


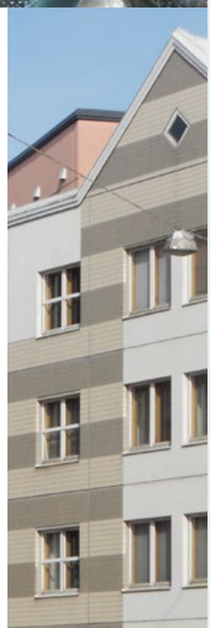

Craft, Technology and Design

Tarkko Oksala, Tufan Orel,
Arto Mutanen, Mervi Friman,
Jaana Lamberg & Merja Hintsa (Eds.)

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HÄMEEN AMMATTIKORKEAKOULU
HÄME UNIVERSITY OF APPLIED SCIENCES

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Tel. +358 3 6461
julkaisut@hamk.fi
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Content

Project description

What is CTD? Shortly it stands for Craft, Technology and Design. The project started from negotiations between Tarkko Oksala (Finland) and Tufan Orel (France) after their co-operation in Design theory. The intent was to build a bridge between theories of Design and Craft and in this sense, it is good to notice Technology as well. First challenge was to find active participants and host for the project. We have been happy in finding HAMK for this duty. Quite soon HAMK opened home pages used actively. First Call for papers were send during the summer of 2019. The home pages were used in communication relatively long, because Covid19 pandemic forced us to proceed in distant mode and somewhat slower than expected. Good is worth to wait and now the e-publication is ready.

The Finnish Society for Practice Based Inquiry (PraBa, www.praba.fi) is a multidisciplinary research association. One of the most central tasks of the association is to collect all the researchers interested in practice based inquiry together to study fundamental questions of the practice based inquiry. Some examples of such fundamental questions: methodology, philosophy of expertise, and knowledge and skills. The main activity is the Annual Congress of Methodology which was held first time in 2002. The Methodology Congress is a multidisciplinary congress; some of the congresses have been international. The association has published several books on fundamental questions of practice based inquiry.

Acknowledgements

We like to thank Häme University of Applied Sciences, as the main sponsor, and the editorial board for encouraging co-operation and generating inspiring atmosphere for all of us to plan and manage the project. We like to thank all the reviewers for their contribution to the content of the book. Most importantly, however, we want to thank all the authors, each of whom made an important and valuable contribution to the book. The authors represent different fields of science, of arts, and of skills which make the book rich in content. Names of the authors can be found in text, reviewers are acted anonymously and Editorial Board is listed below. We hope the book will inspire readers to further develop the themes of the book.

Double-blinded referee procedure was used.

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Marinella Ferrara & Shujun Ban

Women and Maker Cultures – the Relevance of Technological Appropriation from History to Current Phenomena

Introduction

In recent years, consumers and designers' interest in crafting related to *Do-It-Yourself* (DIY) and *maker culture paradigm* (*fabbing, hacking, etc.*) has grown in Europe, USA, and, lastly, in Asia as well. Crafters and makers' exhibitions, fairs, shows, magazines, forums, blogs, image banks, tutorials, and web platforms are echoing the Arts and Crafts movements of the past.

In Europe, as a matter of fact, the interest in craft has never disappeared. Due to different reasons and implications, the culture of craft cyclically returns to be an issue of debate in the design discourse. This is particularly evident in Italy, for example, where design, artisanal skills and industrial manufacture are strongly connected: the debate on craft has been particularly lively in the 70s, together with a new interest for experimental practices. The protagonists of this debate (Alessandro Mendini, Ettore Sottsass, Andrea Branzi and many others) would have subsequently redefined the role of design, marking the passage from design as a tool for the industry to a process of collective and social creativity.

Apart from the numerous and diverse contexts involved in this worldwide phenomenon, one common aspect of the crafting movement is the growing communities of women sharing their creations and activities. This has been regarded as a political act, which can be partly related to a third wave of feminist DIY movement (Carpenter, 2010; Hackney, 2013; Burton, 2015; Salle, 2016).

Another peculiar feature of the current makers' paradigm is the centrality of digital technologies and ICTs: women and ICTs are the harbinger of significant empowerment of our society (Cummings & O'Neil, 2015), as this combination is promising in terms of gender equality, social innovation and sustainability. Women's maker culture can represent a form of opposition to deterministic trends, by rebalancing the way technology is used and by giving voice to a larger part of the society.

Our experience in university teaching has shown us the uncritical adoption of many trends proposed by students and younger colleagues. In particular, from the perspective of digital natives, analogue and manual modes of making may represent a fascinating novelty, regardless of the environments they come from, the material conditions in which they are practiced and what they represented in the past. Ignoring historical processes can lead to falsification or distortion of actual phenomena. To avoid this danger, with this essay, we propose an overview of the worldwide phenomenon of women's making. We aim to contribute to the understanding of the current phenomenon as the result of a gradual women's empowerment in the design field, by regarding it as a part of a century-long process which is still not complete.

We firstly provide a diachronic analysis of the female role in creative practices and technologies appropriation along the history of design from 18th century up to the current time (paragraph 2).

Secondly, we offer a synchronic analysis of the current creativity and design conditions by introducing the reasons and the various characteristics of the craftswomen (who may also be called *crafters* or *craftmakers*) phenomenology. Based on the current literature on the topic (paragraph 3), the critical stances are supported by a number of selected examples drawn from different countries, communities and practices, in order to deepen the understanding of the phenomenon.

Women's Creative and Making Cultures in the Industrial Design History

Throughout the centuries, women have been socially active agents and mediators by combining needs and products, creative practices and technological action. Nevertheless, the relation between women and technology along history has still not been thoroughly investigated[1]. However, by analysing the interconnections between design history, history of women, history of economy and history of labour it is possible to draw insights about women's means of production and their appropriation of technologies. We will start from some of these insights to briefly trace the path of women between creative and technical practices in the Western industrial ages. Without any claim to present a systematic historical study, our aim is to correctly frame a discourse about the contemporary women's maker phenomenon as a part of a historical process. To this aim, we highlight some

1 Much about the women's role in art, craft and design in the Western societies was developed by design & arts since the 70s. Twentieth-century historians and design theorists have put women's role on the sidelines, by nearly ignoring them. In the 80s, a big contribution to the research about women's relationship with technology was given in the frame of 'social construction of technology' (Pinch & Bijker, 1984) with the theory of 'social construction of gender' in feminism and sociology of the 20th century.

particular historical periods and aspects of female making in relationship with the technology appropriation processes.

We use a frame based on the theory of economics' historians, which divides the industrial revolution in three phases, considering a time span which goes from the second half of 18th century to current days. This frame helps to understand and display how the maker culture has been changed and reformulated in each phase depending on different socio-economic and technological conditions. By analysing the evolution phase by phase, it is possible to recognise factors of continuity as well as ruptures with the past through the different creative expression.

The start of an empowering process. The 1st industrial revolution

In the farming economy previous to the industrial revolution, women were confined to their home, where they had to handcraft a variety of goods which were mainly aimed at domestic use (food, soap, candles, yarn, clothes, etc.), and they could interact with each other. Since the second half of 18th century, mechanization traced women's path from home to the industrial factory, starting from Britain. Mechanization, as well as the gradual evolution of consumerism, forced women to face profound changes.

Their work in the factory was structured as an extension of their role at home, although this often ran counter to the rationalization that characterised industrial work (Karamessini & Rubery, 2013, 18). Nonetheless, women's labour in specific sectors like textile, clothing and shoes' field has been appreciated for their ability to manage the manufacturing process, accurate manual skills, attention and patience as well as their low wage (Helmbold & Schofield, 1989).

Some of the most relevant and impacting technologies in women's life were the mechanical loom first and the sewing machine later. These technical innovations had a disruptive impact on the modernization of many areas of the world, by redistributing capital and enhancing social emancipation. Although working in a factory was not considered a desirable job, acquiring a technical competence has led to a growth in the culture of female work. Maker culture and economic independence have been crucial tools for the gradual achievement of a new individualism, and they also paved the way for a modernisation in women's behaviour. This led to the creation of a new social class: the women factory weavers (Helmbold & Schofield, 1989). In 1973, Hannah Wilkinson, an American textile worker and wife of the entrepreneurship Samuel Slater, was the first woman to receive a patent for the two-ply cotton sewing thread (Thorne, 2019).

In the areas where industrial modernization or factory installation were delayed, the productive processes (weaving, embroidering, sewing, etc.) involved women in their homes. Crafting has trained women to deal with complex acts, as craftmakers need to think about what they are doing with each action, with each stitch.

In Britain, bourgeoisie women started to gather in female-led spaces for discussion and education while crafting. In these circles they could share the projects they were working on and express their ideas, as well as their aspiration towards a better society, by conversing and interacting. Starting from 1825, the Female Society for Birmingham, which was born from a small female circle, involved the middle-class women in the first large-scale anti-slavery campaign. Those women handcrafted work bags – a common accessory for women to carry materials for embroidery – and used them as vessels for anti-slavery literature, raising funds and increasing awareness among the population (Midgley, 1995).

During the crucial transition from applied arts to industrial design, women's crafting has echoed the Arts and Crafts movement of the last decades of the nineteenth century: a concerted socio-political stance against the Industrial Revolution, the mechanization of labour, the alienating conditions in the industrial factories and the economic liberalism. Inspired by the Victorian idealism, and the Utopian Socialism of concerted work by Robert Owen (cooperatives), John Ruskin (workers' guilds) and William Morris (craftsmen's workshops), the movement greatly influenced its members' philosophies on the moral of work[2] and spread the idea that the relationship between arts and crafts was a guaranty of the designers' freedom. The movement quickly became an international trend, as it promoted a revival of tradition in the decorative and fine arts, highly valuating the vernacular style.

