recombination experiment, material sample and material performance test and analysis, firstly, obtain the material sample by the material recombination experiment; then take the performance test and analysis on material samples, including tests and analysis on material mechanics, physics, degradation and poison; if the material sample passes the step, it can enter in the final product output stage, if the material sample is inadequate in the test analysis stage or it can not meet the productization demand, return back to the material recombination experiment again, adjust the detailed configuration method of material recombination again, enter the final product output stage after the material samples meet all the tests and analysis. The product output stage is the third stage of the whole, the strict second stage (material recombination and recycling stage) shall be passed before entering in the stage, but if the inadequate productization demand issues are still found in the bulk material, sheet material output or product prototype stage, return to the second stage again and adjust from the material recombination experiment. The third stage is not only production and manufacture, but also to pay attention to the issues of new materials or new products after using up the wastes, all the RePlastic project outputs in “Reconstituting-Plan” can flow backward the front end, and become “raw materials” again upon simple classification; however, the output in BioPlastic project can be decomposed harmlessly and naturally, the following researches of harmless decomposition still continue at present, the model is a kind of ideal “cradle to cradle” systematic design process.

In the quest for improved sustainability and enhanced performance, ... designers become scientists, and artisans become social entrepreneurs. All are crossing boundaries in the pursuit of a multidisciplinary approach; a spirit of collaboration is encouraging the exchange and sharing of knowledge and ideas. Designers learn from scientists in the material recombination and recycling stage, and use the scientific experiment, test and analysis methods, that is the common experiment methods of scientists, like control variable experimental method and comparative experiment method; the “material samples” after recombination enter in the test and analysis step, and use the common mechanical test analysis, physical test analysis, degradable test analysis and poison test analysis, the materials which are passed the test and analysis steps can enter in the product output stage, if there is some defect or issue found in

“material sample” in the analysis and test stage, drive new materials to return back to the material recombination experiment in the second stage.

To use a large number of intuitive and visual pictures to record, compare and analyze in the experiment is the difference from the scientific experiment in the material recombination experiment, the emphasis of material recombination experiment is not to study the microcosmic change and reaction principle, but to concern the material property and availability, it transfers information in the intuitive way, then pays attention to the aesthetic features of materials on the premise of meeting basic functions, like texture and tactile sense experience.

Application of control variate method in the material recombination experiment: Each group fixes a variable, changes another two variables, from the point of view of maths, it is called the control variate method. The experiment adopts the basic scientific experiment method, but the difference from the scientific experiment is to record the data changes behind materials in the image and graphic ways, to visualize the abstract and professional materials, and to use the experiment conclusion to find the waste materials combination mode as expected. Figure4, In BioPlastic project, prepare for the organic bioplastic with the waste egg shell, seek the final material ratio and dry curing time through the experiment. In this experiment, fix the component steps and overall dosage of material samples, change the dry curing time and the mixing ratio of starch colloid and egg shell, finally obtain the most suitable dry curing time.



[Figure4] BioPlastic—variate method in the material recombination experiment—Find the right ratio and drying time

Application of comparison method and mechanical testing analysis in the material recombination recycling stage: The comparison method is that designers reach the experiment target by comparing the unknown quantity to be tested and the known standard quantity. For example, in BioPlastic project, proceed the hardness test on the “material sample” of organic bioplastic and the traditional plastic food packing box to verify the availability of “material sample”. The experiment result can be seen from Figure 5, obtain the hardness average value of each tested material by the hardness test records, the “material sample” of organic bioplastic reaches the hardness of traditional plastic packing box as well.

Rigiscan	Test Object	HD	ERAGE
	 BioPlastics	45.8	52
		56.2	
		55	
	 Plastic Wrap	51.8	50
		50	
		48.8	

[Figure5] BioPlastic—The hardness test of BioPlastic and traditional plastic Wap boxes, comparative experiments.

Application of degradation test experiment in the material recombination recycling stage: The significance of taking the degradation experiment test in BioPlastic project is to investigate the “material sample” after the productization, end the rear-end issues in the life cycle which the product is used, roughly calculate the “material sample” of BioPlastic in the experiment, understand the degradation velocity and time cycle. The experiment is situation, simulate the degradation scene with the basic elements, like soil and water, record one change every 5 days in photos, the degradation process can be completed in about 30 - 45 days. The poison test analysis experiment and data in the project is ongoing actively.

## 5. CONCLUSION

Re-thick the relation of product design and society, as Victor Papanek said, the main challenge has not been the commodity production any more. Instead, you must make selections, “how well” can you handle? It is not the issue of “how many”. We are one the brink of a materials revolution that will be on a par with the Iron Age and the Industrial Revolution. We are leaping forward into a new era of materials. It is possible to contribute to balance the relation between human and earth again, and recreate the society. Share some relevant experience and project implementation methods with us through the “Reconstituting-Plan”, acquaint and concern the “rubbish, waste” treasures around us, discuss the possibility of material recombination and re-design, and conclude the approaches and models which can transfer the current rubbishes to raw materials and products, hope to provide a kind of better and more periodic design method for the sustainable future from the aspect of material recombination and redesign. The ecological and sustainable product design can't do without the material recombination and redesign, as well as the scientific design process and method.

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## **BAMBOO SUPPLY CHAIN: OPPORTUNITY FOR CIRCULAR AND CREATIVE ECONOMY**

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### **ABSTRACT**

This paper presents as a theme the productive capacity of bamboo related to the circular and creative economy. It aims to discuss at potentialities for its development in Brazil. It has become clear that the various stages of industrial production must respect the natural capital, rescuing issues such as the extraction of raw material and its impacts, the optimization of resources, the quality of the material, the use of materials available locally, the generation of employment and local income, socio-environmental responsibility and the search for sustainable and low-cost materials. In the national scenario one can see the abundance of bamboo and its economic potential, both on the scale of family and industrial production. At the same time, new ways of thinking about the economy, including circular and creative economy, are gaining space.

Key words: Supply chain; Bamboo; Circular and Creative Economy.

## **1. INTRODUCTION**

Bamboo is a renewable material that has about 1200 species around the world. In Brazil there are approximately 250 species (endemic or introduced), which can be used in food, products, building constructions, among other purposes. The bamboo presents fast growth, stores carbon and has great resistance, being considered a material with low environmental impact, economical and technical feasibility with great possibility of social assimilation.

Currently, the supply chain is in a consolidation phase, since bamboo requires knowledge about the properties of each species, its characteristics of use, guarantee of supply according to age, as well as the treatment used. It requires qualified suppliers capable of ensuring the origin of the product and manpower enabled for handling, as well as equipment that can ensure a qualified industrial or craft production.

In this way, there are many possibilities of generating products at each stage and filling the gaps, which occur from the production of seedlings and planting to the distribution of the products benefited. So, along with the ecological and social advantages that bamboo already presents today, one can notice its easy connection with the circular economy and the creative one.

Such integration would enable a considerable economic growth, which, adding value to a product of national abundance, with great aptitude for agriculture, could make Brazil a world reference in the planting and industrialization of the product, generating new jobs, creating income and economic development in local and national level. This article discusses this potential and identifies the possibilities of obtaining products from the bamboo raw material.

## **2. THEORETICAL REFERENCE**

The understanding of the processes, treatment and use of bamboo in Brazil is still incipient. Many studies were carried out, dispersed in the Brazilian states and with little national dissemination (Cardoso Jr., 2000, Manhães, 2007; Silva, 2011; Soares, 2011; Drumond E Wiedmann, 2017). In order to achieve the sustainability of the use of bamboo, it is necessary to integrate all stages of the production chain and to encourage good practices: management of plantations, natural preservation (preferably without harming the environment and human health due to the use of toxic chemicals), efficient equipment for the processing and production of primary, semi-elaborated or higher value-added materials and finally, the commercialization and use of components in industrial production.

Bamboo has many uses, and in the first decades of 1900, more than 1500 uses had been registered (Manhães, 2007). There are registered uses in agriculture, for irrigation, as biomass, as coal, as food, in construction, in the manufacture of plates and paper, as furniture, as a musical instrument and a series of decorative uses. These uses, the supply chain and circular and creative economy are addressed in more detail in the following items.

### **2.1. SUPPLY CHAIN**

According to the Brazilian Flora Species List (Flora Do Brasil 2020, 2019), Brazil is the country of the Americas with the highest incidence of bamboo in its territory. There are 258 species of bamboo in Brazil, as well as one of the largest native bamboo forests of the world, located in the South-Western Amazon. In some parts of the southwestern Amazon, bamboo is considered a pest, due to its high incidence and rapid propagation of some species (Ferreira, 2014), causing the rest of the flora to lose space in the place. What could be an ecological problem can become an economic and sustainable benefit.

According to the International Bamboo and Rattan Network (Inbar, 2018), the global bamboo market moves more than 60 billion dollars a year. With this information, the great diversity of bamboo in the Brazilian territory and the aptitude of its population for agriculture and creativity, one can observe the great economic potential that this tropical material represents for the development of the Country.

Some measures are already being taken by the government, such as the State Plan for the development of bamboo for the state of Acre, whose vision is to use bamboo to improve the per capita income of the state, increase the quality of life of local community, and minimize the environmental problems generated by the degradation of forest areas. All this through technical education, which is being applied by the Technological Center of Bamboo, inaugurated in May 2018, where the engaged population learns about aspects of the supply chain and their possibility of assimilation of employment.

The first step for an optimized chain is the production of seedlings or the identification of clumps. In the latter case, the extraction must undergo an environmental licensing process, like the other species of flora. In a familiar process, the seedlings can be made from the stem, roots and rhizomes of the bamboo at the time of harvest. There are other forms of propagation, such as seeds, by means of chusquines (method colombiano - Oliveira; Pereira; Pascoli, 2017) and *in vitro* propagation.

The second step is correct soil management. Cultivation is simple, but larger-scale production can be ensured through some care, such as soil analysis, mowing, herbicide use, ant and termite control, soil pH correction, subsoiling, fertilization, spacing between seedlings and depth of coveamento should be ensured. For woody bamboos, some peculiarities such as their adaptation to hot and temperate climates (rainfall of 1260 to 4500 mm annually incident in the Brazilian states) once again incites the Brazilian aptitude for the production of bamboo. The age at harvest influences the strength of the material and may vary depending on the intended use. It is recommended that

the harvest be carried out in drier periods when the bamboo has less sap, reducing moisture, facilitating transport and storage, reducing losses due to cracking as much as possible. However, this depends on the feasibility of material commercialization and on the climatic variations of the site (therefore, generalizations about the most suitable months for harvesting should be avoided).

Immediately after harvesting the bamboo must be treated. There are several possible treatments, from curing in the forest, impregnation of products by immersion, fire treatment, impregnation with CCA (Chromated Copper Arsenate) among other variations. This last treatment, much used for the woods, is prohibited in some countries. So, it is an option not recommended. Another option is the immersion in octaborate (boric acid and borax), which is an economical procedure with good environmental results and durability still under study (about 5 years, according to some professionals - Chalupe, 2018). Treatment should be carried out according to the purpose of the use and species of bamboo. After treatment and drying, the raw material is then transported to the desired industrial purposes.

The stage of industrialization is very wide, since all parts of bamboo can be used: from its leaves, to the water that accumulates in its culms. The leaves have the highest concentration of silica throughout the plant kingdom, being rich in proteins, fibers, antioxidant compounds and flavonoids (compounds present in foods like fruits, vegetables and cereals with antioxidant, anti-inflammatory and disease prevention function). The leaves of some species such as *Bambusa vulgaris* Vittata and *Phyllostachys pubescens* are used to make tea, contributing to the strengthening of bones, hair, nails, assist in detoxification, are anti-inflammatory, antioxidants, immunity regulators, aphrodisiacs and can be employed in the cosmetic and textile industry, as green manure and in the manufacture of the famous Zhuyeqing, which is a traditional Chinese tea made by the monks.

The bud of bamboo is more targeted for the food industry, for popular segmentation and high gastronomy. From it is made bamboo sugar, juice, beer and so many other millennial and current recipes.

From the culms is produced numerous components for the construction, bridges, furniture, musical instruments, bicycles, handicrafts, prostheses, coal (it is known that bamboo charcoal is of excellent quality, and its rapid growth balances the relationship between gas carbon dioxide emitted and absorbed), biomass, flour made with young stalk (rich in starch and used by celiac people), among others (Beraldo; Felisberto; Miyake, 2016).

With the fibers it is possible to produce a high quality artificial silk, as well as antiallergic mattresses, mats, nets, ropes, clothes, pulp, paper, crafts, etc. There is still the possibility of extracting the water that accumulates in the stalks in order to treat intoxications, hemorrhages, hemorrhoids and diarrhea. The water of the culms is digestive and soothing.

After all its possible uses by the user, the bamboo can undergo a process of extraction of biochemical raw materials to then go to anaerobic digestion and return to the soil as fertilizer or serve as a sustainable fuel through biogas.

Brazilian governmental initiatives already address aspects such as the definition of norms for sustainable management and for use in civil construction. It is necessary to identify market niches, invest in high value-added products such as bamboo laminate, furniture and window frames, observe the possibilities of exporting and partnerships with countries that dominate the material market, such as China, for example. Such perspectives of export were envisaged in the Memorandum of Understanding between the Ministry of Science and Technology of the People's Republic of China and the Ministry of Science and Technology of the Federative Republic of Brazil on bilateral cooperation in science and technology in the area of development in bamboo in April 2011 (Bambus No Brasil, 2017).

## **2.2. CIRCULAR AND CREATIVE ECONOMY**

The economy that governs humanity at this time is still linear. This economy has as a form of operation the extraction of the raw material, production, use and finally the discard.

This model was consolidated during the second Industrial Revolution, and becomes progressively unsustainable and obsolete for the modern world, considering the scarcity of natural resources, global overpopulation, global crises and inefficiency in waste management. We are approaching the fourth industrial revolution, the so-called industry 4.0, where technology, the internet of things, shared use, allied with personalization and product flexibility, promises to make sustainability tangible and maximize people's well-being. Never have the concepts of repair, redo, redesign, and rethink been so necessary to product design (Weetman, 2016).

According to the UNEP (United Nations Environment Program - Un Brazil, 2018), 99% of the products we buy are disposed of within six months and more than 2 billion tons of waste are produced for year worldwide.

From this perspective, the circular economy emerges as a new trend of an economic model that aims to articulate a conscious and optimized way of extracting, producing, consuming and discarding (Sampaio et al, 2018). According to the Ellen McArthur Foundation (2015) definition, this form of economy aims to "[...] maintain products, components and materials at their highest level of usefulness and value all the time, distinguishing between technical and biological cycles. This new economic model ultimately seeks to dissociate global economic development from the consumption of finite resources. The circular economy responds to challenges related to resources for companies and countries and could generate growth, create jobs and reduce environmental impacts [...]"

It is known that Brazil is currently the largest exporter of agricultural commodities and minerals. Thus, arable land and biodiversity become the essential elements that structure this economy. So, environmental certifications, soil regeneration, post-cultivation and restoration of degraded areas are the least that can be done in a country that depends mainly on natural capital.

A precept of the circular economy, and the perspectives of the Ellen McArthur Foundation for Brazil, is the investment in agricultural technology coupled with vernacular knowledge to change the country's impressions as an

exporter of agricultural commodities and biological raw materials, working for an economy that adds value to the product, with the goal of putting the country at the forefront of global sustainable innovation.

Another form of economy that aims to add value to the product in a differentiated way is the creative one, which is a set of businesses based on intellectual, cultural and creative capital. The definition of the Brazilian Service of Support for Micro and Small Enterprises says that this form of economy “...stimulates income generation, creates jobs and produces export revenues, while promoting cultural diversity and human development.”

The Creative Economy covers four areas: Consumption (Design, Architecture, Fashion and Advertising), Media (Editorial and Audiovisual), Culture (Heritage and Arts, Music, Performing Arts and Cultural Expressions) and Technology (R & D, Biotechnology and ICT) which according to the Creative Industry Mapping (Firjan, 2016) collaborated with 2.64% of the national GDP in 2015, with more than 851.2 thousand professionals.

## 2.2. METHOD

In order to achieve the sustainability of the use of bamboo, it is necessary to diagnose all phases of the production chain in a circular and creative scenario, and to encourage good practices: plantation management, preservation, equipment for the processing and production of primary materials, semi - elaborated or of greater added value and, finally, the commercialization and use of the products. To achieve the objectives of the research, it is presented the modeling of the chain and possibilities of product generation in the stages, in order to obtain its development, by filling the gaps in the process.

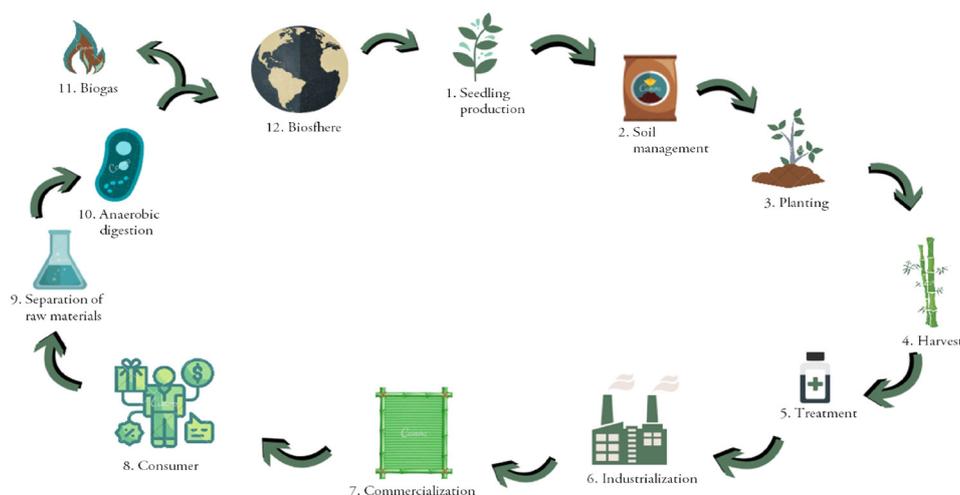
As results, it is expected to show the employment potential, technological transfer and knowledge about the supply chain in Brazil.

The first stage of the research consisted of a bibliographical review. The words: bamboo, circular economy OR creative economy and supply chain were used as operators. The initial search in google academic returned 20,200 references, not all relevant to this research, which were confirmed by the research in the CAPES journals portal, presenting the following most relevant authors: Waite (2013), Murray; Skene; Haynes (2017), Weetman (2016), Van Wijk, Van Wijk (2015) and Van Dam (2005).

For the understanding of the bamboo supply chain, several references were consulted, besides those found in the systematic review. To understand the activity of the bamboo developed, the book *Bambus no Brasil: da biologia à tecnologia* (Drumond; Wiedman 2017) was consulted. At the stage of understanding circular economy, the Ellen McArthur foundation’s support material “Rumo a economia circular: racional de negócio para acelerar a transição.” was used, and the national perspectives in “Uma economia circular no Brasil: uma abordagem exploratória inicial” (Ellen McArthur Foundation, 2015). The second stage consisted of the supply chain modeling followed by the identification of the potentialities for the circular economy.

## 4. NATIONAL POTENTIAL FOR THE CIRCULAR AND CREATIVE ECONOMY

To understand the steps and how they relate to each other, what their products are and what the employment possibilities generated at each stage, a scheme was developed that demonstrates the phases of the bamboo supply chain within a circular and creative economy. [Figure 1]



[Figure 1] Stages of the supply chain. Font: authors.

The products in the steps are as varied as possible. In step 1 we have the production and sale of seedlings and seeds, followed by soil preparation and planting. In the fourth stage, the product is the bud of bamboo, the seedlings rom parts of the bamboo (stems, roots, rhizomes), the green manure and the use of bamboo water that accumulates in the culms for homeopathic purposes.

In the treatment phase a possible product is sodium octaborate, a salt which serves as a fertilizer. In step 5 we

have a vast product range, more than 1500 cataloged applications (Manhães, 2007), among them: enzymes, hormones, cosmetics, bacteria, coal, energy, biofuel, alcohol, textiles, aqueducts, ropes, bridges, paper, handicrafts, food, silica extract (tabashir), asthma medicine, medicinal drinks (as a substitute for steel), in sealing elements (panels with adobe, quinchas and bahareques, decorative plaited panels, esterijas (mats or mats), tiles, linings, ceilings and beams in civil structures, which can be used in the production of paper, can have various applications in composite materials. The leaves, due to the high concentration of silica are widely used by the cosmetic, pharmaceutical and textile industry, the stalks due to its great resistance are aimed at the civil construction, furniture industry, handicrafts, coal, among others. With fibers it is possible to produce an artificial silk pulp, clothing, among other things.

Opportunities for the creative economy can be found from the beginning of the chain, for example in the manufacture of canned bamboo for human consumption, or even in the purification of springs by simple planting. The greatest potentials arise in the stage of industrialization, commercialization and consumption.

Through the technical and cultural stimulation of the use of bamboo, creative forms of use can add value to the material. Examples include the initiative of the Brazilian company PetBamboo in the production of feeders and drinkers for pets with bamboo fiber. There is also a group of artisans from Acre who produces more than 100 bamboo guitars per year. The production of only one guitar takes about two weeks in an artisan way. Sustainable marketing and differentiated sound and more acute than bamboo provides are aspects that add much value to the product that already has perspectives of industrialization and export. We can also mention the Canadian company ChopValue, which works making furniture and accessories using chopsticks for Japanese food, hydraulic press and a water-based resin for the creation of products with high added value.

After initial use, the circular economy provides for optimization by reusing or using by-products. This means making the sequential use of the material, predicting the smallest internal circuits of the systems, such as restore, renew, re-pass, only to recycle. At this point, the importance of designing for durability is emphasized, as opposed to the linear system that feeds on programmed obsolescence. Professionals of the future need to be molded to design for remanufacturing, renovation and recycling.

After cascading, according to a circular economy, the bamboo can undergo a process of separation of the raw materials that make up the product. Many products can be studied for this destination, including use as fuel for stoves, boilers, engines and sustainable electricity generation through biogas. At the end of the cycle, the material will return to the biosphere, nourishing the soil and allowing the fertilization of other plants in a sustainable cycle.

## 5. FINAL CONSIDERATIONS:

Through the understanding and improvement of the stages of the production chain of bamboo at the national level, primarily in the treatment (to confer quality), industrialization (adding value to the product) and commercialization (export and recognition of the national product of the world market), Brazil would assume an active role in the world market with exports of manufactured bamboo products. There are many opportunities to explore. The production chain of bamboo in Brazil needs promotion, dissemination and incentives that go through governmental policies, innovation in research to develop new uses, adequate equipment, technologies for treatment that do not compromise the health or the quality of the environments where the material is workshops and activities to disseminate the best techniques for the material. Finally, as a gift from the gods, the human being can not miss this opportunity to search for a more sustainable way.

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## **ALTERNATIVE MATERIALS TO IMPROVE THE ASSEMBLY PROCESS OF FURNITURE FOCUSED ON SUSTAINABILITY DESIGN**

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### **ABSTRACT**

The design of furniture is an area in constant evolution. The development of new materials (especially wood panels and transformed special metal hardware) allied to modularization and standardization has facilitated the process design. The aspects of sustainability (social, economic and environmental) must be present in furniture design. It is considered as a tendency that furniture should be designed so that assembly could be made without screws or tools. For this, the use of alternative materials like bamboo, coconut fibre, sisal, recycled materials and hemp can contribute in the reduction of the environmental impact. Assembly with these materials is simpler. The entire process contributes to the understanding of the real meaning of the LCD (Life Cycle Design) and designing for the life cycle.

Key Words: Sustainability, Materials, Furniture, Design.

## 1. INTRODUCTION

Furniture is part of our everyday lives, and over the centuries, it has evolved to meet consumer needs. The development of new materials (especially wood panels and transformed special metal ironmongery) allied to modularization and standardization has facilitated the design of kitchens and cabinets in general, for example.

The assembly of the furnishing, though, is a relatively complex process, and often requires qualified professionals to perform it. Few companies provide the public detailed and easily understandable instructions that would allow the installation, even to those who are unaware of the concepts of technical drawing. A relatively large amount of tools is also required.

On the top of that, various social factors are leading to a behavioural change. Nowadays the homes tend to be unoccupied during office hours, when it would be most proper for assemblers perform their job. This problem is mainly due to two main factors:

- The absence of the figure of the housewife. The rising cost of living coupled with the arousing of the women workforce in the labour market, allied to others women's achievements in the professional field have virtually extinguished the wife as the housekeeper, or housewife, as it was commonly called the woman who did not work (except at home);
- The rising cost of living and labour achievements of domestic workers increased their wages and benefits, so many families have dismissed such workers.
- The reduction of the nuclear family (nowadays is common for couples to have a maximum of 2 children, whilst on the 70's the average was 4 children, and on the 50's it was 6 (IBGE, 2013). This fact, associate with the low-sized apartments trend, reduces the housework considerably.

Thus, during office hours, parents work, children go to school and the houses are empty. The assembly of the furniture by professionals is subject to alternative schedules, making the installation time longer than its delivery time. This fact generates frustration and annoyance for both sides: the seller wants to complete the service and the client wants to use the appointment, especially because the payment has often been made. Many consumers prefer assembling the furniture they have purchased, to avoid waiting for that long. Some stores even offer different prices for those shoppers that purchase, take and assemble the furnishing themselves, which reflects the adoption of a new strategy.

When addressing this problem, it was decided to import the study of furniture confection design to project disciplines, as a part of design project. Designers need to consider the mounting procedures by the user's point of view, in order to make it as easy as possible, so it can be done by unaware people. This requires an interdisciplinary approach in design practice, working in the area of Product Design (furniture design), Industrial Design (design for assembly, component design and manufacturing) and Graphic Design (instruction manual and assembly procedures for users). Sometimes even to Animation Design, creating animated videos with assembling procedures by internet.

The "Do It Yourself" (DIY) approach has disseminated to other areas, and one of these is the house-building sector. In this field, the DIY methods brings new initiatives which always use the local materials available, as clay or bamboo, and not-necessarily includes the prefabrication method, although it could implicate on performing.

This paper presents the partial results so far obtained from projects realized on a subject of an Design, Architecture & Urbanism and Civil Engineering brazilian courses, which focus are furniture that can be assembled by the user, using alternative or not conventional materials. In second plan, it's considered the expansion of the DIY approach to housing construction, by the use of local available materials, through experiments involving the Architecture & Urbanism and Civil Engineering courses.

## 2. LITERATURE REVIEW

Romeiro Filho et al (2010) have demonstrated the importance of project integration, so the intended objectives are achieved in the present study. In accordance with the foregoing designers, planning often requires mental strategies and external representations as modelling and prototyping.

This research has applied the concepts associated with "design to the life cycle" along with development of product concepts, emphasizing the early stage of use. So the concepts approached were the ones presented by Manzini and Vezzoli (2008) and LCD (Life Cycle Design) and Rozenfeld and others (2006).

The worries about the furniture assembling are evident. Most companies of furnishing sector have been endeavouring in this sense, even draftsmen and furniture designs have already noticed that it's a crucial point to the craved success.

According to design sites (DOPLUDO, 2013), the russian designer Leshia Galkin, along with Dopludo Collective, make the furniture they design together available through internet files. The point is releasing pictures and videos explaining the assembly process so the user can build it by himself.

The idea behind the project is to share information (participative design) and then making the original files available. The point is that any assembling may be realized by the user. The most recently project created by them, called APTEK Bar, is already available. The typical design projects are simple furniture, even though they are creative and modern.

The company MVX Móveis Planejados, for example, provides an assembly manual in an easy understanding

and viewing form. The mostly furniture are assembled only by a Philips key and a hammer. Although, when it is necessary something more, they describe it in detail on the guide - the manual contains information for unware users in assembly, as example “Why is affixing the bottom important?” or “before removing the internal shelves make sure the doors and drawers are closed”. However, on the company’s site, there are recommendations for hiring an assembler (MVX Móveis, 2013).

Today, most companies which sells appointment by the internet do not offer the installation of their projects. It would be unsustainable, since they deal with large areas. By the other way, they can sell their products on a lower price, since it does not have the setting tax. And that is an advantage of buying furniture by internet. Nevertheless, the most part of the producers recognize that the users are not able to do some parts of the assembling, compromising the quality of the product or even being in a risk situation. So, it is necessary the project to forecast that, what is not necessarily occurring.

The approach “Do It Yourself” emerged in 1950s at USA, aiming to low the service-cost. Then, in an amateur way, by the theory of “try and error”, corporative managers start developing products easy to install, with appropriate package and construction guide. Nowadays, furnishing projects demand a specialized service with knowledge that overcomes the user’s one. The personal requirements to apply for an assembler’s job are a proof of that, like the examples below:

- Founded in a job-offer site (Vagas, 2013), the requirements refer to an assembling job offer in Grande Florianópolis, Brasil: “Will be responsible for delivery/assembling of company’s products in the costumers homes, using appropriate tools and equipment, checking all components, avoiding defects.”
- Alike the first one, many others can be founded in a simple search in specific sites and newspaper, as an announcement for a Curitiba – PR – Brasil company (Emprego Certo, 2013): “Will work with conventional and planned furniture assembling. Preview experience and knowledge in conventional and planned furniture is required. Must know to handle tools and piece finishing.”