The creative work, including ceramics, furniture, textiles, jewellery, and metalwork, actually merged into elitist, expensive productions, which were only available for the upper social classes (Dardi & Pasca, 2019, 25). Moreover, the Arts & Craft Society, established in 1887 in London, excluded women from the *guilds* and the best that women could get was the benevolent tolerance from male leaders, helping their artisan father or husband. Women could only contribute to the decoration of the pieces, most of the times by using the name of the male artist (Wolf, 1989). Different was the case of the Arts & Craft Movement in USA (Kaplan, 1991) and in New Zealand (Calhoun, 2000). Here women had the possibility to establish independent small studios and shops where they were free to pursue

2 Owen's work focused on reforming society with the cooperation of school and the pursuit of happiness, Ruskin's work denotes nostalgia for the past as a guide for future reforms, and Morris' work concentrates on the pursuit of beauty as a way to reach social harmony. At first, the movement encouraged amateur practice of both men and women to produce their own furnishings and decorative objects.

their own creative interests in productions as pottery, metalworking and bookbinding: for instance, the ceramists Robineau Perry and Elizabeth Overbeck (Cumming, 1991, 101). In most cases, however, crafts production gathered women in a labour-intensive environment, providing a meager income in exchange for long hours of work. In some contexts, handicrafts were for women a means to increase their income, but only under certain conditions: it could be an economic help for the family, a collaboration with the husband or a diversion for women who didn't need to worry about financial return, since crafts were specialized activities that could only offer limited market opportunities. Women's motivations[3], technical skills[4] of embroidering, weaving, sewing, mixing colours, painting, composing forms, choosing the right materials for each piece, started to be appreciated as a dominant craft sensibility. These factors influenced other categories, especially motivations, cognitive processes and skills. With craft's long-standing roots in women's work, it may not be surprising that women were elevated as tastemakers. Their sophisticated perception of goods has been appreciated also in the service sector during the first development of consumption in the XIX century and then in many other fields during the XX century.

The second phase of industrial revolution. Towards the modernity

Across Europe, the bourgeois families have gradually accepted the possibility for non-married women to study and be engaged in arts and crafts working activities in sectors which have been historically influenced by women making and consumption, like home decoration, textiles and fashion. Crafting was often an opportunity to break free from oppressive domestic roles and experience a creative activity with sensory intensity. Women's maker culture has been appreciated but at the same time underestimated in economic and entrepreneurial terms.

The First World War has acquired a central place in the birth of the *new women*. Wartime posed a challenge to the traditional role of women as homemakers in the private sphere, due to the absence of men: women started to carry out different professions. Invested with a new greater responsibility, they have gained awareness of their ability to manage risks, investments, and business relations. The socio-technical environment triggered dramatic changes in the interaction with other people concerning technical actions and socioemotional support such as the exchange of ideas, the access to sources of information.

3 These include intrinsic factors related to personal interest and inclination.

4 Technical skills are knowledge and expertise in a specific domain and the ability to manage the creative process.

The *Roaring Twenties* represented a cultural discontinuity, and a promising time for the women's emancipation in connection with the renewal of the arts and the industrial expansion. The new ethical function of *Art into Industry for mass production* by Walter Gropius at the Bauhaus renewed the aesthetics and the qualities of the industrial production in relation to manufacturing processes. A rationalist language was developed by the students of the Bauhaus workshops, including the female students at the textile laboratory. Elementary forms, abstract compositions, and references to primitive arts replaced the traditional repertoire of domestic interior.

This cultural renewal which also involved cinema, theatre and ballet, ended up influencing everyday life by proposing new female models. In Paris, where feminism became a political movement since the 1890s, women wore trousers, coloured socks, clothes with soft materials which made body movements easier and more comfortable, overcoming the preconceptions about female sexuality. Among the first women who became role-models for other women, there were artists and designers such as Sonia Delaunay (1885–1979), the American interior designer Elsie de Wolfe (1865–1950), the British Vogue management editor Dorothy Todd and the fashion editor Madge Garland, the Irish architect and furniture designer Eileen Gray (1877–1976), the French fashion designer Coco Chanel (1883 –1971), the textile designer Gunta Stölzl (1897–1983), Marianne Liebe Brandt (1893–1983), and Margarete Shütte-Lihotzky (1897–2000) coming from Bauhaus. All of them dedicated their creative and critical energy to the modernist reconfiguration of domestic spaces and to the design of suitable products for the new woman.

In many difficult times and contexts women’s production has been marginalized, but in time of war, austerity and autarchy, female work was carried out in the name of the country (Karamessini & Rubery, 2013).

In Italy, during the Fascist Autarchy (1930s–40s), a national policy aimed at the defence of artisanship encouraged female entrepreneurship: many proto-designers in the textile and fashion sector (the so-called *artists of thread)* introduced *avant-garde* trends in the country thanks to their work and experience. The experimentation on local, natural fibres as well as on new synthetic materials was one of the interesting aspects of their modern handcraft. (Lecce & Mazzanti, 2018) Among the many, Fede Cheti (1905–1979) founded her company of artistic fabrics in Milan in 1936: she started to collaborate with the famous architect Gio Ponti and, during World War II, she also patented her own synthetic straw, called Lin-Lan, hand-woven by rural crafters from the city of Cremona. During the 50s, along with the shift towards industrial manufacturing which brought innovation in textiles and design, she patented the *tessuto cinese*: a composition of nylon fibres. She rapidly gained international resonance by exhibiting her work in Paris and New York (Lecce & Mazzanti, 2018).

Both in Italy and in Austria-Hungary (Lees-Maffei, 2008, 11), female professions of interior decoration can be regarded as arenas in which stereotypical gendered roles have been renegotiated.

The sewing machine appropriation between modernization and social resistance

Sewing machine has been a democratic and fundamental technology in women's making culture. This machine played a decisive role in women's experience of the modernity both as producers – in factory or at home – and consumers. Accelerating and decelerating its movement, this machine effectually represents the specifically feminine experience of modernity, i.e. a mediated experience between women's emancipatory progress and social stagnation[5] (Friedrichs, 2018).

The use of this machine in industry has been a drive towards women's social mobility and traced their path into the public sphere by offering them employment and the opportunity of wage earning for subsistence.

As soon as it became affordable, re-designed, *domesticated*, well communicated and promoted as a consumer product, sewing machine entered into women's life. Being previously experienced and used under convenient working conditions, in a context of social interaction[6] sewing machine represented a powerful means for women to enhance their abilities. Manuals and fashion magazines, which provided women with new ideas and prompts like paper patterns for finished garments, contributed to their independence and introduced them to the production and systematization of labour. By sewing clothes for themselves, their family or for sale, women could feel a sense of accomplishment, as they were able to contribute to the family income, or to challenge their role in society as entrepreneurs. As a consequence of this process, it is possible to witness an upheaval of gender-based power hierarchies into the traditional family.

5 The sewing machine has been negatively reviewed by feminist criticism. Most of the critiques are addressed to the promotional claims which declared that sewing machine would make women's life easier by speeding up their work and increasing their free time. On the contrary, the truth was that sewing machines could cause the exploitation of scarcely paid women who worked at home and would end up in actually increasing the amount of housework, reducing women's free time. Compared to manual sewing, which could be done while chatting with other housewives in common spaces, the sewing machine relegated women to their home, favoring isolation, and reducing the possibility of interacting with others.

6 Singer Corporation, the most famous manufacturer of consumer sewing machines, adopted a successful strategy to improve women's appreciation of the machine. They organized courses and other collective events proposing a new experience of interaction among potential users.

The autonomous crafting of clothes allowed women to express their own individuality against a uniformity of appearance. Even after the *pret-a-porter* fashion diffusion, in particular contexts, some women continued to sew thanks to the pleasure that such activity could bring as a creative and technical practice, enabling image control, personal expression and independence from manufacturers (Kramarae, 1988). In more recent times, in developing countries such as Ecuador, Iraq and Pakistan the machine helps to generate economies, and serves as a means of creating and transforming clothes into forms of artistic or political expression, as in the case of the *molas* of the Cuna women from Panama (Berlo, 1992).

As demonstrated by the sewing machine example, when a technology allows autonomy, provides a pleasurable experience and enables personal expression, interacting with it may deploy a huge innovative potential. Any creative process, whether it is handmade or supported by technology, proves to be in principle a source of empowerment. But the appropriation of a technology is unlikely to be effective in this sense if we ignore the wider social environment within which it is designed and used.

The mature industrialization

After World War II, the emancipation of women resulted in a bigger impact of industrial production in their life. In general, middle- and upper-class women's experience of modernity has been related to mass cultural production, the introduction of the department stores, advertisement and consumption of mass-produced goods. The system of mass production boosted women's entrance into the public sphere. Women were involved in industrial production, related professions, and in new department stores. Traditional hierarchies and rules were gradually subverted in working and domestic environments, infusing workers with increased self-confidence and raising awareness of the importance of their work (Porter Benson, 1986).

With the improvement of socio-economic conditions, women became major sellers, consumers and users of mass-consumer goods and technologies. During those times, a general handcraft and low-tech anti-climax emerged. Due to the high level of quality of industrial products, to the promotional activity of brands, and to the enhancing of modern lifestyle, handcraft began to lose its relevance. It was impossible for artisanship to compete with industrial manufacturing. As a result, craft has gradually lost consumers' interest, its cultural capital, perceived value, and legitimacy.

Increasingly complex technologies and products gradually made their way into households and offices, following a path started during the interwar years, firstly in the USA. Home-appliances had a profound impact on women's daily activities and enabled the construction of self-consciousness and the distinction between private and public spaces[7]. Obviously, social class made the difference in terms of accessibility to new technologies, triggering many inequalities between countryside and cities. In the spirit of functionalism, connected to the mechanization and rationalization of work, women professionalised their role as housewives. Many promotional activities contributed to teaching women how to rationalise their work, make it more efficient and raise its quality. Household technology appropriation and the rise of living and working standards have been an important part of the development of the modern industrial society. However, as was noted by Landström (1998), since male engineers and designers developed appliances, these technologies were conservative in their view on what home and women's place in modern society should be[8]. This bias clearly emerged in a study of microwave design in the UK (Cockburn & Ormond, 1993)[9].

A parallel perspective shows that in a consumerist society, which firstly developed in the USA, the home becomes an important market outlet for thousands of products. For the first time in history, women became responsible for the purchase of an ever-growing range of products. As a consequence, enterprises and the distribution sector started paying more attention to women as consumers.

In the same years, the home economist and marketing expert Christine Isobel Frederick (1883–1970) published the popular book *Selling Mrs. Consumer* (1929) which instructed manufacturers and advertisers to take female interest into account. Women were welcome in advertising agencies, industry, and selling fields as the number of agencies increased. Industrial designers added the feminine touch to automotive design suggesting a broad-based demand for women to reach the expanding women's market (Sivulka, 2008).

7 Electricity triggered a systematic change in the mid-class interiors. After the electric iron, the electric sewing machine was the first technology to become widespread, progressively followed by vacuum cleaner, washing machine and refrigerator.

8 For more than two centuries in the design history – as denounced by many feminist scholars – product design has been mainly shaped by the young, white, standard male. Male influence takes over any stage of the social process of shaping technology, (fabrication, marketing, retailing and distribution) starting with the representation of the customer, the construction and control of the consumer up to the user experience.