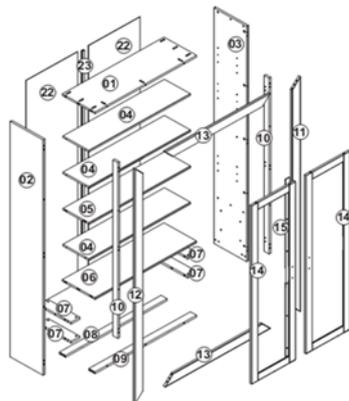
These demands show how the appointment building process is difficult, specialized and expansive. And, by the end, all the seller wants is to conclude the selling and the client wants to see the furniture in use, because the disbursement has already been made in most cases. So, the consequence is that many consumers prefers to assembly the furniture by themselves, in order to not expect so long. But, the lack of experience may harm them. The results may compromise:

- the aesthetic factor: incidence of uneven surfaces, finishing problems at all, etc;
- the technical aspect: doors that do not close properly, problems in composing modules, for example;
- security issues: misplaced screws and bushings, risk of injury by improper lifting of loads and uncomfortable positions in the assembly.

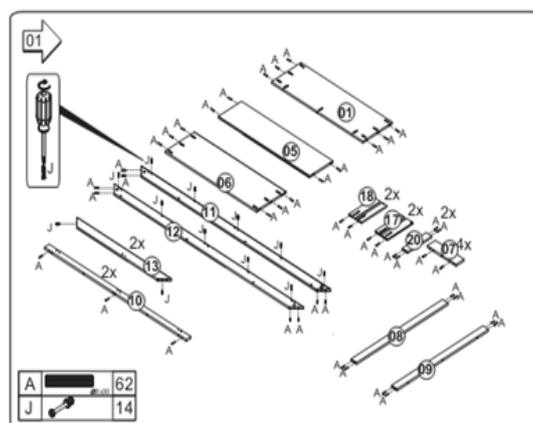
Some stores offer different prices to the user who purchase, take and assemble their own furniture. This reflects a new strategy adopted by them. Designers and others professionals from the area have noticed the problem and started developing guides increasingly detailed. They explain all the tools that are needed, the assembly time and steps. Figures 1, 2 and 3 represent the proceeding used by a supplier. Figure 1 shows a perspective view of a shelf and figure 2 shows the exploded perspective view, aiming to help on the pre-classification of the pieces, making the building up easier. Figure 3 details the basic ironmongery (quantity and types of screws, bushing, etc).



[Figure 1] Shelf in Perspective



[Figure 2] Exploded shelf perspective.



[Figure 3] Basic ironmongery details.

Source: <http://meumoveldemadeira.com.br>, 2013 ce: <http://meumoveldemadeira.com.br>, 2013 Source: <http://meumoveldemadeira.com.br>, 2013

Usually, the companies also provide information about how many people are needed (2 people, for example), the necessary tools (as hammer, Philips keys, etc.) and the estimated time for assembly.

The “Do It Yourself” (DIY) approach has disseminated to other areas, and one of these is the house-building sector. Obviously, some of the traditional characteristics, as prefabrication and installation facility, were updated and modified in reason of the local resources available. Many of these, as bamboo, requires a different way of designing and building, where the designer often interacts with the construction and ends being the final user of his product.

Many examples of DIY can be found: from pallets houses to earth bag and lumber ones. In these cases, not necessarily they present an easy assembly, although the use of alternative material is a common characteristic. An important example of DIY on civil construction is the “Paper Log Houses”, originally created by Shigeru Ban Architects (SBA), where the construction structures are made by paper tubes. The first models were built in 1995, aiming to shelter the victims of the Kobe earthquake in Japan. Due to be large constructions, the professional assistance may not be dismissed. However, during the constructive process, volunteers and community can freely be the constructors by themselves.

Some of the Shigeru Ban observed requirements to use the paper tube construction method are: 1) it must be easy to assemble and disassemble the components, in order to reuse them in the future; 2) it must use local materials, with practical fabrication and modelling, in reason to include community in the constructive process; 3) thermal comfort and favourable aesthetics; 4) respect the needs, privacy and culture of the users, aiming to build a dignified temporary shelter; 5) the construction time must to shelter the needed as soon as possible.

### 3. METHODOLOGY

The methodological procedures of this study were: defining the problem (presenting the proposed research to the students group), literature review, field research (visits have occurred to furniture fabrics), conceptual designing, laboratory tests (model building, drafting the assembly instructions, testing the assembly feasibility), considerations and adjustments.

Figure 4 illustrates the searching process used, showing the main steps.

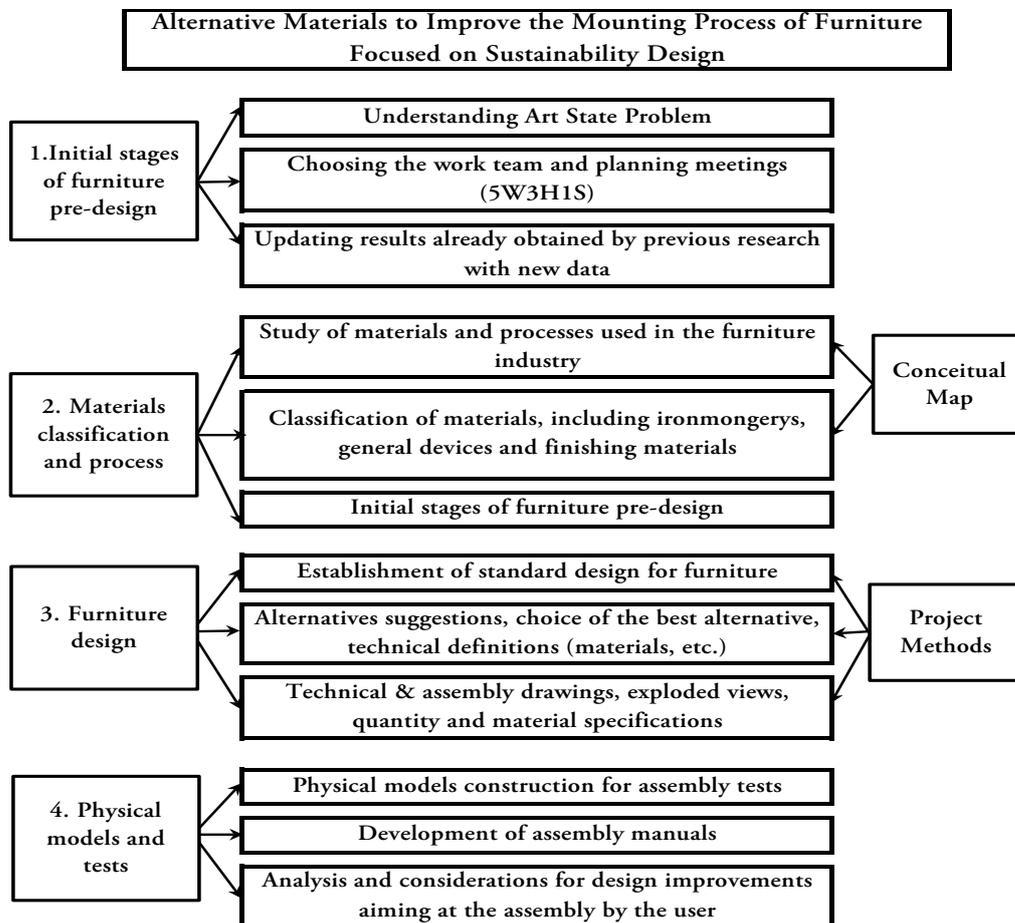


Fig 4: Searching process.

### 4. PROCESS

The assembly procedures were incorporated into the furniture project, and were confectioned small-scale physical models. The construction was conceived in order to simulate real situations, where the designers studied the metal ironmongery, the weights and proper procedures for non-professional customers.

The final step is constituted of exchanging guides and improving them: one group, using other’s one guide, tried to assemble the appointment, checking for possible problems. Considering the comment received, they reformulated their guides, making the installation easier.

Has been settled as an assembling standard that the user should need just two tools: Phillips keys and hammer. Both should be provided to the client with the bought furniture. To simplify, was settled that would be used just 3 different screw sizes.

The final results were: a booklet to be delivered accompanying the furniture with step-by-step instructions; a basic tool kit, which was added to the assembling kit; and a virtual instruction manual, with the assembly procedures available online. The entire process contributes to the understanding of the real meaning of the LCD (Life Cycle Design) and designing for the life cycle.

Keeping the DIY approach, it was realized the assembly of a bamboo housing modular prototype (figure 5), in partnership with Architecture and Urbanism Department of UFSC, (VITOR, 2018). The author and engineer realized the project and the construction, also trained the team for construction, intervening in all stages of the process. One of the biggest results was the importance to align engineering and design, which must be included as a parallel form of construction, inside the engineering precepts.



[Figure 5] Bamboo habitation prototype. Source: Victor (2018)

## 5. FINDINGS/RESULTS

The project is still in progress, and so far it can be concluded that is possible make available, in large scale, pieces of furniture that can be assembled by non-experts. Other way is the simple fitting process of furniture construction, eliminating the use of screws and other tools. In habitation, the DIY approach using non-conventional or alternative materials like bamboo rise the necessity of a new culture of design and construct with the users participation. In a general view, the necessity of a deeper research with unware public was noticed, in order to verify their behaviour about lecture and interpretation of guides.

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## SUSTAINABLE DESIGN PRINCIPLES FOR USING BAMBOO STEMS

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### ABSTRACT

This paper sets out to explore possibility of increasing the usage of bamboo stems in product design. The researchers argue that bamboo stem is a sustainable material that provides similar benefits as bamboo sheet materials and represents an untapped resource. Through market research, field study, and interviews with manufacturers, the researchers found that both internal and external constraints prevent bamboo stems to be adapted for mass production. The main internal constraint is the inconsistency of bamboo stems' diameters. The researchers examine several forms of connectors used in bamboo stem products and found two joint types that might help solving this problem. To better understand the external constraints, the researchers conducted a survey and follow-up interviews to reveal the gap between user needs and the capability of manufacturers. In conclusion, several key issues that should be resolved by design are listed to provide design directions.

Key Words: Sustainability, Bamboo Stem, Product Design, Structure Design

## 1. INTRODUCTION

Bamboo, as a fast-growing, biodegradable, and renewable material, has long been used in building construction and product design in many parts of the world. Bamboo is an acceptable alternative for wood because it offers similar physical-mechanical properties while having low negative environmental impact that meets the criteria for sustainable materials recommended by several organizations such as Cradle to Cradle Product Innovation Institute and US Council for Green Building, etc. Presently, bamboo plywood (also known as plybamboo) and fiber board<sup>1</sup>, both sheet materials, are two main forms for utilizing bamboo in design and construction.

Bamboo stems retain the natural cylindrical form of bamboo and have been used as a material in traditional craft making as well as in building construction in bamboo-growing regions such as Eastern Asia, Africa, and South America for centuries. It shares many of the same environmental advantages as the sheet bamboo materials. However, as new materials and became available and industrialization of manufacturing became a norm, the market for bamboo products shrank. People are less and less likely to encounter bamboo products, including products made with bamboo stems.

As the movement of sustainable development gains traction around the world, bamboo stems once again gain the attention of designers because they could be a more economical material than plybamboo. Designers hope to increase the use of bamboo stems to save resources as well as investment. There are many award-winning designs utilize bamboo stems, including some appearing in international awards such as the Red Dot and i.F. design competitions. But according to our observation, bamboo stem products are still largely absent in our daily life. There are also no established and well-known brands of such products. Innovative bamboo stem products are even rarer.

We argue that there is a great potential in using bamboo stems as a sustainable material in product design if we can find better ways to overcome the internal constraints (material properties) and external constraints (viability and desirability) of the material (Arce, 1993). Due to the internal constraints, bamboo stems can only be used in specific scenarios. What are these scenarios? Can these scenarios be expanded? We also understand that sustainability is only one of many factors in product design. Designers choose materials mainly based on the products' functional, economical, and aesthetic needs. How do we market the full potential of bamboo stems to designers? What are the obstacles in the mass-manufacturing of bamboo stems that prevent them from being widely used? To answer these questions, a list of guidelines for using bamboo stems in design needs to be created. By interviewing designers and manufacturers of bamboo stems and analyzing the current usage of this material in design, our study intends to improve the understanding of this material and its use in product design.

## 2. THEORETICAL BACKGROUND

Our hypothesis for this research project are: What are the obstacles in the mass-manufacturing of bamboo stems that prevent them from being widely used and what can designers do to help overcome these obstacles?

### 2.1 Bamboo as a Sustainable Material

Bamboo stems and plybamboo/bamboo fiber board share an origin but their usage in design are quite different due to their manufacturing process. First of all, bamboo stem retains the anisotropic property of the original plant and has superior specific strength (Dixon & Gibson, 2014) compared to bamboo boards, which allows it to become a structural component by itself. In architectural design, bamboo stems have been tested and proven to be available alternative to steel bars, based on the results of several studies conducted since the 1970s (Janssen & P.M.; Ramanuja Rao, 1991; Ogunbiyi, Olawale, Tudjegbe, & Akinola, 2015). In furniture design, bamboo stems could be seen frequently used as supporting components (Esteve-Sendra, Moreno-Cuesta, Portales-Mananos, & Magal-Royo, 2012). Their lightness also makes bamboo stems a good option in the case when weight is an important factor in design.

Secondly, bamboo stem's natural and distinct form inspires users to associate Eastern culture with the products made from it. This is because bamboo products and its cultural meaning occupy an important position in the material and spiritual life of the Chinese people (Fang & Yan, 2015; Shen & Zhang, 2005). Bamboo has been widely used in traditional Chinese art forms such as calligraphy and painting. Products made with bamboo stems can also be associated with the enjoyment of nature. Therefore, the use of bamboo stems might be desirable for city dwellers who would like to incorporate natural elements into their home decor.

In terms of sustainability, Lugt, Vogtlander, and Brezet (2009) pointed out that transportation has a large influence on the eco-costs of bamboo stems: due to their hollow shape, smaller quantities of the stems can be shipped in a shipping container compared to sheet materials. In their report, 94.5% the eco-costs of bamboo stems were caused

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<sup>1</sup>Definition of terms:

Bamboo stems: hollow bamboo sticks with nodes.

Bamboo stem products: products made of mainly bamboo stems.

Cultural symbolism: the association users make between certain materials and culture. In this paper, this symbolism specifically means the texture and the grain of bamboo stems often remind users with traditional Eastern/Chinese culture because their extensive presence in traditional Eastern/Chinese paintings, literature, and furniture.

Association with nature: means users commonly associate the material with nature, which provides a sense of comfort, relaxation, and affinity.

Material properties: Toughness, pulverability, rigidity, plasticity and elasticity/ductility.

Application of Materials: to maximize the benefits of a particular material to fulfill certain functional requirements or provide superior quality.

by the sea transportation from China (the material's origin) to the Netherlands where the study was conducted. But if the production and consumption were completed at the origin, the eco-costs of bamboo would be drastically lower than all other materials they had calculated, including various wood materials and steel. In the era of globalization, these transportation costs might be inherently associated with many products that utilize materials from around the world. Therefore, we can argue that bamboo remains a viable option for sustainable design.

Based on life cycle assessment, bamboo stems have the potential to have less environmental impact than bamboo boards because the manufacturing processes of these materials have significant differences. Bamboo stems do not require additional manufacturing procedures such as gluing and pressing the bamboo strips as does plybamboo (Lugt et al., 2009). A common alternative to this method is to extract the fibers of bamboo and then hot press them into fiber boards without any adhesives (Ogawa, Hirogaki, Aoyama, Taniguchi, & Ogawa, 2010). The processing of bamboo stems also omits these procedures, thus it has the potential to reduce overall energy consumption, which makes promoting the use of this material worth pursuing.

## 2.2. Physical Structure for Contemporary Bamboo Stem Product

To understand the current usage of bamboo stems in products, we created a database of products using bamboo stems currently in the market. These products were categorized into furniture, building construction products, household products, and heritage-based products. These products' material use, sizes, component numbers/complexity, nodes design, cultural attributes, functionality, costs/prices, etc. were documented and compared. In this paper, we focus on categorizing and analyzing three groups of bamboo stem products by structure: Traditionally structured bamboo stem products; Contemporary product designed for mass production; Contemporary bamboo stem product design based on computer-aided manufacturing<sup>2</sup>.

### Discussions

When considering borrowing joint design of bamboo stems in architecture, the scale of design must be taken into account. Users are usually sufficiently far away from joints of building materials to ignore their complexity or irregularity. But people interact with products made of bamboo stems closely. Joints that are overly complicated or coarse will negatively impact user experience. We conclude that minimalizing complex joints should be a goal in product design using bamboo stems.

Bamboo stems are hollow like plastic or metal pipes. Bamboo fibers absorb moisture in the air like wood. These characteristics led us to contemplate the possibility of borrowing joggle way and design from wood. However, we found that bamboo and wood have vastly different expansion rate with temperature and moisture absorption rate, which affect the durability of products made of them.

Since it is likely that bamboo stems will be used with other materials such as plywood, glass, or metals in mass processed products, we argue the joint design for bamboo stems must be able to also accommodate other materials to allow for easy assembly and disassembly.

## 2.3 Joint Design of Bamboo Stems for Standardization of Production

Bamboo stems might need to be joined with other materials to create products. We conclude there are these possible joint design to use bamboo stems in products<sup>3</sup>:

- Hoop plate joint: two bamboo stems are connected through a round wood part collinearly, then tightened by a hoop plate.
- Mortise and Tenon joint: shouldered joint, through and wedged joint, plastic joint, etc.
- Pull and screw rod joint.
- Embedded metal and plastic joints: metal parts are embedded into the bamboo stems and then connected into other parts.
- Rod and screw joint: a rod goes through several stacked bamboo stems vertically, then it is screwed down on both ends.
- Multi-connector joint: using multiple connectors to fit into bamboo stems.

### Discussions

Bamboo stems are hollow, have many nodes and variances in diameters, which make standardization of production difficult. The joints shown above are commonly produced and widely available. However, they still require a high level of consistency of the material. During our field study of the bamboo forest, we observed that the harvesting of bamboo stems is highly mechanized and non-discriminatory. Artificial intelligence in the near future might allow us to be more selective in this process. Nonetheless, currently we have to rely on people to select bamboo stems to ensure consistency in forms, which is an undesirable job for most. Consequently, the consistency of the diameter of bamboo stems is difficult to guarantee.

Another problem is that as joint parts can only be fit into a certain diameter of bamboo stems, to reach the re-

<sup>2</sup> Images available in presentation and upon requests.

<sup>3</sup> The stability and weight bearing capabilities of these joints need to be studied further. This paper only discusses the possibility of utilizing these joints in mass production of bamboo stem products.

quired structural integrity, the ends of the stems must be inspected and modified by hand. This procedure increases the labor cost and prolongs the production time.

Since one direction to solve this problem is to design joints that can accommodate variance of diameters as much as possible, we found the solution might lie in the following joint design, the embedded metal and plastic joints and the rod and screw joint. These two joints, especially the latter, have the potential to connect bamboo stems of various diameters with standardized joints.

### 3. RESEARCH METHOD

In this study, two research methodologies were employed. First, we conducted multiple field studies in China to interview manufacturers and designers to discover problems they encountered while attempting to use bamboo stems in mass production. Our interviewees included: sellers at bamboo product markets; competitors and organizers at design competitions; technicians and owners at bamboo manufacturing factories; bamboo growers and sellers; bamboo wholesalers. These interviews were conducted at several locations over a period of several years, usually in informal and unstructured settings. These field studies provided us with a general understanding of the current manufacturing and marketing practices using bamboo.

#### 3.1 Survey and Analysis of Consumer Perception of Products Made with Bamboo Stems

To understand the current consumers' perception of bamboo stem products, we distributed a survey in January, 2019 via WeChat<sup>4</sup> to Chinese respondents. Responses were voluntary and 280 responses were received. Because the distribution was done through various chat groups of designers and friends of the researchers, the sampling cannot be stated as completely random and skewed towards design professionals.

Our analysis of the data collected from the survey shows, 50.71% of the respondents have not used bamboo stem products, and however, most reported they have seen images of such products. 48.57% reported that they have little to no knowledge of such products, yet 70% claimed that they like the form of bamboo stems.

Analysis shows that respondents' age affects their preference for the bamboo stem products' cultural symbolism and association with nature: As their age increases, the respondents care more about the practicality and association with nature of bamboo stem products, and care less about the cultural symbolism. Another surprising finding from our analysis is that respondents who have not experienced bamboo stem products prefer the unique style of bamboo stems, while respondents with experience in using these products tend to pay more attention to the value of these products.

We selected 18 images of bamboo stem products to show to the respondents and they were asked to rate the products in terms of their preference and their cultural and natural values. Our survey found that there was a strong positive correlation between the respondents' preference and the product's cultural and natural values.

The main problems of bamboo stem products that we found is that they tend to split after a while, which deters users from choosing these products. One of our interviewees, a craftsman in Zhejiang Anji, said that the nodes and sheath can protect bamboo stems from splitting. He suggested keeping the sheath and nodes. If the ends of the stems have no nodes, then they should be wrapped with ropes or rattan skins to imitate the nodes' function. Though research in preventing stem splitting has been conducted by various researchers (ZOU, Yi-jia, CHEN, Yu-he, WU, Zai-xing, CHEN, Zhang-min. 2012), designer must understand that because the hollow form and moisture retaining quality of bamboo stems, the stems must be treated when close to the ground. There are two ways to achieve this: 1, strengthen the ends with bamboo nodes or similar structures; 2, avoid absorbing moisture from the ground. More efficient and standardized methods need to be developed in the future.

#### 3.2 Follow-up Interviews with Bamboo Product Manufacturers

Besides the survey, we also conducted follow-up interviews with several companies that either manufacture or sell bamboo products. We presented images of bamboo stem products that our respondents preferred in our survey to these interviewees<sup>5</sup>. They categorically rejected bamboo stems as suitable materials because the difficulty in manufacturing. They suggested to retain the forms of bamboo stems but replace them with plybamboo. Furthermore, we interviewed a design/build company in Beijing that specializes in hand-made bamboo stem furniture. They also pointed out that bamboo stems have different characteristics than wood, therefore they might not offer the same stability. They do not use bamboo stems together with wood or plybamboo in their furniture making.

## 4. RESULT AND ANALYSIS

We can draw these conclusions from the above research:

- Internal constraints: Bamboo stems' natural differences and variation in form and sizes makes standardized and mechanized production of them difficult. The manufacturing process still heavily relies on experienced workers who can select, cut down, clean, strengthen, and dry the materials by hand; We identify the design

<sup>4</sup>The survey and analysis charts are available upon request and in the presentation.

<sup>5</sup>The identities of these interviewees are confidential. The companies are located in Fujian, Jiangxi, as well as Guangdong provinces.

of connecting components as an important factor, which must accommodate the differences in shapes and sizes of bamboo stems. These connecting components greatly impact the production and assembly effectiveness, storage and transport costs, as well as the performance of various attributes of products using bamboo stems; Currently, large products made of bamboo stems cannot be easily dissembled. Thus, the storage and transportation costs remain high.

- External constraints: The cultural meaning and association of nature of bamboo stems are important factors in choosing them for consumers; Manufacturers for plybamboo and bamboo stem products have little experience collaborating with manufacturers of other materials. In general, small manufacturers do not have the capacity to work with multiple materials.

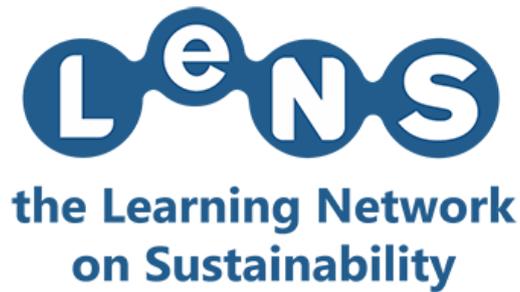
Based on the above results and analysis, we suggest these principles for designing products using bamboo stems: Designers must understand the internal constraints of the material and design around them by accommodating the natural variance of the material in their design; The nodes, joints, and the connections of bamboo stems should be the focus of the design, which might reduce production costs and increase production efficiency; Designers should take advantage of the high specific strength property of the bamboo stem and design accordingly. Structural components using bamboo stems is a possibility to explore; Designers should investigate the modularity possibility of bamboo stems because the material is generally round and hollow. This might help reducing the storage and transportation costs. Because untreated bamboo has a natural durability of less than two years (Boran, Cavdar, & Barbu, 2013) and can be quickly biodegraded, designers should focus on designing products with shorter life expectancy that do not require long-term and repetitive uses.

## 5. IMPACTS ON SUSTAINABILITY

Bamboo has a long history in craft making and has been proven to be a sustainable material. By reducing manufacturing procedures and waste, bamboo stems could be a viable alternative to replace other materials that might have higher Eco-costs such as steel and plastics. While plybamboo is used widely, bamboo stems' potential in product design is largely untapped due to a multitude of internal and external constraints. As designers, we must work with the internal constraints to make bamboo stem products more desirable. By showcasing the beauty of bamboo stems, designers could encourage more economically viable manufacturing technology to be developed for bamboo stems.

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## **SUSTAINABLE MATERIALS AND PROCESSES DESIGN: THE CASE STUDY OF POLY-PAPER**

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### **ABSTRACT**

Polymeric materials used for packaging have unsolved environmental sustainability problems. The ideal packaging must be recyclable and/or compostable, with a unique recycling channel. This is focused on the development of an innovative eco-composite material based on water-soluble polymeric matrix reinforced with cellulose fibers up to 60 % w/w: Poly-Paper. The material can be processed by conventional processes of thermoplastics (extrusion, thermoforming, injection moulding, 3D printing) and can be recycled together with paper-based materials. This work describes the innovative expanded version of Poly-Paper and the developed forming technology: Water Shaping, able to give the material a great impact and energy absorption capacity in packaging applications.

Key Words: Cellulose fibers, eco-composite, recyclable, sustainable processes<sup>3</sup>

## 1. INTRODUCTION

The classes of packaging materials are numerous, since there are many functions that packaging materials must fulfil. In many industrial case studies, different classes of materials are usually combined in a single package: corrugated cardboard, printed-paper, polystyrene foam, low-density polyethylene and various other plastic components, etc..(Del Curto et al., 2016). Each of these materials follows a different path for collection, disposal and recycling. If used jointly, in a single package, it can happen that they are not distinguished from the consumer and conferred jointly to the same waste stream. In a sustainable design process, the different packaging materials must be separable, separated by the consumer, and collected in a specific recycling channel. The cellulosic packaging is a perfect example of circularity: the cellulosic recycling channel represents the most active and constantly growing recycling channel; in fact, the high percentage of recycling rate from the ISPRA, Urban Waste Report was calculated at 80% in the 2016<sup>1</sup>. Nowadays, designers are asked to select, but also to combine and develop responsible packaging materials: the sustainable materials market is a growing trend for the years to come, as reported by European Bioplastics, nova-Institute, 2016<sup>2</sup>.

## 2. BACKGROUND

In the last 20 years, economic, environmental, social and legislative assets have been the main drivers for the development of sustainable packaging materials. The use of natural fibers in bioplastic matrices has made possible the development of sustainable composites, enhanced in properties and performance. Natural fibers have multiple advantages over synthetic fibers as they are renewable, have low density and high mechanical strength and modulus and are not abrasive for machinery and plants (Cheng, Wang, Rials, & Lee, 2007). In particular, the advantages of cellulose fibers used as fillers in sustainable composites are hardness, flexibility, ease of processing, recyclability and eco-compatibility. This green reinforcement has been applied to various researches in the last decades (Thakur, 2013). These applications exploit different characteristics of cellulose fibers as biodegradability, mechanical performances, thermal or acoustic insulation in various fields of application (Curvelo, De Carvalho, & Agnelli, 2001; Graupner, Herrmann, & Müssig, 2009; Huda, Mohanty, Drzal, Schut, & Misra, 2005)hemp, kenaf and man-made cellulose fibres (Lyocell).

The aim of this work is the development of a sustainable composite material for packaging based on renewable fibres in a water-soluble and environmentally friendly polymer matrix: Poly-Paper.

The name Poly-Paper was born from the idea of combining the processes of thermoplastic polymers (e.g., extrusion) and the virtuous end of life of paper materials. The basic idea is designing a material suitable for carrying out all the functions of packaging: contain, protect, transport. In fact, Poly-Paper has been developed to be processed by extrusion, thermoforming, injection moulding to realize all those components that need high technical details but also in the “expanded” version for high performance in protection and transport.

In addition to traditional processes (extrusion, injection moulding, thermoforming, 3D printing), an innovative process has been presented that exploits the properties of the selected materials: water solubility. This type of technology, called “Water Shaping”, allows to improve the resistance to shocks and the ability to absorb energy.

## 3. MATERIALS AND METHODS

The polymer selected as the matrix for the composite is an experimental formulation based on water-soluble polyvinyl alcohol (PVA), a fossil-based material selected to be used as a potential matrix for sustainable composites. This thanks to its biodegradability, biological and ecological compatibility, high tensile resistance tensile, excellent adhesive properties and chemical resistance and gas barrier properties (Chiellini, Corti, & Solaro, 1999; Mandal & Chakrabarty, 2014). The selected reinforcement is microcrystalline cellulose (MCC), environment friendly products, gained from replenishable raw materials.

### 3.1. Poly-Paper Formulations

Seven types of Poly-Paper composites were developed, increasing the MCC content from 0 to 60% w / w. For each considered percentage, filaments ( $\varnothing$  3mm) were obtained through the FSCM series twin-screw extruder (TSA Industriale, Cernobbio, CO, Italy). The filaments were subsequently pelletized to obtain granules which have been used as the main semi-finished products for subsequent processing.

### 3.2. Poly-Paper expansion

The expansion of the material has been obtained starting from the formulation of Poly-Paper and adding 2% w/w of expander agent. The composite expansion was obtained by the same extrusion process described above, without process variants. The PVA:MCC:EXPander mixtures were extruded into filaments with a nominal diameter of 3 mm and granulated as shown in Figure1.

<sup>1</sup> Ispra, Urban Waste Report 2016, available at <http://www.isprambiente.gov.it/publicazioni/rapporti/rapporto-rifiuti-urbani-edizione-2016>.