9 This study demonstrated how the design features were specifically tailored for female or male users, tending to reflect and reinforce gender stereotypes. The microwave was initially designed and marketed as a brown good for single men, who were supposed to only heat pre-cooked meals and to be more interested in hi-fi equipment than cooking. The product was then redesigned as a *white good* and completed with *combi* cooking facilities in order to be sold to family households, assuming that women would take care of the cooking, and that they were both skilled and interested in the topic. The above-mentioned assumptions played a crucial role in the design choices.

Women's role in the job market took several decades to be socially recognised. Women started to create jobs for other women, to organize associations, and created networks to express solidarity and support. After the USA, the focus of marketing on women's consumption patterns moved to Europe. The decrease of women's domestic work as a modern acquisition and their appropriation of technology has provoked the downfall of craftsmanship in many countries.

The 3rd phase of the industrial revolution: the digital revolution

Handcraft revamped as a subversive form of art in the 1970s, serving as a means of feminist expression that criticised patriarchy and the male-dominated society. Textile work by artists such as Judy Chicago and Joyce Wieland attempted to unsettle male expectations of female artists' domesticity and child-rearing (Robertson, 2011, 184). The third phase of the industrial revolution began with the counterculture movement, an anti-establishment cultural phenomenon that widely developed and spread in the western societies between the mid-60s and mid-70s. Within this movement, second-wave feminism helped increase equality for women in the job market. Feminists aimed at improving the private life and the professional skills of women, promoting a greater level of social emancipation and the inclusion of all minorities – an aspect which had its own peculiarities in each area of the world. The social perception of women and the awareness of their role have evolved in most fields and manufacturing sectors.

This phase of the industrial revolution is characterized by the development of digital technologies and ICT, appropriated and used by women. In the digital technology age, the physical power, the command-and-control authority system, as well as traditional hierarchies – including gender-based hierarchy – started to decline, while human capital, information, knowledge, and innovative potential acquired enormous value in the economic competition.

At the beginning, digital technology, advanced electronic products and services – such as mobile phones and social networking – were dominated by men, just like other technologies in the past. As a consequence, all of these innovations did not reflect women's expectations. During the 90s, leading ICT corporations in the USA noted that women were the predominant users of these technologies in the workplace. Their extensive use was related to the benefits that women could obtain: the possibility of increasing social communication and to strengthen interconnections, the chance to have greater flexibility and to balance time between work and family, the opportunity of creating independent networks.

To reach the goal of integrating women's needs in IT, Xerox Corporation started a co-designing process, transforming women from users to designers, and giving shape to new IT-based technical products[10] (Fountain, 2000). They have demonstrated that, compared to men, women tend to have a different point of view on the technological needs of society.

In the following period, digital social media and different application of networking services have consistently increased the number of users interacting, changing the web from an informative solitary activity to a social dimension. Web 2.0, social networking services, open-tools and shared platforms are based on the assumption that people wish to create relationships within the cyberspace. They facilitated relationship building and innovated the way people are involved in collaborative activities. They work as a central mechanism in the design of social systems. We can consider them as new "tools for conviviality" (Illich 1973) because they are flexible to different people's needs, enabling individual freedom in self-expression, and encouraging conversation.

The Expansion of Design and Maker Culture

The third phase of the industrial revolution – in which we live – has clearly marked its discontinuity with the past, since all of the basic conditions of society have changed: one of these is the perception of women's role in the society. "For the first time in history, women have the opportunity to play a major and visible role in a social transformation of potentially monumental proportions. The rich and extensive penetration of information technology into virtually every area of society creates enormous opportunities for women." (Fountain, 2000, 3).

This change, as many others in the field of design, does not come from a radical replacement of the old approach with a new one[11]: design expressions are progressively growing in complexity, and new issues are emerging.

Speaking of design today, we can quote the Italian scholar Vanni Pasca (2020), who claimed that "design has expanded" in three-dimensional axes because of the industry's transformation and globalization. Firstly, design has expanded in quantitative terms all over the world: the number of designers, both female and male, has been growing since the 1990s and is still rising in emerging countries, so is the number of design schools. In addition, new creative practices have been developed by prosumers

10 This obviously led to a strong competitive advantage for the companies.

11 As in each of the past phases of the industrial revolution, the previous model gradually shatters due to new conditions, and new practices and expressions of creativity are formulated. Previous modalities remain as elements of continuity, but new elements of discontinuity become progressively dominant.

(Toffler, 1980) and by individuals engaged in DIY communities such as hobbyists, hackers and *proams* (professional amateurs).

Secondly, design has expanded geographically. A few decades ago, design was practiced only in a few industrialized countries: UK, Germany, Italy, Scandinavian countries, USA, Japan, and few other areas. Today, design is gradually becoming a global activity. Emerging countries, like China or Brazil, regard design as a global competitive edge not only for companies but also for the country itself.

Thirdly, design is expanding in typological terms. In order to compete in the global market, or at least to resist the competition of imported goods, from automobiles to face-masks, from furniture to services, from tangible to intangible goods (as services) all products are invested by design. Design thinking in particular represents the approach to solve all problems and is increasingly called to deal with complex problems such as world hunger.

As a consequence of these design expansions, the ways of practicing design generate a *multiverse*, i.e. a set of coexisting and parallel universes. From industrial design to *design art* (Pasca, 2010), the expanded creative class acts with a combination of practices involving a mix of creative capability, technical ability, aesthetic judgment, community spirit, innovation, and experimentation. This process involves craft, art, design, technology, electronics, informatics, public realm, and science, as well as common users, who are turned into active designers. Made as freelancers, contract micro-entrepreneurship or DIY, design activities can vary over time and result in being more or less flexible labour. This expanded creative class, as those presented by Richard Florida (2004), generates ideas and regards the aesthetics of making as a cultural economy. As a result, it is possible to witness the rise of a new economic phenomenon, in which plenty of independent labours act as cultural production.

In such unprecedented situation, an expanded *maker culture* emerges. It is characterized by "an interconnected play of social, cultural, ethical and political elements." (Nascimento & Polvora, 2016) It seems to shape a new paradigm according to which different manufacturing modes, from industry to DIY, from local to global, can coexist without any conflict: not as opposers but as complementary activities, that influence each other (Nascimento & Polvora, 2016).

Phenomenology of contemporary women's DIY

Much has already been written about the emerging women's craft makers phenomenon. At a global level, these informal creative practices constitute a complex and contradictory arena reflecting the complexities and contradictions of feminine emancipation empowering processes and our societies itself. In each country, the phenomenon shows a different size, peculiar features and *raison d'être* but also common elements. The origins of the phenomenon are connected to a reaction to the global financial crisis of the last decades and the following austerity in the USA and Europe. By retrieving some practices promoted during the past austerity periods, the phenomenon symbolises an "*ideal* response" to the current austerity (Bramall, 2013, 112). This is more evident in the UK where the tradition of sewing circles became a symbol of "political and economic subject-formation". The origins are also linked to the gendered labour inequalities as well as the lack of recognition of women's contribution in the creative work, as it happens in Italy, where the phenomenon is more related to the domain of arts than to the crafts field.

The phenomenon challenges traditional constructions of women's making in the domestic place for money or hobby as purely amateur production. In some cases, it is reminiscent of the ideology that originated the Arts and Crafts Movement, since many of its expressions refer to an ethical attitude towards life, work, and environment, as well as a critique of industrial society and capitalism. But this revamping also includes non-political motivations, such as consumers' demand for unique items as a reaction to perceived impersonality of globalized industrial production. The handmade, unique, customized piece acquires desirability at market level and stimulates a return to lost female craft practices. In this sense, the phenomenon slightly reminds the early-mid-50s USA scene, characterised by the burgeoning consumerism in products sectors such as home craft and interior decoration. There are also similarities with the 1960-70s feminist arts and crafts expressions of counterculture to respect in a society dominated by the white-male.

Sally Fort (2007, 3), who has analysed the scene of British subversive craft, claims that the current phenomenon is "just not craft as we know it [...] but this is a remix". Actually, the DIY trend incorporates many aspects of the past crafting phenomena, but at the same time seems to contradict all of them. It is a remix of intentions, as well as of past techniques and expressive languages. Crafting is often used as a nostalgically ironic tool to recall the presumed role of domestic creativity and it represents a means of expression for crafting women rather than an oppressive task of their domestic role (Fort, 2007). It includes hand-made abilities and "technologies of memory" (Sallee, 2016; Sturken, 1997, 4) – which were traditionally regarded as feminine – such as crochet, embroidery, knitting, weaving, sewing, dressmaking, cooking, etc., however it is not limited to these. The reappropriation of these techniques leads to the creation of cultural products, with tangible value and a strong intangible meaning that send messages. The memory can also be mixed with incorporating new techniques and technologies as in the case of electronic crafts.

One of the biggest international communities of crafters is *Craftivism* (Greer 2003), which was born in the USA thanks to the sociologist and crafter Betsy Greer and has now expanded worldwide. Since the 1990s it is an active movement that focuses on the creative re-use and re-appropriation of making, steeped in elements of anti-capitalism, environmentalism and solidarity. Today it provides a website, a manifesto and a blog that connect craftivists around a globalized digital world, allowing them to share their projects and seek for influences and inspirations. Participants give their contribution to the sharing culture with an open-source mindset, teaming up, and learning from each other. On the Craftivism website, the emphasis is placed on handmaking, as well as on activism, by launching conversations about collectivism, uncomfortable social issues and the will to create a better world.

Activism is also a specific trait of *Knitta Please*[12], a group of artists dedicated to knitting site projects, also named *knit graffiti*, in which the *guerrilla* creativity creates a peculiar resonance through handcrafted pieces of public art such as the *yarnbombing knitting*. To give an example, we can mention the craftivist Maria Molteni and the NCAA Net Works – an international, feminist art collective building on DIY skill-sharing models – which create hoops for basketball courts (Fig.1). Their intervention in the playgrounds includes colourful graphics for the floor and walls, showing that courts are for the use of both boys and girls and to defy gender stereotypes. The NCAA collective revitalizes spaces by launching messages both critical and fun.

As noticed by Luckman (2013), crafter communities are contributing to the repositioning of the craft practice in gender and class as well as in space and domain.

12 Born in Houston, Texas in 2005, the movement is known for wrapping public architecture and street art across the USA and around the world. One of the main exponents is Magda Sayeg interested in the materiality of knit to explore environmental changes to make these more challenging, unconventional, and interesting.

Figure 1. Maria Molteni and NCAA Net Works.

In the craftmakers universe[13], the appropriation of ICTs, and other digital technologies as daily devices is the key driver. ICTs and social networking enable individual expression in a free community by creating a social network that ties other creatives as well as users. This mode of action disrupts the traditional relation between creators and consumers, pursuing a post-industrial economy of mutual aid and co-operation (Fort, 2007). According to Fischer (2011), social computing facilitated a shift from a passive consumer culture to active cultures of participation.

Any individual bricoleur or craftmaker, any *community of interest* and any *community of practices* can share their work, creating videos or other multimedia artefacts, individually managing processes that used to be more complex in the past. With the use of various apps, anyone can

13 Many are the communities of crafters (*One of a Kind, Women Crafting Change, Workshopshed*, etc.) born also with the support of virtual space dedicated to women that want to create their women's creative circle, like *Hearthfire*, or the guide *The Millionth Circle. How to Change Ourselves and the World: The Essential Guide to women's circles* by the psychologist Jean Shinoda Bolen. Many are also the individual makers that use marketplace or their own web sites.

generate cultural contents and products, both tangible and intangible. Any crafter can extend their crafts from an offline individual studio, to a wider online environment where she can quickly, easily and cheaply set up her store, share with their informal network, mediate daily conversations, promote herself, manage and grow her microenterprise (Wallace, 2014). Specialist marketplaces like Etsy, make connection with an audience and sell their creations even easier.

For instance, German craft maker and YouTuber Laura Kampf defines herself as a “self-employed artist/designer/maker and content creator” (Kampf, 2020) who is passionate about her workshop, developing new skills and making objects. She started as metal and woodworker, who repaired, recycles and re-uses all sorts of objects and materials. Every Sunday, she publishes a new video on her making challenge of the week to gather potential clients for commission work (Fig. 2). She has promoted her activity up to the point of selling branded merchandise in her online shop.

Figure 2. Laura Kampf’s video frames.

New digital spaces are not neutral: they are rather made up of agents, social structures, habitus, and practices that operate as a social system and are imbricated with various types of capital, including social and cultural ones, as symbolic modes of power accumulation and class distinction (Wallace, 2014, 101). These digital spaces enable a *pro-am* entrepreneurialism based on creative capabilities, technical ability, aesthetic judgment and community spirit that opens a new flexible work opportunity for women. Being a compromise between paid work and unpaid domestic responsibilities, the phenomenon defines a trajectory in the women’s transition from being traditionally employed to managing a micro-enterprise accessing to international marketing and distribution networks.

The act of crafting is also becoming a fashion trend and a social spectacle (University of Mexico & Sallee, 2016, 3). This process also involves fast-changing China, where craft is growing in popularity among young people who live in over-modernized cities. Some clever entrepreneurial realities such as the KWCW Company by Wang Sujuan, is designed to incorporate the craft on new product and devices for women. The rise of craft desirability in China is a reaction to fast modernization of the megalopolis and to a stressing lifestyle. Craft was for women, and it can still be, a means of well-being, healing both physically and emotionally. Young women's relationship to craft combines the urge to live a quiet and nature-oriented life, and the nostalgia for traditional culture. There are young women who made the choice of eating local food and showing how to wear traditional garments into Vlogs and entered the live broadcast economy as entrepreneurs. For instance, Li Ziqi is one of China's most popular web celebrities with 3.36 million subscribers on YouTube, and more than 20 million views on her most popular video. In her videos she performs the work of a farmer cooking organic food, constructing furniture by hand, or producing her textiles with the grace of a fairy, offering a romantic depiction of China's countryside life. Li Ziqi's huge influence is largely attributable to a sophisticated narrative and visual language, and to people's fascination with a paradise made of forgotten handicrafts, which expresses their desire to return to a closer relationship with Nature. Even if she doesn't truthfully show the reality of living and working in the countryside, Li Ziqi has a big audience made of urban millennials attracted by these appealing rural life fantasies: their interest is giving a big contribution to her territory manufacturing, to the dissemination of traditional crafts culture and to an environmentally sustainable life, consistent with the policy that has been recently started in China[14].

14 Li Ziqi was invited to be ambassador of the China Association of Young Rural Entrepreneurial Leaders.

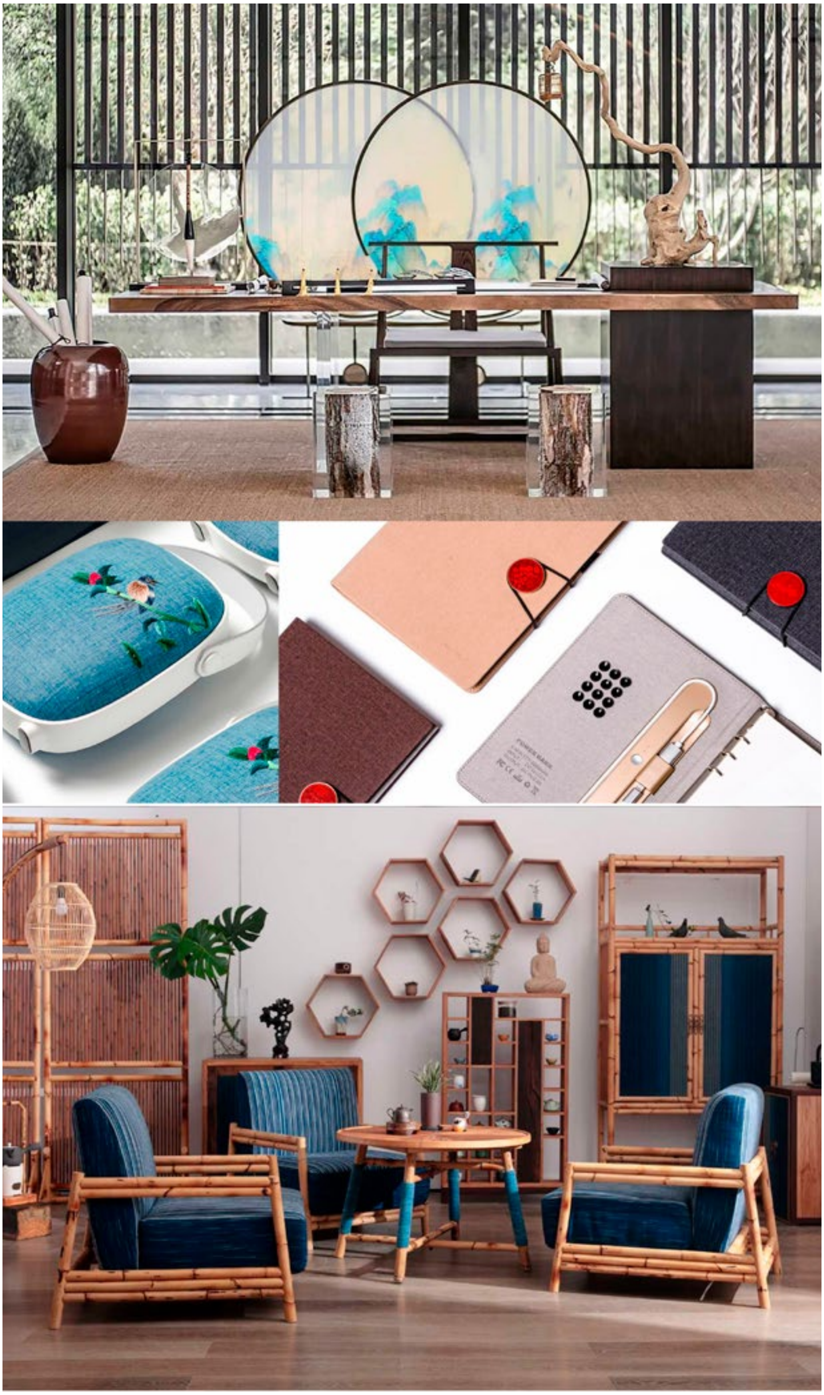

Figure 3. Products by Wang Sujuan and KWCW Company.

Figure 4. Li Ziqi's video frames.

With this paragraph we witnessed how women actively craft a position for themselves and help other women do the same. Creating a new job opportunity in an evolving working environment is not a mere form of resistance to the old system nor just an acritical acceptance of the new, but a continuous interplay between the two. What is crucial in this process is the opportunity for a new domesticity, a new way of working, learning and developing skills, more than just producing and competing. This is a challenge to market processes which can involve all of us as potential producers of things, economies, and knowledge. So, this new kind of products, regardless of their level of quality, carry a much wider range of exchanging values.

The women makers in FabLabs

Moving away from the traditional gendered craft and low-tech DIY, we can delve into the sphere of maker community composed by digital technologies enthusiasts who, regardless of their background, experiment with microelectronics and rapid manufacturing. They shape one of the many facets' phenomenon of the "diffused creativity" (Branzi, 1975) that characterize our times.

In FabLabs (or maker spaces, hackerspaces, innovation laboratories), makers exploit the power of a diversified cheaper set of tools and machines intended for personal manufacturing, as introduced by Neil Gershenfeld (2005). His conception of the FabLab is based on a democratic access to technology, which enables anyone to make (almost) anything[15].

As in the case of ICTs and the web 2.0 for crafters, the FabLabs democratic access to different technologies is the key driver of makers phenomenon. In the past decades, women have been increasingly active in this innovative scene. This first happened in the fashion field, in which women are used to being active entrepreneurs more than in other fields. Protagonists of fashion-tech aesthetic evolutions such as Pauline van Dongen, Lisa Lang, Iris van Herpen and Anouk Wipprecht, infuse their creation with a strong character, exploiting original expressive languages of new technologies.

Following their experiences in fashion and technological visions, young women are encouraged to approach the world of digital manufacturing. For instance, the Italian designer Annalisa Nicola has reconsidered the 3D prototyping potential in the tailoring of female products and created the concept of the XYZBag brand, which offers highly personalized bags.

15 Technologies in FabLab are digital fabrication devices (CNC machines, 3D printers, laser cutters, etc.), open-source and low-cost hardware (Arduino, Raspberry Pi, etc.), and all the multiple digital and analog add-ons from the newest ambient sensors to the oldest materials.

Her start-up adapts the products to differences between individuals, by involving consumers in self-design and self-expression creative processes. Once interviewed, she said: “The result of advances in 3D printing production is going to reset the lines between prototype and product, by revisiting the tradition of hand-made craft as digital craft where hand-made is replaced by a code. The bags are custom designed as per the individual’s personality, mood, or the occasion. Each bag is produced one at a time. Twelve hours of production, layer by layer. A few hours of rest not to stress the piece inside the powder block and finally a hand-made post-treatment finishing.” (Toure, 2016)

Figure 5. XYZbag, a line of highly personalized bags 3d printing manufactured.