<sup>2</sup> European Bioplastics, 2018 Bioplastics – facts and figures, available at [https://docs.european-bioplastics.org/publications/EUBP\\_Facts\\_and\\_figures.pdf](https://docs.european-bioplastics.org/publications/EUBP_Facts_and_figures.pdf).

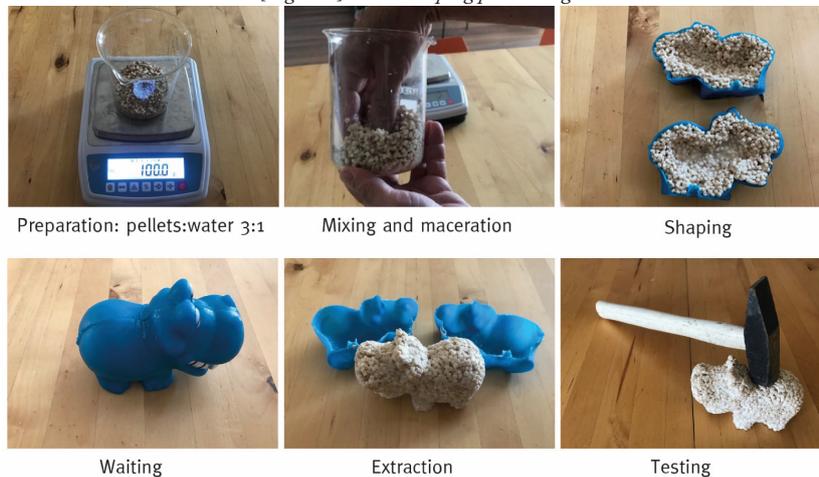


[Figure 1] Expanded Poly-Paper extrusion process (left) and obtained pellets (right)

### 3.3. Water Shaping

A particular method for shaping has been developed using water, taking advantage of the fact that Poly-Paper matrix: PVA is a water-soluble polymer. The process has been called Water Shaping; a scheme of the steps of this process is proposed in Figure 2. A certain amount of Poly-Paper pellets is manually mixed with a third weight of water for 15 min. The obtained mixture is left to macerate for one hour at room temperature and then put into the desired mould. The granules, in this way, after the evaporation of the water excess through drying in the oven (60°C for 3 hours), are firmly bonded to each other and with materials such as paper, cardboard, wood and ceramics. The process has been performed using expanded and non-expanded Poly-Paper pellets.

[Figure 2] Water Shaping process stages



### 3.4. Compression tests

Compression tests have been carried out on a large series of disks (diameter = 15 mm, height = 10 mm). The disks were subjected to compression tests with a crosshead speed of -0.15 mm/s, until a 90% deformation is achieved, i.e., the specimens reached a final thickness of 1.0 mm.

## 4. RESULTS

Poly-Paper<sup>3</sup> can be processed using traditional processes of thermoplastic materials. During the development of the material, in fact, the possibilities of thermoforming, 3D printing as shown in Figure 3, injection molding as well as extrusion have been tested with good results. These production versatility allows the material to open up multiple application scenarios (Testa, 2018).

[Figure 3] Poly-Paper processed by 3D printing (left) and thermoforming (right).



### 4.1. Poly-Paper expansion

<sup>3</sup> Italian patent n. 102015000028276 “Materiale composito ad alta sostenibilità ambientale”, filed 26/6/2015 - granted 30/11/2017.

PCT Application (UE, USA) n. IB2016/053777 “Highly environmentally sustainable composite material” filed 24/6/2016 – published EP 16745832.2 4/4/2018

The Poly-Paper mixture (PVA: MCC) was developed up to 60% of MCC w/w and results was taken as a reference for the expansion attempt (Santi et al., 2018). Various types of PVA:MCC ratios: 100:0, 70:30, 60:40 were extruded with a factor of 2% of expanding agent. Table 1 shows the different types of granules produced for the subsequent experimentation. As can be observed, the expanding agent has little effect on the pure PVA, while it has an important effect in the presence of MCC content of 30 and 40% w/w. By expansion, it is possible to reach an apparent density of about 0.45 g/cm<sup>3</sup> with an expansion of 40% compared to the same mixture without expander agent. Furthermore, the addition of an expander causes the granules to change color, which turns from light brown to whitish as shown in Figure 4.

[Table 1] Expansion factor determination of 100:0, 70:30, 60:40 PVA:MCC ratios compared to the non-expanded Poly-Paper formulations

PVA:MCC ratio (%) w/w	Expanding agent (%) w/w	Volumetric mass density (g/cm <sup>3</sup> )	Expansion factor (%)	Color
100:0	0%	0,74	0%	Translucent brown
100:0	2%	0,73	1,3%	Translucent white
70:30	0%	0,70	0%	Light brown
70:30	2%	0,44	39,7%	Whitish
60:40	0%	0,70	0%	Brown
60:40	2%	0,46	34,3%	Whitish

[Figure 4] Discs obtained by Water Shaping process (diameter =101 mm, height = 36 mm). On the left: 70:30 PVA:MCC disk without expander; on the right: a disk obtained with the same PVA:MCC ratio, added with the expanding agent.

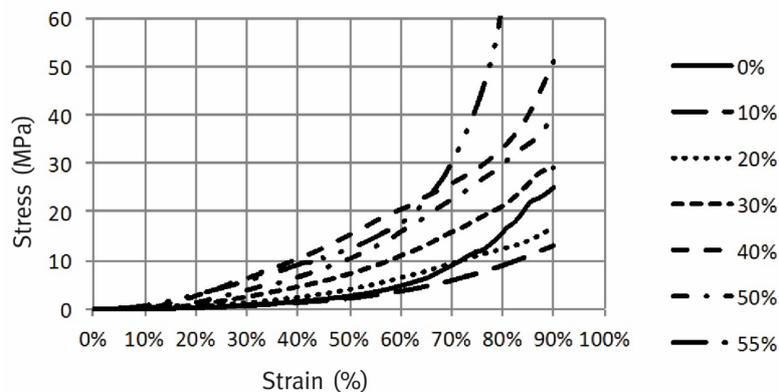


right: a disk obtained with the same PVA:MCC ratio, added with the expanding agent.

#### 4.2. Compression tests

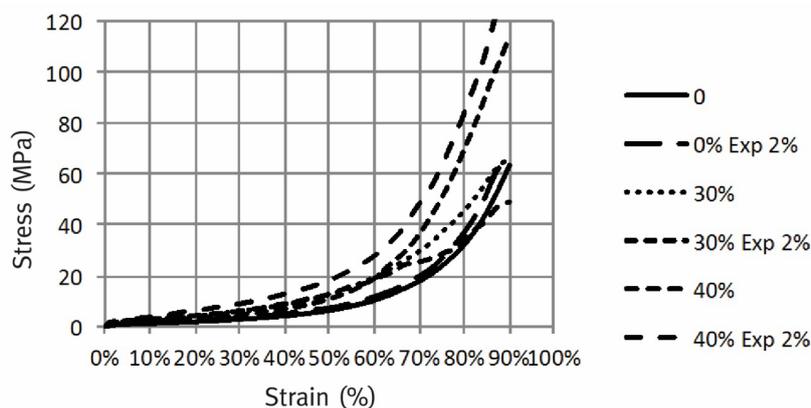
As can be observed in Figure 3, the macrostructure of the material obtained Water Shaping appears similar to that of the expanded polystyrene, a material notoriously capable of absorbing shocks. The porous structure of the expanded foams is in fact able to absorb a high amount of energy during the compression deformation due to a “peak load” effect connected to the expanded structure and to the granular shape. It can be assumed that the structure of the Poly-Paper disks obtained by Water Shaping process may have the mechanical behaviour of the expanded foams. To evaluate these hypotheses, compression test were carried out. The tests results can be analysed in relation to the amount of MCC content or in relation with the expansion factor. To verify the effect of the cellulose percentage, samples with different percentages of MCC content have been obtained, ranging between 0 and 55% w/w. The increase in the percentage of cellulose causes an improvement in the mechanical compression properties, in particular the stiffness showed an increase of about five times in the slope in the first part of the stress-strain curves (Figure 5).

[Figure 5] Representative stress–strain curves obtained by mechanical compression tests performed on the Water shaped disks made with different PVA:MCC ratios.

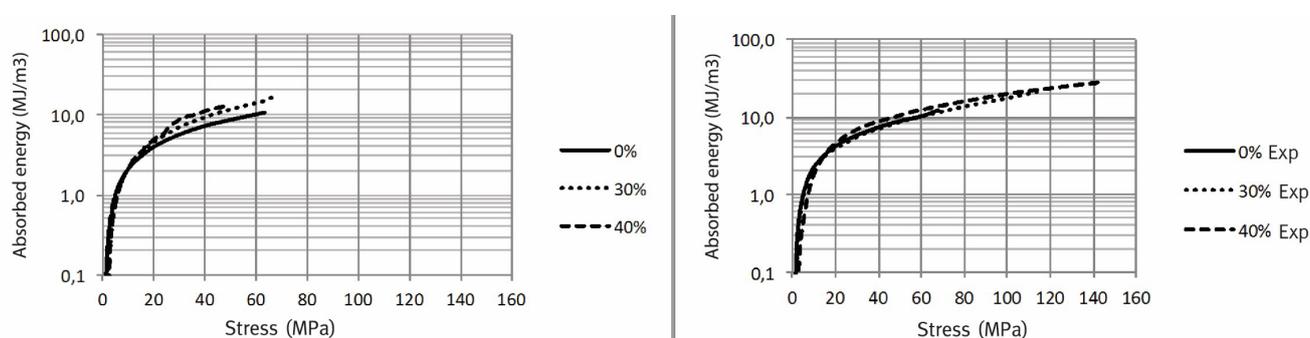


As previously mentioned, the possibility of expanding the granules has been verified by adding an optimized percentage of 2% w/w of expanding agent into the starting dry PVA/MCC blend. As reported in Figure 6, the addition of an expanding agent while decreasing the apparent density of the material (Table 1) causes an increase in the mechanical properties.

[Figure 6] Representative stress–strain curves obtained by mechanical compression test performed on the Water shaped disks made with different PVA:MCC Poly-Paper ratios expanded and non-expanded.



The Stress-Strain curves can be integrated to calculate the absorbed energy as a function of the applied stress. This data was obtained for samples with 0, 30 and 40% w/w MCC content, without and with expanding agent (2% w/w). Results are shown in Figure 7 in semi-logarithmic scale. It can be clearly observed that with 30 and 40% w/w MCC the energy absorbing capacity of the expanded material is greater than that of similar unexpanded Poly-Paper. [Figure 7] Representative stress-absorbed energy of the Water shaped disks made with different PVA:MCC Poly-Paper ratios non-expanded (left) and expanded (right).



## 5. CONCLUSIONS

Poly-Paper, due to the use of a water-soluble (PVA) matrix reinforced with cellulose fibers, has great advantages in terms of eco-sustainability:

- it is produced using cellulose fibers obtained from recycled paper, in a circular economy model;
- It can be selected for the production of “mono-material” packaging and can be recycled together with corrugated cardboard, overcoming the problems associated with the use of expanded polystyrene.

The developed expanded Poly-Paper version allows the production of low-density packaging products for protection and transportation. By Water Shaping process it's possible to obtain complex shapes into simple molds, ideally made of cardboard with hydrophobic treatment, without the need for complex molds or machining operations, and without disposal problems.

Important advantages over actual packaging components have been achieved in terms of ability to absorb energy, lower density and cost per unit volume. Using industrial technologies, the material can certainly be brought to higher levels of expansion.

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## **ENABLING USER KNOWLEDGE TO SUPPORT THE DECISION-MAKING PROCESS IN ENERGY RETROFITTING OF PUBLIC HOUSING: A CASE STUDY IN MILAN**

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### **ABSTRACT**

This research aims at bridging the actual gap between technical improvements and user's practices in energy retrofitting of public housing, by considering the role and relations of key actors throughout the design process and with particular emphasis on the degree at which user's experience is envisaged. To this end, a Milanese case study is analysed through the lens of Quadruple Helix, where a key role is given to the fourth helix, the user, in sharing its knowledge and experience in the decision-making process (Arnkil, 2010). The research method combines tenants' interviews and on-site observations with institutions interviews and focus groups. Evidences show lack of coordination among the actors and the lack of consideration for final users that, as a consequence, adopt thermal comfort solutions according to personal assessments. Guidelines are drawn to support the administrative system in defining energy policies in public housing aimed for an iterative and collaborative management model.

Key Words: Social Innovation, Public Housing, User Practices, Energy Efficiency Gap.

## 1. INTRODUCTION AND BACKGROUND

European Commission sets energy and climate goals to cut greenhouse gas (GHG) emissions below 1990 levels by 20% by 2020. In October 2014 the European leaders define more ambitious aims of reducing GHG emissions by 40% for 2030 and by 80% for 2050 in a long-term vision. To meet the European objectives toward a more sustainable and resilient development, the city of Milan sets political agenda intersecting current issues about energetic and environmental requalification, social cohesion and public property management. As mentioned in the Sustainable Energy Action Plan (SEAP), the Milanese public administration emphasizes the interest in guiding energy retrofitting processes of existing buildings and allocate, to this end, a significant amount of spending for the three-year period 2017-2020.

Emerging issues relate to the so-called energy efficiency gap, defined as the discrepancy between designed solutions for retrofitting existing buildings and effective energy consumptions related to people practices. Energy consumptions in the operational phase of buildings is significantly increased by inefficient practices (Gianfrate et al., 2017). This is particularly evident in public housing contexts, where people of various ages and cultures coexist with differences in lifestyles and ways of space occupation (Belafi et al., 2018; Gianfrate et al., 2017). For these reasons, as underlined by Gianfrate et al. (2017), in these particular cases the use of new installation technologies requires greater attention to possible social implications of interventions.

The present study investigates the case of a public housing context located in Milan, in the framework of EnerPOP project (Polisocial Award, 2017) with the aim of analyse technical and social aspects in the context of public housing retrofitting, in order to identify the causes of detected gap between the expected energy savings and the actual consumptions related to households practices.

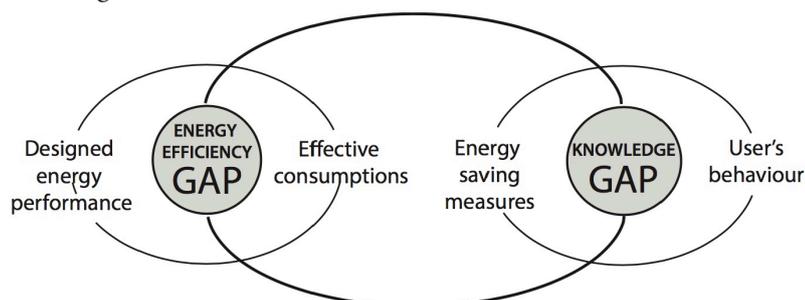
The focus here presented is on the role of the inhabitants in the process of public housing energy retrofitting in Milan, with particular attention to the relations between user's daily activity and the other involved actors of the process (owner, management body, third sector institutions, etc.) in exchanging information and good practices about energy practices and consumptions. The validity assessment of these assumptions is based on a methodology structured around primary data collected in situ (in addition to data from the literature) and comparison of key elements in determining energy efficiency gap directly from households and the other involved actors.