The makers community[16] is seen as the vanguard agent in creating a new society, as well as the leader in generating disruptive innovations that

16 The community is composed of fabricators, artists, designers, scientists, engineers, educators, students, amateurs, professionals of various ages. Associated through the Fab Foundation, a global network of Fablabs, this movement has spread to more than 80 countries and counts more than 1,000 labs worldwide.

largely affect scientific, economic, educational as well as social structures (Deloitte, Hagel, Brown & Kulasooriya, 2014). It has the potential to break down past deterministic hierarchies by using technology, moving from centralized production to decentralized distributed manufacturing, from consolidated processes to a more sustainable and inclusive way of innovation. For this reason, the many fields of research focus their attention on these communities and spaces, with the aim to increase the participation of women and to develop the potential of makers community's innovation. The enhancement of diversity increases the spectrum of ideas and perspectives considered to identify opportunities, opening the range of new products and services. Women's presence is needed for a better understanding of users' behaviours and customer needs, and also gives enterprises the chance to meet those needs (Hillman, Cannella & Harris, 2002; Miller & Del Carmen Triana, 2009; Galia & Zenou, 2013). This is confirmed by what women from FabLabs are proposing. For instance, in the food system innovation research, Engeli Kummeling, a co-founder of FarmHack, uses data and technology to empower smart farming and achieve a more sustainable and diversified food production, in order to change a productive system that is mainly focused on efficiency. Chiara Cecchini, the co-founder of Future Food USA, carries out her research to enhance the reduction, the recovery and the recycling of waste from the agri-food industry. For a big brewery in the USA, she has developed a method for obtaining flour from the large quantities of barley malt waste that remain at the end of beer production. Involving an Italian gastronomic team, they found recipes in which these flours could be used for pasta, bread and sweets. In the field of recycled material innovation, which is currently developing in Italy thanks to many women engaged in sustainability, circular economy and eco-design research, Alice Zantedeschi and Francesca Pievani are transforming the waste of the stone districts into the fabric coating Marm More, with the open innovation project Fili Pari.

A study on makers, related to the EU MAKE-IT project, shows the results of female leaders in term of difference with male. Although both males and females use the same technologies to a similar extent, women tend to have a more sustainable impact than their male counterparts (Millard et al., 2018). This study also shows a difference in hard skills acquisition: males are slightly more likely to be involved in modeling, software development, robotics and Internet of Things (IoT), while females tend to use a wider range of technologies and to be less specialized in their technology use. Major difference between male and female soft skills: learning is more important for males, whilst interaction is a crucial skill for females. Men are also slightly more likely to use the technology for commercial purposes than females, and again females tend to be more generalist in their use of technology.

Unfortunately, despite women-in-tech being a rapidly growing phenomenon, it still remains a minority. In fact, women's participation in FabLab is low if compared to men. In the 3D printing field, women only represent 12% of the people involved, as reported by Sculpteo and Women in 3D printing in 2019.[17]

The issue of women's underrepresentation in maker culture represents a contemporary challenge to achieve gender equality in the twenty-first century[18] (Cooper, 2006).

Final Considerations

With the aim of understanding the current phenomenon of women makers, we have been proposing a historical excursus of women's creative and technical practices during the industrial ages in the context of Western societies.

As noticed by Jill Seddon (2000), we can confirm that the pseudo-inclusion of women in the design profession is a recent conquest of the first half of the twentieth century. For this reason, we framed the excursus in very blurred boundaries between crafting, design, making, and user practices. We highlighted the various ways in which women have been active agents of making in different cultures, sectors of activity, techniques, labour situations, times and environments. Examples include areas that have traditionally been seen as women's domains, i.e. individually crafted houseware in the domestic settings as well as collective work in spaces like circles, studios, agencies, or factories designed and created for others. Women have also been regarded as tastemakers in public spaces as consumers. Women's creative practices were, and still are, linked to self-realization, self-expression, resolving economic or family problems, pleasure, positive emotions and interplay of emotions, identities and relations with other people. These practices empower women, link them to other people, allow them to build products with a subjective or social value. From all these

17 The under-representation of women-in-tech is mainly caused by some anachronistic preconceptions that prevent women from undertaking technical or technological studies, especially during high school, resulting in a decrease of their job opportunities. Other causes have been identified in the interplay of socio-cultural barriers such as gender stereotypes, male dominance within the co-working space, and a lack of female role models.

18 The search of solution to this problem may concerns initiatives aimed not only at democratising digital technology by making it more approachable to a wider audience of people who may be reluctant to work in the field, but also to foster a transformation of traditional school systems and provide pathways to achieve social and environmental sustainability goals. FabLabs should work to overcome cultural stereotypes (Maric, 2018). A number of FabLabs (such as FabLab London, FabLab Trójmiasto and Solidarity Fablabs) have been working on this. US-based organizations such as Code/Art, CODeLLA, Girl Scout, MakeGirl, and other maker initiatives such as Double Union, Mothership, Hacker Moms or Seattle Attic are some examples of co-working spaces established and run by women with the aim of actively transforming the male-dominated image of maker culture (Maric 2018).

practices, women's *everyday creativity*[19] strongly emerges by embodying the interaction between *individual processes* as well as *social processes* of creativity. The latter is a particularly suited and relevant concept in the contemporary discourse of empowering society through cultures of diffuse, collective and social creativity (Branzi, 1975; Fischer, 2013; Amabile, 2017).

Moreover, the nuanced path of women has been characterized by times of acceleration as well as times of deceleration towards modernity. Women's participation in the public sphere as makers or consumers is considered as an acceleration[20]. On the contrary, the segregation of the making in private space is seen as a deceleration, often connected to ideological movements against modernity and its effects[21]. The social complexity of this path has profoundly shaped women's behaviour. Women have introjected specific creative modalities linked to an *artistic approach*, and got a *soft mastery* characterized by soft skills of negotiation, compromise and give-and-take as psychological virtues (Turkle, 1984). Women's creative modalities create a space for mutual support and trace a path towards an inclusive society, which is more democratic and respectful of diversity, founded on diverse perspectives by making all voices heard. The *creative approach* and *soft mastery* are fundamental to complement hard skills in order to manage complex projects (Azim, Gale, Lawlor-Wright, Kirkham, Khan & Alam, 2010).

The democratization of digital technologies has opened new opportunities for anyone to engage in creative acts and to contribute to an increasingly diffused phenomenon of *social creativity*, characterized by *the culture of participation* in which digital technologies are an integral part. Like a *multiverse*, it is a complex system, unitary and manifold at the same time, which cannot be understood in its intrinsic unity. It is constituted by different and parallel communities of prosumers, amateurs, bricoleurs, crafters, makers, and professionals that grow around different types of creative

19 Many researches recognize the peculiarities of women's creative processes in everyday life, among which there are the complex mechanisms of integration of creative activities and tasks related to care, upbringing and household responsibilities. Day-by-day creativity and production are significantly influenced by experiences, emotions, perceptions, and motivations. It "brings together tradition, imagination and innovation." (UNESCO, 2014 p. 74)

20 For instance, the sewing machine appropriation shows gender-based boundaries of public and private sphere in modernity. The oscillation between these two different spheres, the domestic and the public one, gives evidence to the fragility of modern feminine gender identity.

21 Such movements have accompanied more or less every new step of modernity, making a stand, but so far, all forms of resistance have turned out to be rather short-lived and unsuccessful, like in the case of the Arts & Crafts movement.

processes, cultures and meaning of their practices, that follow different rhythms, patterns, aims and horizons, and bring different visions and identities. This multiverse is relevant as a potential sphere of opposition to deterministic trends and also promising in the perspective of moving away from a world in which a small number of people defines rules, creates artifacts, and makes decisions for many consumers. It has the potential to shape a reality in which everyone can have the interest, motivation, and possibility to actively take part in building the future (Fischer, 2013).

We have shown that many crafters remain as hobbyist at an amateur level, others create nostalgic products, gadgets and playful experimentation, some others become entrepreneurs and launch start-up companies or produce value in the maker community, but only a small number of makers design for disruptive innovation of strategic importance.

This happens because their production remains in a significant social gap and sustainable innovations require stronger connections with communities that have been active – commonly for decades – in the improvement of the living conditions of marginalized people, by protecting the environment or caring for older generations.

As suggested by Fischer (2013, 26), we believe that today's challenge is to reduce the gap between making and sustainable social innovation. Maker culture should stimulate social creativity further, not by reducing its heterogeneity and its specialization, but by building bridges between different communities, and exploiting conceptual collisions as sources of real innovation. Canalising participatory design processes (Manzini, 2015) towards the resolution of complex social issues, such as environmental sustainability, is one of the greatest challenges of our time to achieve meaningful large-scale innovation.

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III
DESIGNER'S KNOWLEDGE AND THE PHILOSOPHY OF ARTIFACTS

Huopalahti housing in Helsinki (1986–) contains mixed signs of handwork, concrete technology and digital design (Photo: Tarkko Oksala)

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Arto Mutanen, Tarkko Oksala & Mervi Friman

On Visual Reasoning

Introduction

Visuality and reasoning are not generally integrated into one concept. A reason might be that visuality is principally connected to human senses and experiences, whereas reasoning is an intellectual act that is connected to human reason which should be formalized. Visuality is studied through aesthetics and reasoning through logic. So, it might seem that these two are mutually exclusive conceptually. However, the situation is not so simple. Human reasoning is a practical activity which includes different kinds of activities. Moreover, visuality is much more than mere aesthetics and reasoning is much more than logic.

Currently communicating with memes, sharing photos and videos are an essential part of our lives. Even if the pictorial communication is strikingly present in our societies, the phenomenon is as old as human societies (Neurath, 1936). Pictorial information has shown its strength in education, and present-day computers, via computation, BigData, and CAD, open new possibilities of dealing visual information. So, it is necessary to explore visual reasoning deeper. In this article we want to illuminate the connections between visuality and reasoning from the perspectives of pictorialism, design science and architecture. Inspiration to this study rises from the relationship between theory and practice and the possibilities of non-linguistic communication.

To start with, let us take a look at what Lewis (1976) says. Lewis (1976, 133) says that "Everyone who speaks English is familiar with two meanings for the word *sense*: (a) ordinary intelligence or 'gumption', and (b) perception by sight, hearing, taste, smell or touch, which we shall call *aesthesis*. In our individual linguistic histories gumption is undoubtedly the earlier meaning." So, Lewis shows us that the word 'sense' is polysemic. Moreover, the meanings lead to directions we are interested in. As the starting point of his study, Lewis (1976, 134) takes the meaning of sense which is "something like 'to experience, learn by experience, undergo, know at first hand'" which is closely connected to reasoning.

The notion of aesthesis "descends from the concept of taste" (Shelley, 2017). It is connected to "fine art" in which it is tied to "subjective effects, which were the central concern of" (Gage, 1999, 135) artists. However, the artistic experience and even scientific knowledge have some common ground which can be seen, for example, in our understanding of colors (Gage 1999). For example, we can find in both multitalented groups working together in order to create something new. The working groups are creative but systematic like experimental laboratories, trade unions, or industrial organizations (Jaeggi, 2009). Moreover, Beyme (2009, 352) writes about the close connection between science and art, but emphasizes that "art has more possibilities at its disposal, because it is able to influence the human psyche directly".

Jaeggi (2009) and Beyme (2009) explain the idea of Bauhaus, an avant-gardist institution which integrated art and design. In fact, Neurath and Carmap gave some lectures at Bauhaus. Their formal, logical and pragmatic philosophical attitude was the connecting link to Bauhaus philosophy. (Cat, 2019b.) The notion of design integrates planning, engineering, and science, which was expressed by Simon (1969) as design science or as science of the artificial. Design science is an important example of how visualization and (scientific) reasoning go together. Moreover, it is possible to understand works of art as part of a more general design science.

Artifact can be defined as "an object that has been intentionally made or produced for a certain purpose" (Hilpinen, 2010). However, such a definition does not specify artifacts very precisely. Still, as the definition specifies, an artefact has some properties arising from the intention of the designer. They characterize the "intended character of the object" (Hilpinen, 2010). Even more deeply, one can formulate a dependence condition which says that the existence and some properties of the artifact are dependent on the designer (and maker) of it. Galle and Kroes (2014, 204) characterizes an artifact by its function, physical structure and social aspects. Moreover, they discuss how extensive the class of artefacts should be.

In planning artefacts, the planner or designer might use different kinds of notation, for example, linguistic, symbolic, pictorial, or cinematic. The distinction between these types is intended to be neither exhaustive nor exclusive. So, design science might be a good example to show how visuality and reasoning go together. In fact, Priest, de Toffoli and Findlen (2018) show how diagrams from logic and mathematics can be used in engineering and architecture and how they can be understood as proper reasoning in a logical sense.

Visuality and Visual Language

Visuality is something that is present everywhere, but, at the same, it is difficult to specify. In science, perception, or more generally observation, plays a central methodological role. Perception gives visual information to the perceiver. What kind of information perception gives or may give is a question that has been studied in the philosophy of science. A natural method of expressing perceptual information is pictorial (Neurath, 1936; Priest, de Toffoli & Findlen, 2018). The logic of perceptual information provides a lot of indication on how the perceiver might attain some information via perception. However, the basic idea is that the information is linguistic in character. (Hintikka, 1968; Niiniluoto, 1982.) The idea of visual information as linguistic information is also supported by Husserl. He thought that phenomenal information can be, in principle, expressed via linguistic means. Carnap (1969, 307) says that "the cognition of processes of consciousness of another person is 'based upon' the perception of his motions and linguistic utterances; that cognition of a physical object 'goes back' to perceptions; that a given experience 'consists of' the visual perception of a bell; the auditory perception of a sound "consists of" individual perceptions of such and such tones". He still agrees with the philosophical orientation of the book: the very method of his Aufbau says that the concepts of different fields of sciences "refer to the immediately given" (Carnap, 1969, v).

The role of visuality in semantics is emphasized by Wittgenstein in his "picture theory of language". The very idea is that language "pictures" the reality. This picturing character is present also in colloquial language, where we use pictorial and metaphorical phrases. Moreover, the pictorial character is present also in logical and mathematical language, which is noticed by Wittgenstein and by Peirce in expressions like "We make to ourselves pictures of facts" (Wittgenstein 1922, 2.1). This observation is a fundamental semantical fact. Even if there cannot be a semantical theory, sentences show their meaning. This is expressed by Wittgenstein in Tractatus (6.127) as follows: "Every tautology itself *shows* that it is a tautology." So, in the strict sense there cannot be any picture theory in the Wittgensteinian sense.

Pictures might convey linguistic information and they might act as the semantical medium of language. Then, it seems that a language might be wholly pictorial. This was the idea driving Neurath (1936; 1939; 2010) while he was developing his pictorial language. The very idea of pictorial language is extremely important. Neurath (1936, 10) starts with simple examples of pictures that "are very small and in black and white and red only". The idea is to show how to construct the language and to manage the syntax (and semantics) of the language. Neurath (1936, 17) explains why and how pictorial language in fact works. His example is of a traveler arriving in "a strange country" and getting all the information they need via pictorial instructions. These instructions are still in use in such places as railway stations, metro stations, and airports. In fact, these pictorial instructions are very informative and their information content can be managed, as the present discussion about the traffic signs shows. These pictorial instructions show the idea that Neurath had in mind of pictures in a pictorial language being simple, which also means that they do not have perspective. (Cat, 2019b.)

To develop proper pictorial language supposes that pictures should be combinable. Without this property there cannot be a proper pictorial language at all. However, there are limits to how much they can be combined. In particular, pictures and pictorial combinations cannot be compositional (Pietarinen, 2011; Mutanen, 2016). However, Neurath (1936, 54–56) shows that his pictorial language has several properties that a proper language needs to have, in particular he gives examples which show that it is possible to formulate statements in a pictorial language.

The applications of Neurath's pictorial language are intricately connected to design science, such as picture design and typography (Pietarinen, 2011), which has also inspired artists (Holter & Höller). The other direction of application has been in urban planning and design (Pietarinen, 2011) which deepens the understanding of the close relationship between Neurath and Bauhaus (Cat, 2019b). So, we will consider more closely design science, but before it, let us consider briefly pictorial thinking in mathematics and logic.

Pictorial Thinking

Pictorial thinking can be utilized and applied widely in mathematics. In geometry it is usual to use pictures and figures to express the problems to be solved. The solution includes some more drawings and analysis of the pictures and figures such that searched solution or proof can be constructed. The method of analysis and synthesis follows such a procedure. The method originates from ancient geometry. However, the method is not restricted to geometry but can be applied to all fields of mathematics. Moreover, according to Aristotle, the method of analysis and synthesis explicates general human deliberation which is expressed by Niiniluoto (2018, 22) as follows: "In *Nicomachean Ethics* (1112b15-29), Aristotle compares it [the method of analysis and synthesis] to the structure of deliberation: in the process of planning, a decision-maker searches for the means to obtain a given ends, and further means to obtain intermediate means, etc. until this reasoning 'backwards' comes to something that can be done or is impossible."

In the quotation, the double directedness of the method is explicated. The decision-maker starts form the intended goal and goes backwards until he or she finds out something from which he or she can construct the intended goal or, should they be unlucky, he or she recognizes that the goal is impossible to achieve. The analysis from the intended goal to the foundation of the task maps a road from the present to the intended goal. The task of designer is, obviously, structurally similar.

Pictorial thinking in mathematics is not restricted only to geometry, but it can be utilized more generally in mathematics. In geometry, pictures and figures explicate, i.e., make visible, the problem situation. In the algebraic context similar pictures are not possible. However, as analytic geometry (which was developed by Descartes) shows, there is a close connection between geometrical figures and algebraic equations where numbers correspond to geometrical entities and equations explicate the relationships between them. So, the pictorial model can be applied also to algebraic mathematics (Hintikka & Remes, 1974; Hintikka, 1973).

In mathematical reasoning more concrete pictures, such as graphs and knots, are used (de Toffoli, 2017; de Toffoli & Giardino, 2014). These pictorial modes of thinking have also some "transformation rules" which direct the pictorial reasoning. More generally, visual reasoning in mathematics has been studied extensively (Zimmerman & Gunningham, 1991; Giaquinto, 2016). In fact, model theory offers a well formulated mathematico-logical approach to the visual thinking in mathematics and logic, as Gödel's completeness theorem shows (Hodges, 1993).

Mathematical reasoning is part and parcel of scientific reasoning which is demonstrated by the use of the method of analyses and synthesis in several fields of sciences. So, pictorial reasoning has remarkable role in scientific reasoning. Pictorial thinking is meaningful in the context of applied research, especially design science and engineering science need knowledge which give instrumental information about the connection between the present situation and the intended aim.

Design Science

Scientific research aims at new knowledge. The target of basic research is new knowledge "for knowledge's own sake". Instead, applied research aims at new knowledge "because of some practical utility". However, both basic research and applied research aim at new knowledge. Basically, basic research aims to acquire descriptive knowledge about the reality. This entails that epistemic utilities are the primary utilities in basic research. Applied science, like engineering science or practical social science, aims to acquire "new knowledge which is intended to be useful for the specific purpose of increasing the effectiveness of some human activity" (Niiniluoto, 1993, 5). Because of the intention of applied science, the acquired knowledge is meant to be useful for some practical purpose, which entails that besides epistemic utilities, also practical utilities are present in their planning and use.

The notions of techniques and technology refer to several different but interrelated things. Niiniluoto (1984, 258) characterizes these notions by saying that they "are used in many different senses" and he divides the different senses into six categories: (i) They refer to concrete or abstract manmade tools and artefacts. There are several different kinds of characterizations of what kind of entities these might be. (ii) Besides the tools and artefacts, the notions refer also to the use of such tools and artefacts which open several interrelated areas of study, like (iii) the knowledge and skills needed in the use of the tools and artefacts. Technical tools might be extremely complicated to use. Moreover, (iv) the design of such tools and artefacts supposes special skills and knowledge, like mechanical engineering and product design. However, it is not good enough to have a plan or a prototype of a tool or an artefact, but one also needs to produce these tools and artefacts. The (vi) knowledge to design and produce these tools and artefacts is a special area of practical knowledge, namely design science and engineering science.

The technological science or design science refered to above needs to be specified more closely. Simon (1969) specified the notion of sciences of the artificial or design science. In his book, there are chapters that focus on the distinction between "the natural and the artificial worlds" (Ch. one), the special characteristics of "the science of design" (Ch. five), to "social planning" (Ch. six) and to "the architecture of complexity" (Ch. seven). The structure of the book shows that the scope of the science of the artificial is extremely wide. However, there is still something common behind the whole approach: humans plan and produce artifacts and the artificial environment systematically – at best this might be science based. However, it is not obvious what kind of scientific foundation there can, or should, be behind the design and production.