Results of this work are addressed to public authorities, to inform the actual organizational and management system in retrofitting Milanese public housing stock. Major contributions appear in the definition of guidelines for implementing social support measures in different steps of retrofitting process, able to include a comprehensive knowledge about different social interactions and households' everyday practices in specific public housing contexts.

## 2. OPERATIVE FRAMEWORK AND HYPOTHESIS

With the aim of investigating the gap between the predicted and the actual energy consumptions in buildings, current literature gives greater attention to technical aspects of energy optimization, by focusing on the sociotechnical diagnostic of the building at the early stage of the process (Rinaldi, 2018; Ortiz, 2018). In particular, various studies focus on simulation programmes advancements and how to model occupant practices (Becchio, 2016; Belafi et al., 2018; Santangelo, 2018). The methods experimented adopt mainly a deterministic or statistics approach that oversimplify users practices into quantitative parameters solely (occupants number, operating hours of devices, temperature set-point, etc.) (Hong, 2016; Ben and Steemers, 2017). Only few studies consider more latent and non-measurable aspects such as people attitudes, preferences and social norms (Ortiz, 2018; Rinaldi, 2018). Very little focus has been placed on organization and operational aspects of the process, that in turns might greatly influence in determining the entity of energy efficiency gap (Gianfrate, 2017).

In this context, the main hypothesis of this research is that the discrepancy between designed energy savings and current practices in public housing context is partly influenced by a gap in knowledge related to interaction strategies and communication tools between users and the other actors involved in the management of retrofitting process (Fig.1). This appears to be particularly true in public housing contexts where the use of new installation technology requires greater attention in terms of final user support and participation (Gianfrate, 2017). This specificity derives partly from socio-economic conditions, such as the lack of interest in adoption of energy saving measures, in taking care of a space owned by someone else or the interpersonal and social difficulties related to different lifestyles and ethnic background (Becchio, 2016).



[Figure 1] Relation between energy efficiency gap and knowledge gap (from Delzendeh, 2017)

The investigation of actual situation is carried out through the lens of Quadruple Helix model defined as “a cooperation model of an innovation environment in which users, firms, universities and public authorities cooperate to produce innovations” (Ahonen e Hamalainen, 2011). Interactions among the actors constitute the key element to produce a new knowledge, considering demands and supply factors (Cavallini et al., 2016). Particular emphasis is put on the Fourth Helix, the users, in making its crucial contribution by sharing its experience and knowledge within the more decision-making process (Arnkil et al., 2010). More specifically, Wise e Hogenhaven (2008) recognize the beneficial contribution of Fourth Helix in the renewal of public sector, by promoting public services production and managements modes based on the combination of users’ and experts knowledge. In this context, according to recent regional legislation (Lr 16/2016), public housings in Milan are considered as specific category of public services. Therefore, in the selected case study, the Quadruple Helix model is adopted with a twofold aim: as operative framework that allows us to look critically at current roles and relations among the actors involved in the energy retrofitting process; as support tool to guide public policies towards more collaborative approaches.

### 3. APPROACH AND METHODS

The study focuses on the case of Feltrinelli 16, a public residential building located in the south-eastern outskirts of Milan. The building was part of a wider urban policy launched in 2010 aimed at renovating existing public stock in the city of Milan. Between 2015 and 2017 the municipality invested 180 million for ordinary and extraordinary maintenance, of which 50 million allocated to energy efficiency measures. The municipality of Milan, in partnership with Energy Department (DENG) of the Politecnico of Milan, selected the pilot case of Feltrinelli 16 in 2013, in the framework of the European project EU-GUGLE, for implementing new majors energy refurbishment measures such as external insulation, PV panels, mechanical ventilation, chrono-thermostat devices etc. After the entry of new 500+ households in 2015, the monitoring activities of following years reveal that effective consumptions appear to be not coherent with estimated energy savings.

In this context EnerPOP project, funded by pre-tax donations for Politecnico di Milano, aims to analyse the technical and social aspects in retrofitting public residential buildings, in order to identify the factors of the detected gap between calculated energy savings and the actual ones, and propose options to reduce it. The aim of the present research based on Feltrinelli 16 case study is not to generalize findings but to understand the specific conditions and to eventually verifying the representativeness as compared with other public housing stocks contexts in the city of Milan. Partners of the project include: Milan municipality, owner of the public stock; Metropolitana Milanese SpA (MM), the management authority; the Residents Committee “Feltrinelli 16”(CdI) that carries out activities of door-keeping and socialization for the inhabitants; Unareti SpA, the energy provider; l’Agenzia Mobilita Ambiente e Territorio (AMAT) and Legambiente (LA).

Public housing stock in Milan counts around 66 thousands households unities, among which about 30 thousands are owned by the Municipality of Milan and managed by Metropolitana Milanese Spa (MM) that succeeded Azienda Lombarda Edilizia Residenziale (ALER) in 2014. Around 25 thousands families live in the public stock managed by MM, for a total of 51 thousand tenants, among which 17% foreigners and 33% over 65 years old. In this context, the building of Feltrinelli 16 consists of five floors above the ground, with 154 apartments ranging from 40 m<sup>2</sup> to 64 m<sup>2</sup> at the first and second floor and from 70 m<sup>2</sup> to 80 m<sup>2</sup> at the third and fourth floor. At present, the community living in the selected building includes 500 people, where only 5% of the inhabitants are over 65, while a significant 30% are under the age of 15 (particularly young population if compared with the average in Milan). 60% of the families are foreigners (triple then the average in Milan), including more than 30 different nationalities.

A double approach is adopted in exploring the role of the inhabitants in the process of public housing energy retrofitting in Milan. The first one focuses on the user experience to understand daily practices and habits regarding thermal comfort adjustments, their access to energy consumptions information and advices and their relations with others involved actors during the operational phase of the building. The second one concentrates on technical expertise of involved local actors to learn about the role they play in the process, their relations and their interests in involving actual user practices into the design path.

Data is gathered by a combination of semi-structured interviews and participant observation. Interviews are addressed to a sample of representative tenants and local actors living and acting in Feltrinelli 16, conducted (respectively) at their home and institutional places and lasted about 60 minute each (on average). In particular, 6 families are interviewed on a voluntary basis, selected among those living in the 17 apartments equipped with environmental sensors and express availability with the researchers. Moreover 6 local actors are interviewed, as partners of the project EnerPOP, belonging to 4 different interest groups: municipality of Milan (CdM), Metropolitana Milanese Spa (MM), Social Cooperative “Officina dell’Abitare” (CooP) and the Residents Committee “Feltrinelli 16”(CdI). Interviews are recorded, transcribed full verbatim and analysed by NVivo text coding software. Participant observations are conducted during activities included by EnerPOP project (focus group, events, informal meetings, etc.), organized in common spaces of the building and in institutional places. During these activities data are collected through field notes and photographs.

#### 4. DISCUSSION OF FINDINGS

Main themes arise from results obtained in the investigation of the selected case study. Evidence reveal important issues regarding the relations among the actors involved along the design path of energy retrofitting a public housing context and the ways they take into consideration households' uses and habits. Results allow us to express few thoughts about specific context-based conditions that characterize Feltrinelli 16 building and to put forward some comments about the operating and management system of public housing renovation in Milan.

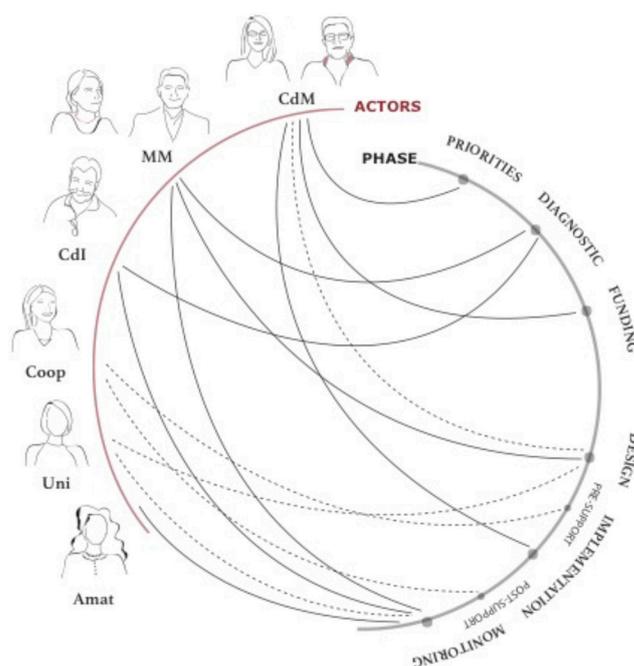
##### 4.1. Relation among actors and process steps

Within the energy retrofitting process of Feltrinelli 16, it appears that the redistribution of roles and responsibilities are not clearly defined nor shared. The relations among groups of actors involved result from the coexistence of different interests and skills that are not always led by a common direction.

As showed in Fig.2 at early stages, the priorities for intervention on the existing public stock are defined by the Municipality of Milano on the basis of purely emergency reasons (mostly linked to safety and health issues) and in the absence of a planning reference framework. In fact, it emerges from interviews that the energy savings intervention is strictly linked to the overall maintenance state of buildings, including issues that are not exclusively related to the improvement of energy performances in Feltrinelli 16. The Municipality commits funds to intervention, generally from municipal economic resources or exceptionally from EU grants.

Moreover, as confirmed by the municipality, the phase of design is more and more passing to the managing body (MM in the case of Milan) in recent times. However, it seems that in the cases of regional and community projects the planning phase returns to the owner body responsibility, generally supported by external actors. This is the case of Feltrinelli 16, where the university collaborates with the owner body both at the design phase, about the purely technical interventions, and in the monitoring phase. Before implementation of the project a process of social support for tenants, in response to a public administration ban, is set with the aim of informing about the reasons and implications of future interventions. However the support is offered only in the cases of exceptional maintenance, when inhabitants are forced to temporarily move from their own apartments while works are being undertaken. In Feltrinelli 16 a social cooperative intervenes after completion of the work in 2014, taking care of the accompanying services to the entrance of new tenants. However, in practice, some problems arise, for example, due to the limited duration of the Cooperative assignment that does not allow perpetuating virtuous relationships and collaborative mechanisms between the maintenance manager and the inhabitants.

Furthermore, the monitoring of interventions is coupled with the ordinary management activity of MM, which carries out various kinds of checks and controls on their stock. In this monitoring activity, evidences show that a relevant role is played by Residents Committee "Feltrinelli 16, that carries out concierge services and, at the same time, is asked by tenants about devices functioning or mediation with MM. Nevertheless the Residents Committee shows greater difficulties in promoting actions involving and motivating residents towards projects of common interest. These difficulties seem to be attributed, to the lack of adequate tools and effective dialogues with external bodies (such as the municipality) and local associations. It is interesting to note that the cooperatives and the university bodies, which intervene with the intent of carrying out on-site activities that can stimulate and support socialization between tenants, are perceived by the inhabitants as sporadic presences and not always effective.

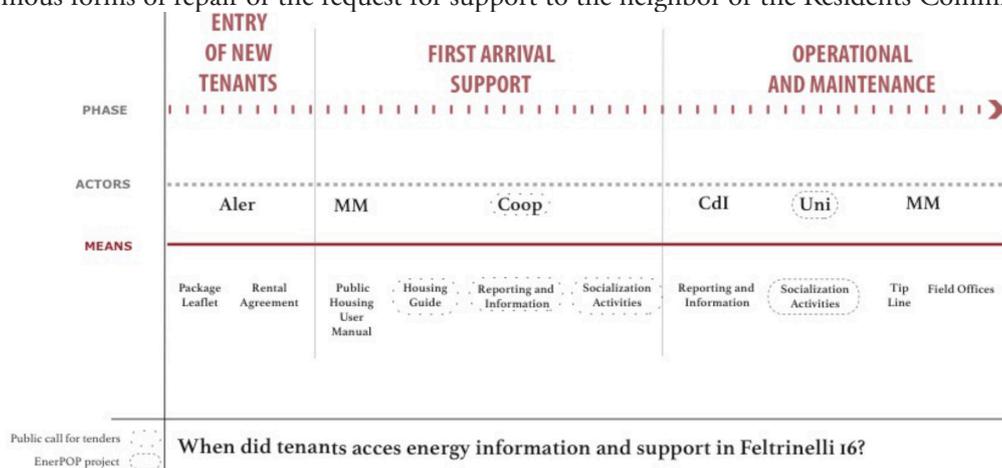


[Figure 2] Phases and relations among actors involved in the process.

#### 4.2. Relations with household and interaction modes

At present, the involvement of household in the retrofitting process is sporadic and it is not capitalized internally cause public authorities do not create a legacy that take care of these kinds of socio-behavioral aspects throughout the process. As a matter of fact, it is found lack of awareness among users about the kinds of energy measures undertaken and their benefits, good thermal practices and advices on heating devices of their flats. However, we noted the presence of informative materials (such as “Public Housing User Manual”) in the flats of interviewed people (Fig.3). According to tenants, these text materials turn out to be ineffective in their intentions due to the difficult availability and comprehensibility that characterizes them, in a context that sees the cohabitation of a variety of cultures and ages. In the event of breakdowns or malfunctions at home, tenants are discouraged from referring directly to the property manager and generally make use of self-repair solutions or refer to the on-site Residents Committee.

Specific information on the use of thermoregulation devices and energy advices are currently available, mostly proposed in the form of user guides and condominium regulations. A “Guide to living” was developed by the social cooperative “Officina dell’abitare” in 2014, delivered together with the lease agreement at the entrance of new tenants. However, the guide contains general and standardized information about good practices for energy savings at home that do not take into consideration specific conditions of Feltrinelli 16. Moreover, with regard to specific information about the use of thermoregulatory devices in the lodgings, only a leaflet is provided to the tenants at the entrance to the house. In most cases, this document is missing or doubtful as it is considered difficult to interpret. In addition to this, any malfunctioning at home can be reported through a toll-free number managed by MM, or by going to one of the manager’s local offices, which operates through a code assignment logic for each report received. The use of the toll-free number is in fact less immediate for the tenants, who opt for alternative choices such as the use of autonomous forms of repair or the request for support to the neighbor or the Residents Committee.



[Figure 3] Phases, actors involved and means adopted for tenants to access energy information and support in Feltrinelli 16.

## 5. CONCLUSION AND IMPLICATIONS

The results described pointed out the need to overstep the consolidated techno-centric approach currently adopted by public authorities for retrofitting public housing. To reach sustainable development goals in the field of energy and vulnerable groups, practical conclusions are derived for upgrade the practice of retrofitting public housing in Milan in the form of recommendations and guidelines for energy and social policies designer.