According to Niiniluoto (1993), basic research as descriptive research is searching truthful lawlike results, like

(1) "X causes A in situation B" (or its probabilistic variants).

These results describe how the reality (or some aspect of it) is or behaves. They can be used in descriptions, but also in predictions: we know that if we are in situation B and we observe X we can predict that A takes place.

In design science, descriptive results of the form (1) play a central role. However, in prediction the results of the form (1) are useful independently of the character of the factor X. In design science, the factor X must be human manipulatable to be useful. So, prediction and design (and planning) share a similar structure but still have an essential difference. In design, the result of the form (1) explicates an intended goal (A) and means (X) to get the goal from the present situation (B). The result (1) explicates beliefs needed to make design rational. If the belief is used in the design, then it can be called science-based design which is the topic of design science which is closely connected to the practical syllogism which originates in the philosophy of Aristotle.

It is not easy to specify what kind of knowledge is needed in design. The basic idea is that the knowledge should give instrumental information about the connection between the present situation and the intended aim. Von Wright (1983) characterizes this instrumental information (knowledge) as a technical norm: “If you want A, and you believe that you are in a situation B, then you ought to do X” (Niiniluoto, 1993, 12). Of course, this might be formulated in probabilistic mood. The basic idea is that effectivity (truthfulness) of the technical norm is based on descriptive knowledge characterized above by formula (1).

As we recognized, a remarkable difference between the prediction and design is that the factor that causes the effect must be human manipulatable. So, because we cannot manipulate the factors that cause sunshine we cannot, in a proper sense, design sunshine for the forthcoming garden party. That is, the scientific laws of the form “X causes A in situation B” are behind predictions and design. But we can speak about design only if the factor “X” is human manipulatable.

The notion of human manipulatable is technology dependent. The essential aim of technology is to make our living more pleasant and good, as already Bacon recognized. In this task, scientific knowledge has played central role, but there has been and still is a lot of technology which needs no scientific knowledge. Technology makes some acts and activities possible that were not possible before the corresponding technical invention. An example is the airplane which made it possible for humans to fly. In general, technological development opens new possibilities for humans. However, technological tools are not mere tools. They give some new skills and possibilities, but, at the same time, they change several other things. Airplanes made it possible for humans to fly, but they also generated a new way of life that we have nowadays. Marx was one of the first who studied systematically how new technology changes social structure of the societies. (Niiniluoto, 1993)

A good example is architecture, the art and practice/science of designing and constructing buildings and cities. Architecture is not the mere planning of artefacts. While used for designing buildings and environments, at the same time it re-orientates humans to others and to the environment. Moreover, in architectonic planning, pictorial thinking plays a central role. So, let us take a closer look at the logic of design in architecture.

Architecture

Architecture is multi-sensory, but visual sensations dominate in it. One explanation is that visual sense transmits most effectively environmental information (Hintikka, 1986). Architecture is action which participates in the production of environmental artefacts, but also more abstract cultural objects. In this work it needs planning and design languages. In fact, the language view is extended into architecture itself (Perret, 1948; Oksala, 1981).

The revolutionary development of design languages coincides with the adoption of digital computation into daily life, starting from the syntactic level. The idea to apply semantic information theory into design (Oksala, 1981; Niiniluoto, 1990 a; b) opened the doors to the interpretation of design patterns with real design works. This also gives tools to discuss practical design questions in an exact frame like that of practical conduct (compare above Oksala, 1981). The connection of architecture with artefacts is fundamental (Simon, 1969/1981; Hilpinen, 1984/1986, Mänty, 1984; Coyne, 1987) for design theory. This idea can be developed under the notions of planning science and design science. The latter has been developed using the notion of designology (Gasparski & Orel, 2014). In the area of more general planning we may mention the exact development around planning preliminaries in engineering ontology and "Towntology" (Teller, Billen & Cutting-Decelle, 2008). These kinds of sciencelike activities can be summed under the notion of knowledge-based planning and design (Gero & Oksala, 1989; Linn, 1998).

In a changing world we need new viewpoints, and even the classical definition of architecture (Vitruv, 1991; Mänty, 1984; Eskola, 2005) needs parallels. Architecture is the skill and art to plan, design and build (realize) prototypes (of environmental artefacts or institutions). In this sense the basic work of an architect can be distributed to teams and corporations in advance. Then we have products of environmental care, which citizens see as concrete actual architecture. The work of an architect contains a lot of decisions in social decision networks connected to visual reasoning. This is all supported with reasoning around practical conduct (Oksala, 1981).

Architectural Languages and Reasoning

Visual grammars

August Perret expressed the idea of architectural languages in the 1948 promotion of the predecessor of Aalto University by saying:

> *Structures are an architect's (mother) language. An architect is a poet who thinks and speaks with structures.* (Oksala, 1974/1978)

This idea may be understood to lead to the application of poetics (Ingarden/Oksala, 1976) in which realizations are derived in standard steps from an idea. Then we are working toward classical art studies. The need for exactness in recent digital architecture was solved by using grammars as pre-poetic (syntactic) devices. This may happen at the level of formal languages (Oksala, 1974/ 1978) or using languages of logic as a frame. The final goal is evidently to use natural language in the design of natural (human) architecture (Perret, 1948; Aalto, 1972) under some design-scientific analysis. Then the big problem still is that architecture is synthetic. One solution to this problem is to use the method of analysis and synthesis with the appropriate interpretation.

Logic of Architecture (Oksala, 2014) is the doctrine of right thinking (involved) and gives conditions for that at the syntactic, semantic and pragmatic levels. In this sense it is reasonable to start from grammars which have as their goal the correct usage of language. Grammars are also key tools in structuralism.

In the use of grammars, the notion of idea is replaced by a start symbol. Intermediate poetic forms are called non-terminals and final ones as terminals. To act we need some meta-rules, production rules and rules to terminate the process. The notion of meta-rule is added here because architecture is generated in complex social situations and thus related to ethics.

Grammars serving architectural production may have real content like buildings (Wright, 1954), graphic content like in design and symbolic content like in planning. The notion of grammars can then be extended to concern right action as regards skills (Kotila, Mutanen & Volanen, 2007) and arts. They offer a toolkit to formally produce the needed product. These are known as prototypes.

Visual languages and information

The problem involved in architectural generation stays open, even if we have formal grammars. Creation and poetry are replaced at this formal level by production. Semantics can be introduced into the formal game (Hintikka, see Oksala, 1981) using semantic information theory, whose semantic analysis is done by the “Possible World Semantics” – preceded by the necessity semantics of R. Carnap (Malatesta, 2014).

In design language it is possible to refer by one abstract sign to the derivatives of it (Wittkower, 1973; Oksala, 1981; Mänty, 1984). Such professional, often “tacit knowledge” (Polanyi, see Wåhlsröm 1986/1988) can be expressed exactly in quantitative information theory. At the same time, qualitative information theory has also its value, especially in complexity and order aesthetics (Oksala, 1976; Smith, 1979), and there we have a key connection to the level of quality and value discussions (i.e. pragmatics).

Formal languages of architecture simulate composition or construction of building blocks, etc. This corresponds to the idea of formal picture languages in CAD based on configuration or formal symbol languages in computation based on concatenation. Now we have, however, the problem of dimensions. In "time-space-action" meta-space (Oksala, 1972) we have a lot of parameters. Symbols can be concatenated in time, but in the case of notations and pictures 2D becomes a problem and in architecture we need at least to think in 3D. In this sense architectural composition is similar to that of music. If we have spatial or action related additional needs then notations should be enriched accordingly. There are of course evident compositions like laying out bricks in a row or making grid layouts, etc. In principle there are also challenges like free-form composition (see also elastic standardization) (Aalto, 1972; Oksala, 1986).

Meaning in visual language usages

The syntactic innovations, as regards visual languages, in the 1960s were important, but one-eyed. The problem was the lack of automated semantic skills needed in pattern recognition (Zusne, 1970). In comparison to these achievements it is interesting to note that the pictorial language of O. Neurath (1936) was from the beginning semantically oriented. The simple reason for that was the pragmatic intent to guide human action, for example in the case of passenger arrival. (Cf. Majurinen & Oksala, 2009)

When we use language ideology in architecture, real semantic problems start in using two languages. This is based on the idea of mixing the role of certain languages and reality. (Hintikka, in discussion 1969) Languages form thus realities of their own and architecture (even as language) may act as "model" of requirement language. (Oksala, 1981) Chained interpretations are then also natural, like those between plan, design and building.

In semantics we differentiate between extension and intension. Then the notification of qualities becomes important. In standard architectural practice we may differentiate quality types, like (Niukkanen & Oksala, 1986):

Technical, experienced, usability (quality)

Ideal, formal optimal (quality)

Technical quality is roughly the same as satisfaction of intent in the same sense as in sport-critique. This idea is closely related to the notion of practical conduct. In experienced quality we note enjoyment or suffering connotations / person by person. In usability the satisfaction interpretation is by nature of collective origin.

In working with quality problems, we have ideals to adapt with formal requirements. In multi-optimization these are noted together. A good example of architectural success is Pareto optimality, the idea of which is visible already in the theory of beauty by L. B. Alberti. According to it, nothing can be added or taken away from a masterpiece without worsening it.

Qualitative criteria can be roughly used in quality or value analysis in systematic planning and design, but the clarity of master-intuition is of course difficult to achieve. The situation is analogous to the problem of axiomatic and intuitionist work in mathematics. The ideas of Gödel in particular (Linn, 1998) show how limited the logic approach is, but it is the start of rationality in any case. In more complex decision making we know the paradox of Arrow. This shows how difficult it is to run teamwork or notice politics in prototype creation. The same problem concerns user participation in housing design and city planning, for example. This means that the method of trial and error has its role in human craftwork and bodily made design (Ylinen, 1968) like architecture.

Visual style as print of hand and way of thought

Computation, ICT and AI promise computation power up to the limits of Big Data. In this sense it is possible to make classical slave work nearly limitless. The need for computer power is, however, so big, that trial and error methods become costly. There is also the dream that AI assistants in design will become cleverer than their “masters”, which is called technological singularity. This may concern the problem at some collective and average level, but in human architecture we are interested in the development of personal styles of masters even with “mistakes” (i.e. point of beauty).