At present some critical elements are evident. There is a break between the actual users’ experience and the decision-making process, this latter does not take into consideration cultural and thermal practices differences of specific contextual conditions. Moreover internal discrepancies among administrative sectors show a lack of coordination among local actors acting on the same object of interest. It seems that the public body acts by looking at the retrofitting project in a static way, without considering individual circumstances.

In this context we underline the major role that the public authority should play in acting as a supervisory body and throughout the process of public housing retrofitting, assuring the coherence of all steps and the internal coordination among the actors that intervene for various purposes. In addition to this, management authorities have a major role and responsibility in communicating the project and in valuing the existing network of internal practices. In this sense, the recognition of a concierge by the public body is crucial, acting as a bridge in between households and local authorities. Instead of having a big centralised infrastructure we could allow spontaneous forms of social and diffuse infrastructure.

Some guidelines can be drawn to support the administrative system in defining energy policies in public housing aimed for a collaborative and iterative management model, able to integrate thermal practices and users’ knowledge in order to replicate good practices and to valorise the interventions made. With a view to capitalizing on investments in retrofitting existing public stock, greater attention has to be placed on the monitoring phase considering the process as part of the project itself where greater importance is given to households thermal practices (Santangelo et al. 2018). A more participative process is advisable by embedding co-design activities after the reno-

vation project so that the users experience, and housing providers expertise are mutually influential, with particular attention to most vulnerable people. Considering informative and feedback strategies particular emphasis has to be placed on the timing and the ways final users can be included into the system by promoting an iterative process in which experts inform residents about energy saving measures and, in turns, residents send feedbacks to the experts that can then provide solutions at an early stage.

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## EFFECTS OF COLOURED AMBIENT LIGHT ON PERCEIVED TEMPERATURE FOR ENERGY EFFICIENCY: A PRELIMINARY STUDY IN VIRTUAL REALITY

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### ABSTRACT

The built environment has a great responsibility for energy consumption and carbon emissions worldwide. Thus, energy conservation in building plays a vital role in sustainable economic growth. Researchers from many disciplines have devoted to the field of design for energy-efficient buildings. However, human factors, as the way people interact or use the designed environment, are also fundamental. In particular, colour-temperature perceptual associations might be used to influence people's thermal experiences. In this study, we presented two national groups of participants with four rooms in Virtual Reality (VR) to test the effect of coloured ambient light on the perceived thermal comfort, context of use and ambient atmosphere. The results showed that room-lighting could affect the thermal comfort perceived and its advantage for energy conservation. Detailed analyses and future developments are also discussed.

Key Words: Coloured ambient lighting; Thermal comfort; Virtual reality;

## 1. INTRODUCTION

The central theme of the Sustainable Development Goal 7 of United Nations is ensuring access to affordable, reliable, sustainable and modern energy for all, with the ambition of reaching the energy targets for 2030 (Economic and Social Council, 2018). It is reported that buildings and construction are responsible for 36% of global energy consumption and 39% of energy-related greenhouse gas emissions (International Energy Agency, 2017). Also, the Joint Research Centre of European Commission announced the economic growth has a positive relationship with the efficient use of energy, especially in the residential sector (Bertoldi P, Diluiso F, & Castellazzi L, 2000), due to the increasing demand of thermal comfort and the trend towards efficient buildings, as well as the use of advanced appliances and systems (Pérez-Lombard, Ortiz, & Pout, 2008). In fact, space heating takes up the highest proportion of building energy consumption (The World Bank, 2018).

With a spacious room for improvement, smart and energy-efficient buildings (L. Wang, Wang, & Yang, 2012), as well as sustainable architecture and green design (Amirhosein GhaffarianHoseini et al., 2013) have becoming a tendency in the built environments industry. Specifically, implementations include optimised adaptive control systems (Yang, Yan, & Lam, 2013) whereas adaptive models tend to have a broader comfort temperature ranges. Higher indoor temperatures in summertime conditions would lead to less prevalence of cooling systems as well as less cooling requirements. Raising summer set point temperature has good energy saving potential, in that it can be applied to both new and existing buildings.

Further research and development work conducive to a better understanding of thermal comfort and energy conservation in buildings have been identified and discussed. These include (i, innovative energy-efficient appliances (Chua, Chou, Yang, & Yan, 2013) particularly for hot and humid climates. Today, air conditioning, comprising cooling and dehumidification, has become a necessity in commercial and residential buildings and industrial processes. It accounts for a major share of the energy consumption of a building or facility. In tropical climates, the energy consumed by heating, ventilation and air-conditioning (HVAC and embodied energy construction materials (Cabeza et al., 2013).

Nevertheless, human factors such as the ways occupants make use of the designed environment should be likewise addressed. The built environment can affect human comfort and wellbeing. On the other hand, people's choices and behaviours also influence indoor energy use, building operations and performance (International Energy Agency, 2017). Therefore, more design and implementations in the human-building interaction aspect are needed for energy efficiency without sacrificing the human thermal comfort, health and wellbeing.

In this work, we attempted to use Virtual Reality (VR) for investigating the effects of coloured ambient light on people's perception of thermal comfort, ambient atmosphere, and space function for energy efficiency. Simulation technologies such as VR have already been employed as a valuable tool for design and research purposes because of their time and cost efficiency (Thrash, Dalton, & Hölscher, 2015). Besides, this work follows the results of our previous study (Scurati, G.W., Etzi, R., Huang, S., Graziosi, S., Tagliabue, L.C., Gallace, A., Ferrise, F., & Bordegoni, 2019) with a further validation on the comparison between two different cultural groups (fifteen Chinese and fifteen Italian subjects).

## 2. EFFECTS OF COLOURED AMBIENT LIGHT ON HUMAN PERCEPTION AND BEHAVIOR

People all over the world make colour-temperature matchings. These associations are influenced by environmental and natural phenomena, human experience, cultural and geographic origin (Wierzbicka, 1990; Wright & Rainwater, 1962). At the same time, colour perception affects human physiological reactions, cognition and behaviour (Madden, Hewett, & Roth, 2000), despite this kind of influence varies individually (e.g., age, gender, personality) and situationally (Priluck Grossman & Wisenblit, 1999).

In the research field of space and interior design, plenty of studies showed that there is a significant correlation between the occupants' visual comfort and lighting conditions (Hwang & Jeong, 2011). In fact, among different indoor lighting systems, the coloured lights are leveraged as an active element in creating environment atmosphere, influencing occupants' mood, visual-related thermal comfort, and cognitive performances (Huebner et al., 2016). Moreover, coloured ambient light has been widely used in indoor environments like workplaces (Juslen & Tenner, 2005), residential buildings (Frontczak, 2012), health and clinical locations (Dalke et al., 2006).

Indoor lighting can affect people's perception of thermal comfort that may result in energy-efficient behaviours (Huebner et al., 2016; Juslen & Tenner, 2005). One vital aspect is the hue-heat hypothesis, which postulates red links to warm and blue to cold temperature (Bennett, 1972).

As a laboratory study indicated that visually comfortable light could improve the satisfaction towards indoor environments like thermal comfort, which may serve the benefits of energy-saving and healthy building design (te Kulve, Schlangen, & van Marken Lichtenbelt, 2018). A study conducted inside of an aircraft cabin showed that participants report a higher temperature when exposed to yellow ambient light than the condition of blue hues (Woldemedhin, Raabe, & Hassel, 2013). Another experiment carried out in a climate chamber supported the hue-heat hypothesis based on a subjective assessment with collected heart rate data (H. Wang, Liu, Hu, & Liu, 2018).

### 3. CURRENT STUDY

#### 3.1. Participants and experimental conditions

Thirty subjects voluntarily participated in our study. They are all students and belonged to two nationalities: fifteen Chinese (seven females; mean age= 26.6) and fifteen Italian (seven females; mean age= 25.13). Before entering the experiment, subjects read and signed a consent form. All of them reported normal or corrected-to-normal colour vision, as well as normal colour perception. The study received the approval of the University of Milano-Bicocca ethics committee and respected the ethics guidelines by the Declaration of Helsinki. Three simulated rooms are in red, blue and yellow lights respectively. An additional colour (e.g., white) served as a neutral condition (see Figure 1). The virtual scenarios were designed in Unity 3D (<https://unity3d.com>) and were presented with the Oculus Go headset (<https://www.oculus.com>) together with the questions about the scenarios. The participants used a controller to answer.



[Figure 1] Four simulated virtual rooms in red(1); blue(2); yellow(3) and white(4) ambient light conditions

#### 3.3. Procedure and measurement

The experiment took around 15 minutes per person and was performed in a room with a constant temperature of about 22 °C. The participants sat at a table and for each condition were instructed to observe the ambient indoor room. When they reported being satisfied with and having acquired sufficient information about the environment, a series of questions were shown up within each virtual scenario. The order of presentation of the rooms associated with the lights, as well as the order of the questions, were randomised among participants. The evaluations mainly covered three aspects: (1) Thermal comfort; (2) Lights and ambient atmosphere; (3) Perceived context of room usage (Table 1).

[Table 1] Sub-descriptive statements in experiencing simulated virtual rooms

Category	Sub-descriptive statements			
Thermal comfort	Q1 This room is pleasantly warm.	Q2 This room is pleasantly fresh.	Q3 It is too hot in this room.	Q4 It is too cold in this room.
Lights and ambient atmosphere	Q5 This room is cosy.	Q6 This room makes me feel stressed.	Q7 This light is pleasant.	
Context of use	Q8 I would play with friends in this room.	Q9 I would like to relax in this room.	Q10 It is easy to focus in this room.	

For each evaluation, the participants were asked how much they agreed with an affirmation on a visual analogue scale (VAS). This scale was anchored to the labels “not at all” and “very much”, respectively placed on the left and right extremes. The cursor on the line was moved through the Oculus Go controller and subjects could interactively select the position of a slider which always appeared in the middle of the rating scale. For the data analysis, the colour lights (four levels: red, blue, yellow, white) and the nationality (two levels: Chinese and Italian) served as independent variables. The responses to the rating scales were used as dependent variables. Scores were obtained by measuring the cursor position along each scale. The subjects’ scores for each question were submitted to separate mixed analyses of variance (ANOVAs), using “colour light” as within-subjects factor and “nationality” as between-subjects factor. The statistical significance level was set a  $p < .05$  and significant effects were further analyzed by running HSD Tukey corrected posthoc tests.

### 4. RESULTS AND DISCUSSION

As shown in Figure 2, for Q1 – pleasant warmth, the significant main effect of colour [ $F(3, 84)=4.19, p=.008$ ] indicated that the red ( $p=.05$ ), white ( $p=.03$ ) and yellow ( $p=.01$ ) rooms were rated as pleasantly warmer than the blue-illuminated room. This result confirms the findings by previous experiments conducted in the real world (Har-

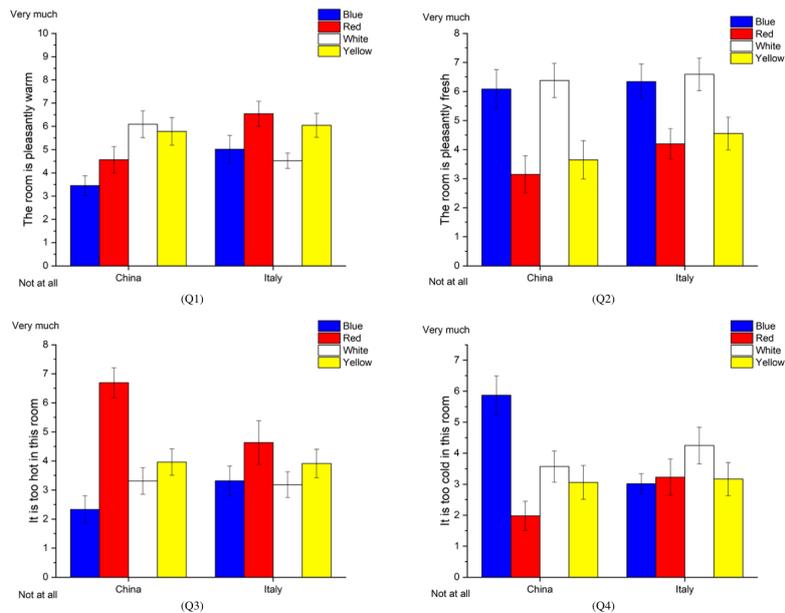
din, 2000). For instance, a study conducted inside of an aircraft cabin showed that participants reported a higher temperature when exposed to yellow ambient light as compared to blue (Woldemedhin et al., 2013). The interaction effect of colour \* nationality [ $F(3, 84)=3.06, p=.03$ ] was significant as well and indicated that the difference between blue and white (with lower ratings for blue) was present for Chinese ( $p=.01$ ) but not for Italians ( $p=.99$ ). This result is similar to a comparative study on the colour-associations: 71% of Chinese subjects linked white with “cold,” while 96% of American respondents linked to blue (Courtney, 1986). The main effect of nationality was not significant [ $F(1, 28)=1.33, p=.25$ ]. Q2 – pleasant freshness: The main effect of colour was significant [ $F(3, 84)=9.08, p<.001$ ]. The blue and white rooms were rated as pleasantly fresher than the red (both  $ps<.001$ ) and yellow (respectively,  $p=.03$  and  $p=.01$ ). Similar findings are also found in package design, where blue and white are always selected for indicating the semiotic sense of freshness as in the case of yoghurt label due to a natural representation of sky (Ares et al., 2011) a multidisciplinary approach was applied to answer the question: do consumers perceive what semiotics want to convey? The idea behind was to determine if consumers’ expectations and associations raised by simulated yogurt labels, designed with different sign combinations frequently applied in commercial products, were in agreement with results from a semiotic analysis, and to check for cultural differences, comparing results from two Spanish-speaking countries (Spain and Uruguay). The effect of nationality [ $F(1, 28)=1.80, p=.19$ ] and colour \* nationality [ $F(3, 84)=0.44, p=.71$ ] were not significant.

Q3 – too much hotness: The significant main effect of colour [ $F(3, 84)=13.12, p<.001$ ] indicated that the red room was rated as more “too much hot” than the other coloured rooms (all  $ps<.001$ ). The significant interaction colour \* nationality [ $F(3, 84)=03.06, p=.03$ ] revealed that this effect was present for Chinese (all  $ps<.001$ ) but not for Italians ( $p>.05$ ). The main effect of nationality was not significant [ $F(1, 28)=0.09, p=.75$ ]. Q4 – too much cold: The main effect colour was significant [ $F(3, 84)=5.81, p=.001$ ]: participants rated the room with blue light as colder than the red ( $p=.001$ ) and yellow ( $p=.01$ ) lights. Findings from Q3 and Q4 comply with the previously discussed hue-heat hypothesis. Likewise, a study on the cold-hot association showed that yellow and orange are prone to the scale of warmness, while red has the highest linkage to hotness. Also, blue is more associated with coldness and coolness (Lewinski, 1938). Another research on colour-concept matchings showed that red is associated with hotness and fire, also revealed red lights can refer to a very high-temperature sensation, even sometimes to the signal of danger, as compared to the comforting sense induced by yellow lights (Pravossoudovitch, Cury, Young, & Elliot, 2014) we used two different variants of a Stroop word evaluation task to test for the possibility of an implicit red-danger association using carefully controlled colour stimuli (equated on lightness and chroma). The effect of nationality [ $F(1, 28)=0.21, p=.64$ ] and colour \* nationality [ $F(3, 84)=2.25, p=.08$ ] were not significant.

Q5 – cosiness: The main effects of colour [ $F(3, 84)=2.08, p=.10$ ] and of nationality [ $F(1, 28)=3.28, p=.08$ ], as well as the interaction effect of colour \* nationality [ $F(3, 84)=1.34, p=.26$ ] were not significant. While in Q6- stress, the main effect of nationality was significant [ $F(1, 28)=3.92, p=.05$ ] and the Chinese sub-sample gave higher ratings than Italians. The main effects of colour [ $F(3, 84)=1.83, p=.14$ ] and the interaction effect of colour \* nationality [ $F(3, 84)=1.57, p=.20$ ] were not significant. Q7 - light pleasantness, the significant main effect of nationality [ $F(1, 28)=7.52, p=.01$ ] indicated that Italians gave higher ratings than Chinese. One interesting point worth mentioning is the impact of colour showed a trend toward significance [ $F(3, 84)=2.38, p=.07$ ], which indicates that the white room received higher ratings than the blue ( $p=.07$ ). The reason of this trend may be that white has a general reference to pleasant and positive traits (Clarke & Costall, 2008). The interaction effect of colour \* nationality [ $F(3, 84)=1.98, p=.12$ ] was not significant. Q8 – leisure: The main effects of colour [ $F(3, 84)=1.49, p=.22$ ] and of nationality [ $F(1, 28)=0.24, p=.62$ ], as well as the interaction effect colour \* nationality [ $F(3, 84)=2.21, p=.09$ ] were not significant. Q9 – relaxation: The main effects of colour [ $F(3, 84)=0.84, p=.47$ ], of nationality [ $F(1, 28)=1.34, p=.25$ ], and the interaction effect colour \* nationality [ $F(3, 84)=1.50, p=.21$ ] were not significant. Q10 – concentration: The main effect of nationality [ $F(1, 28)=6.67, p=.01$ ] indicated that Italians gave higher ratings than Chinese. The main effect of colour [ $F(3, 84)=4.05, p=.009$ ] indicated that the white room was evaluated as more suitable for focusing as compared to the red-illuminated room ( $p=.004$ ). The result towards the attention is in agreed with a study of using white light is more appropriate for office settings than red and green colours (Kwallek & Lewis, 1990) red-fire, and red-hot. However, the designers and non-designers had different color associations for the concepts of escape (green, red).

#### 4. CONCLUSION

The current study proved that indoor ambient light affects the human perception of indoor climate according to the colour-temperature association, together with its advantage for energy conservation. Besides, the effectiveness of different hues on perceived temperature, the preferred activities under different lighting conditions among two cultural groups are in demand of advanced investigation and explanation due to the limitation of this ongoing project (e.g., sample size, light exposure time, level of immersiveness in VR, manipulation of other environmental factors, and etc.). However, the adoption of VR as a research tool for study human-environment interaction is validated since the finding is following previous studies that were conducted in a real-world setting. Future development of the study could be the integration of different hues, control of photometric parameters, the collection of physiological data, and more sophisticated analyses.

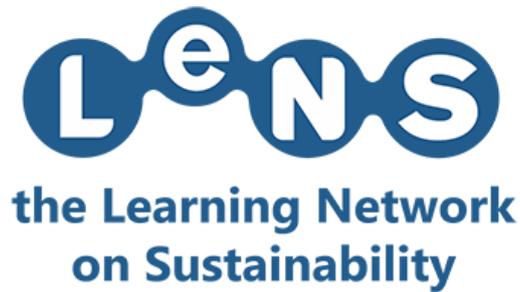


[Figure 2] Mean responses to Q1, Q2, Q3 and Q4 (the error bars represent the standard error of the mean)

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## **BUILDING INTEGRATED PHOTOVOLTAICS (BIPV): SYSTEM APPLICATION GUIDELINES AND ALBEDO ASPECTS**

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### **ABSTRACT**

The integration of renewable energy systems into design and architectural projects is a topic and prevalent theme that presents opportunities for innovative approaches. Since the process combines energetic, structural, design characteristics and also the context in which the project is inserted, there are important variables to be considered in a Building Integrated Photovoltaics (BIPV). The goal of this article is to classify them in order to support designers, architects and engineers closer by means of guidelines for good practices in BIPV design. The realization of this study is justified by the fact that there is a disinformation and a cultural thought that photovoltaic systems depreciate de project design, which characterizes the lack of incorporation of such elements.

Key Words: Design project, Building Integrated Photovoltaics, BIPV, Guidelines, Albedo

## 1. INTRODUCTION

Photovoltaic technology is able to convert solar radiation directly into electric energy. It can be used exactly where energy is consumed ('on-site') and provide any kind of building energy request (thermal and electrical). As a great differential to other renewable energies, "photovoltaics can be easily integrated anywhere into the building envelope, for a number of functions: on/in rooftops, opaque and semi-transparent envelope surfaces, having a structural function as well as sun shading and cladding function, and enabling also a construction costs reduction" (Scognamiglio; Røstvik, 2013). In this context, Building Integrated Photovoltaics (BIPV) are projects in which photovoltaic modules become an integral part of the building envelope, replacing roofing, facades, or other constructive elements, while Building Applied Photovoltaics (BAPV) systems are installed in a structure parallel to an existing building, superimposed on the roof or facade. The great difference between the two models lies in the fact BIPV is conceived integrally and indispensable to the architectural project as a constructive piece, while BAPV is a later addition to the already finished project, often hindering the integration and development of quality architectural projects.

As a focus of increasing global interest, Building Integrated Photovoltaics are considered to be essential tools for the diffusion of photovoltaic technology and to achieve the worldwide goal of Zero Energy in buildings, defended by Shukla, Sudhakar and Baredar (2016, p.100), as energetically self-sufficient buildings, with Zero Net Energy. To achieve this goal, the Strategic Design for Environmental Sustainability supported by Marseglia (2017 p.1727), claims that within a design project (product, service or system integrated development) should approach interrelationships with the environment, cultural, technological and social aspects to reach a good result. These relationships are essential in creating quality BIPV projects and emphasize the fact that in Brazil this technology was known more like a market process than a public policy, highlighting the fact that some aspects are not contemplated and are faulty for its effective implementation. Besides that, there are important barriers to be transposed.

Those barriers include the use of photovoltaic technology on unsatisfactory architectural projects, a low social acceptance, the fact that information about the technology is scattered and uncorrelated and disinformation "as education is seen as one of the barriers for BIPV deployment" (Tabakovic et al., 2017). In addition, Santos and Rütger (2014, p.116) discuss that architects are often reluctant to adopt photovoltaic technology because of lack of training and information about the performance potential of non-ideally oriented and inclined photovoltaic modules. There is a false perception among these professionals that solar modules should only be installed on ideally oriented and inclined surfaces, leading to the lack of incorporation of BIPV systems in buildings, the poor quality of architectural projects or non-adoption of photovoltaic systems, problems that justify this research development.

In response to the problems raised, some guidelines for BIPV projects were developed with the purpose to summarize the information and with the intention of being improved in future work. The goal is to present the important variables to be considered in a BIPV project in order to bring architects, designers and engineers closer to the presented reality, with an interdisciplinary vision. For this reason, subjects like albedo, usually discussed in research articles which are distant from design and architecture but of great importance, were studied and makes part of the discussion.

## 2. RESEARCH METHODOLOGY

The main data source of this study is the Swiss research center BIPV ISAAC-DACD-SUPSI, focusing on development of architecturally integrated PV systems. To complement the data source of this article, a literature review was made, including bibliography about design, BIPV, albedo and solar energy. These data are from qualified journals on the subject.

## 3. BIPV SYSTEMS GUIDELINES

When applying the concept of building integrated photovoltaics (bipv), it is essential to classify the variables that must be taken into account when a bipv project needs to be done. the literature review allowed the knowledge of principles and implementation points that were transformed into guidelines. those were organized to the support of professionals involved in the design process as shown in table 1:

The principles considered are: budget, market, scale and project type, energy demand, building footprint, technology, photovoltaic module design, fixation system, the context in which the building is inserted and aesthetics. Data have been collected from the catalog developed by the SUPSI-SEAC report 2017, the Manual for BIPV projects published by Odersun (still in use despite the deactivation of the company) and articles published in relevant journals. These variables are usually analysed separately and without being related to each other, what causes unilateral decision-making when in fact the design process is complex and holistic. Besides that, because the solar energy study field is extremely interdisciplinary, communication is not facilitated and the incorporation of technology into design projects is impaired. Overall, here we present the sketch beginning of the tool that articulates the different points to be taken into account in BIPV project and that facilitates communication within the different study fields of solar energy.

Principle	Guideline	Implementation
Budget	Determine the economic plan	Paytime
		Available investment (\$)
Market	What is the market in which you are inserted	Stakeholders
		State incentive policies
Scale and type of the project	Scale determines how to work and insert the technology  *Single building or cluster of buildings	Furniture design
		Architecture*
		Landscaping
		Urbanism
Energy demand	The energy needed as an input for design	Building energy demand
		Passive and active strategies connected to the urban network
		Batteries
Building footprint	Space requirements for energy self-sufficiency	Relation between energy and form
		Building envelope area requirements
		Energy generation 'on-site'
Technology	The technology chosen as a relation between efficiency, area to be used and desired integration effect	Crystalline cells
		Thin-film cells
		Organic photovoltaic cells
Photovoltaic Module Design	Module design properties as a important factor to achieve certain integration objectives  *Quality, strength, structure, coating, colour, tinted glass, etc. **such as insulated glazing	Module Size
		Module shape
		Covering glass*
		Cell background or reverse side of module
		Semi-transparency
		Arrangement of solar cells in the module
		Interconnections
		Multi-layered superstructures**
Fixation System	How the system will be integrated into the envelope and what role it will play in the building (roof, facade, window, outdoor partitions, etc)  *Modular fixation, not adaptable and not always have a role in the water-tightness functionality **balconies, parapets, outdoor partitions, shading systems and several other elements	Mounting systems (partially integrated)*
		Full Roof solution (totally integrated)
		Prefab systems
		Solar tiles
		Lightweight systems
		Skylight/Solar glazing
		Curtain wall
		Rain-screen façade
		Accessories**
Context in which the building is inserted	The context will directly affect the efficiency of the system and the presence of the PV modules will affect the building surroundings	Shadow
		Dazzle
		Albedo
		Urban density
Aesthetics	Aesthetics directly related to the level of integration and social acceptance	Integration into the building's skin
		Project quality
		Social sustainability
		Social acceptance

[Table 1] Main sustainability guidelines for a Building Integrated Photovoltaics based on literature review. The authors (2019)

#### 4. THE IMPORTANCE OF ALBEDO FOR SOLAR BUILDING SKINS

As most projects and related articles do not consider albedo as an important factor for the design project, it was chosen to create an item that explains the relation between albedo, the photovoltaic system, the surroundings and how they affect each other. Albedo, or reflectance, can be understood as a light reflected by a surface or, according to the

Oxford dictionary, “the proportion of the incident light or radiation that is reflected by a surface”. Using these definitions in a photovoltaic energy context, Brennan et al. (2014) affirm that “Albedo irradiation changes the spectral distribution of the incident irradiation on the surface of the PV device, which in turn affects system output”.

In this context, the project process considering albedo may become improved since the amount of light reflected by the surface can increase the efficiency of the system, and most surfaces surrounding the PV modules are the result of design choices. For instance, if the surroundings (a wall or ground next to the building, for example) of a photovoltaic facade are white, the indirect light reflected to the photovoltaic facade will be more intense than if such surfaces are black and this relation changes the system efficiency. In this context, Brennan et al. (2014) discourse the significant contributions from albedo in different topologies. The authors used systems with a large tilt angle relative to the ground as an example that can have large albedo contribution. In addition, Andrews and Pearce (2013) include that vertical PV systems (for example BIPV facades) are severely impacted by albedo.

Some authors calculated the albedo factor by grass, snow, water and reflective surfaces, for example Andrews and Pierce (2013) make a comparison between grass albedo (0.23) and snow albedo (0.78), when 0.00 configures no reflection and 1.00 total reflection. Otherwise these authors comprehend snow albedo as a transition, because the thickness changes reflection index. Considering that, Andrews and Pierce (2013) say that when the surrounding irradiance is high, albedo can provide a large effect on the performance of photovoltaics systems. When these systems receive more reflected irradiation the energy production is improved. For example, the BIPV project Monte Rosa Hut, made by Bearth & Deplazes Architekten (image 1), is directly affected by snow albedo in winter periods, when the energy demand is increased.

Besides the albedo influence, the implementation of a BIPV project can affect the surroundings producing increased heat, dazzle and visual impact. This variables need to be considered and taken into account before the system application. For instance, when dealing with historic regions the visual impact of a Building Integrated Photovoltaics project can cause damages, or when the project is situated in a street with a big flow of people and cars the dazzle caused by a photovoltaic facade can be discomforting. Therefore, the social acceptance and sustainability is extremely important to the system implementation and should be considered, as mentioned by Marseglia about the Strategic Design for Environmental Sustainability.

Summarizing, when one decides for a photovoltaic system, the project needs to include surrounding data for understanding albedo and improving the solar energy generation. In addition, the designer always has to remember that the building and the surroundings affect each other and some extra care has to be taken to maintain the balance between them.



[Figure 1] Monte Rosa Hut, Switzerland. Surroundings with and without snow. Tonatiuh Ambrosetti (2009)

## 5. CONCLUSIONS

As discussed in this study, BIPV and BAPV projects are important for disseminating the use of solar energy and achieving the worldwide goal of Zero Energy in buildings. The users involved in this process still do not consider energy as an input for design, a work that designers and architects are responsible for. The energy we use should be seen as “a variable able to relate itself to the form of our buildings (or clusters of buildings or even cities and landscapes) instead of being seen as a kind of abstract variable that design cannot deal with” (Scognamiglio; Røstvik, 2013). To facilitate this implementation, the creation of guidelines helps to recommend good practices in BIPV projects, makes connections between interdisciplinary variables and are a sketch beginning of the tool that will be improved in future work.

For that, some principles like budget, market, energy demand, building footprint, scale, project type, technology, photovoltaic module design, fixation, aesthetics and the context in which the building is inserted, needs to be considered. Moreover, albedo - which is usually not linked to the architectural integration of photovoltaic systems - should be included to optimize the efficiency of the modules in non-ideal orientations. These principles characterize a change of thought about the way buildings are designed. This re-think need is corroborated by the fact that in Europe starting from the end of 2020, all new buildings will have to be Nearly Zero Energy Buildings (Nearly ZEBs - ED2010/31/EU recast) and demonstrate a paradigm change.

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