Style means the way we use our hand in writing, drafting and building in prototyping. It can be studied to a certain extent as related to probability (Hintikka in discussion 1968) and as concretized in information aesthetics (Smith, 1979; Oksala, 1981; Niiniluoto, 1990 a; b). It is well known how it is possible to detect, for example, the style of P. Mondrian or that of Bauhaus (see Bruton & Radford, 2012, 79). In this sense computational art is working on the border of robbery and innovation. All is fair in love and war or art, but in a wiser form. Artists use loans, but in a prudent, honest and useful (Cicero, 1813) sense. It is possible to see the inspiration between the Maison du Peuple of V. Horta (Bruxelles) and the House of Culture of A. Aalto (Helsinki), but the relation is as remote as possible from a responseless copy. So far as devices have no body, neither emotions nor will (Niiniluoto, 1984b), they cannot make deeply interesting aesthetico-ethical choices in comparison to man-made, body-made and hand-made mastery (Wåhlström, 1986/1988).

From the language point of picture or picture point of language architecture is the expression in which the role of the hand (as style) may influence planning, design and building up to action-style and lifestyle. Besides such processes, skills grew up to be arts. They are technical skills like in architecture or "arts of the possible" like we know from politics. Then the idea contains the dimension of care and therapy (Oksala, 1986) of common affairs and common environment up to the dimensions of our globe and up to cosmos.

In solving such problems, we need reasoning and among it visual reasoning consisting of:

- Visual analysis, synthesis, practical conduct (i.e. recommendation)
- Visual in- vs. deduction, ab- vs. adduction, trans- vs. production

This totality supports as preliminary skills visual thinking consisting of:

- Visual ordination, planning, design
- Visual comparison and interpretation, evaluation, conduct and decision making

In this sense visual and other thinking coincide in statu nascendi of the human mind. What we need is the theory opening the potentials of interaction. This is maybe the reason why Aristotle considered architecture as the "Mother of all Arts".

Closing Words

We have seen that visuality and visual language have several important properties. Even if there are challenges in developing visual languages, there are both theoretical (conceptual) and practical examples which show the power and interest of visual languages. In philosophy there is a long tradition of dealing with visuality which gives a lot of philosophical knowledge about different aspects of visuality, visual language and visual reasoning. This plays a central role in developing the use of visuality in science and in practice.

Architecture is an excellent example of an area in which visuality is a familiar phenomenon. In architecture visuality plays several different roles. In architecture the intention is to plan and build buildings and environment. Hence in planning, several different kinds of visualization methods have been used, but in "practice" a concrete object has been constructed in reality. So, architecture builds bridges over the gap between theory (design) and practice (building). The result is not mere buildings but a human environment in which humans and human communities live their lives.

Architecture is intricately connected to technology. The planned buildings have to be built by materials and techniques that are available. This connects architecture to the technology. Moreover, buildings and environment have to be pleasant for humans. This connects architecture to aesthetics and art. However, the connection of visuality to art is not a special property of architecture but all visual languages have aesthetic aspects as Neurath's example shows.

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Carina Söderlund & Pete Evans

Co-design in Immersive VR

Something Old, Something New, Something Else...

Introduction

In the following text we will cover the areas of participatory and collaborative design (co-design) in immersive collaborative virtual environments (CVEs), as well as the experiences of the body and mind while designing together in virtual reality (VR). The aim is to explore immersive VR as a media for co-design, with anticipation of the potential use of this media for participatory design and co-design. The purpose is to investigate if and how immersive VR can facilitate co-design experiences and the collaborative making process, in order to establish a basis for future co-design studies in immersive VR including potential users and other relevant participants. The present study is delimited to exhibit design, more specifically, the design of museum exhibits and low fidelity prototyping (lo-fi prototyping), with focus on the initial phases of the design process, as well as the ideation and the design of low-fidelity (lo-fi) prototypes.

We'll begin with an introduction to contemporary design approaches, or more specifically, human centered design and participatory design as a co-design approach. This will be followed by a note on the development of VR-technology where we'll look at some of the examples of current research that are close to the theme, besides, there is an reflection on the core concepts real, virtual, and actual. Then we'll continue with a presentation of prototyping as a co-design method, including contemporary cognitive psychology theories which highlight the body, mind, space, and interactions that take place with a diversity of tools as part of our thinking process during prototyping. Next, we'll describe the method in further detail, namely, through sharing an introspective study conducted by two co-designers (the authors of this text). In the final section, we'll present a reflection and analysis of the introspections regarding the actions, thoughts, feelings, emotions, and sensations (sensory and bodily perceptual experiences) that take place while co-designing in an immersive CVE. In order to analyze the key moments and experiences when co-designing, the empirical data have been illuminated by theories on direct perception and design fixations, for instance, which emerged during the study and analysis of the findings. Finally, we will conclude by offering proposals for future research and tentative suggestions regarding co-designing in immersive CVEs, i.e., their metaphorical qualities and how they may affect the designed artifact, and how immersive VR technology supports a design relationship among co-designers, which may open up a sincere and genuine dialog when co-designing remotely.

Participatory Design and Co-design in Immersive VR

Historically, before the Second World War, design referred to decorative art and architecture (Dilnot, 1948). Some argue that design can be traced back to the industrial revolution (Bayazit, 2004). Nevertheless, notions of design have evolved over time in relation to vital movements and changes in society. Over the last decades, the concepts of *user*- and *human-centered design* have advanced alongside the progress of the personal computer. Today, there are ISO standards for human centered design (ISO 13407:1999; ISO 9241-210:2010) and how to design usable products based on users' needs, as well as prerequisites related to contextual conditions.

However, Buchanan (2001) argues that human centered design goes beyond usability, and brings attention to other values besides the need to operate and interact with a product, since human centered design relates to "human rights" and the "affirmation of human dignity" (p. 37). In that sense, a designer supports people in being active and acting as agents in their own lives. These ideas relate to the foundations and values behind the approach called participatory design, which is a collaborative (co-design) approach based on Scandinavian traditions and democratic values, which advocate that impacted people should have a voice in the design process (e.g., Ehn, 1992; Björgvinsson, Ehn & Hillgren, 2010). Unlike observing or interviewing users regarding their actions and the context of use, participatory design is about designing and creating together (Salvo, 2001). In that sense it is possible to say that co-design deals with notions such as empathy, diversity, influence, and inclusion.

Nevertheless, there is no unified definition of the concept "co-design". Sanders and Stappers (2008) discuss this conceptual confusion and multiple definitions of co-creation and co-design as these concepts are related, and they suggest that co-design deals with group creativity throughout the design process. According to Ehn (1992), co-designing from a participatory point of view focuses on learning, as users and designers learn from each other and share their unique knowledge and experiences. It situates the designer and the user in new positions and relationships.

Examples of VR-technology and previous research in co-design and exhibit design

Simply put, VR is a computer-generated simulation. It is easy to associate VR with entertainment and gaming used by the younger generations. However, VR is also applied to areas such as psychology and medicine (Slater & Sanchez-Vives, 2016), as well as engineering, product development, and architecture. Today's VR experiences can be accessed with easy-to-use headsets, such as Oculus Rift and HTC Vive. Such VR technology has advanced from principle examples such as the Sensorama (1962), the Sword of Damocles (1968), and the CAVE in the early 1990s.

Historically, VR has been limited when it comes to resolution and movement synchronization (Slater, 2000). Only the highly technical CAVE achieved the potential for active collaboration, at a very high cost. Such VR technology has been the privilege of few professionals and researchers. Immersive VR technology has only recently become affordable and an easy-to-use commercial and consumer product. With that in mind, professional designers and design students are now able to use VR technology in a mediated and embodied making process and, for instance, prototype ideas and co-design with colleagues, clients and consultants via immersive CVEs.

Research on VR began to evolve in the 1990s. During this period, with respect to immersive CVEs and co-design, the definition of VR was broad and covered web-based 3D chats (e.g., Active Worlds and Second Life), CAVEs, and lab-based experimental head-mounted displays and hand tools. Over the last decades, the computer technology has rapidly expanded. Mel Slater (in Pan 2020) recently pointed in one of his presentations the important synchrony of the visio-tactile and visio-motor information, which offers the user a multi-sensory experience, a strong feeling of immersion, and a sense of presence, particularly relevant in the making and co-design process.

Recent research does not give much attention to co-design in VR and immersive CVEs in relation to spatial design, exhibit design, and museum exhibit design. Examples of current research on co-design in VR and virtual environments include a study on co-design and design ideation by Boletsis, Karahasanovic and Fjuk (2017). The study by Koutsabasis, Vosinakis, Malisova and Paparounas (2012) elaborates on situational awareness when codesigning architecture (built spaces). Flint, Hall, Stewart and Hagan (2018) present a study on designing a virtual museum in collaboration with children. However, the co-designing was not performed within a CVE. The case study on virtual design studios in education, by Vosinakis and Koutsabasis (2013), discusses benefits and limitations with designing in VR and the development of digital prototypes. For instance, the virtual environment provides simple shapes and tools that are easy to prototype with, however, the prototyping process is considered to be time-consuming.

Real, actual and virtual in the making process

Now, we will discuss if and how immersive VR can facilitate the co-design experience and collaborative making process in immersive CVEs. The design process takes place in a virtual space. In the dictionaries, the word virtual is defined as almost and not exactly, which could explain the cases where immersive VR and CVE are considered to be less authentic medias.

Nevertheless, the co-design experience and collaborative making process in an immersive CVE do not have to be considered as less realistic or authentic compared to when they take place in a design studio. Pierre Lévy (1998) discusses how that which is virtual is considered to be less true and authentic, and that we may fear that the virtual will destroy the personal. However, Lévy redefines the relationship of "real and virtual" to "actual and virtual." This semantic shift allows for "virtual" to act more as complementary to "actual," which is considered to be in situ and complete. Put another way, prototypes and models can be considered to be virtual, as they are representations and potentials of a designed artifact. It can also go the other way, where shapes of thoughts or actual design ideas can be considered to be virtual, and when the design process is complete the prototype becomes an actual historical artifact. This represents a constant movement, a transformation, between the virtual and the actual.

Thus, it is important to critically consider whether a designer who is prototyping in immersive VR may perceive prototyping as virtual, intangible, and the co-design process as delusory. As Kälviäinen (2005) states, the process of making is multi-sensory with a relationship between body and artifact, which relates to an emotional experience such as empathy and passion, and to qualities such as materiality and meaning. However, in immersive VR, our corporal body is not in physical contact with tools, materials, and the designed artifact, which affects the multi-sensory process that relies on the bodily senses. Malcolm McCullough recognized the importance of the mind-body relationship in using computer technology to, for instance, make a painting. The computer technology supports visual and spatial thinking and a multi-sensory participatory engagement, and McCullough argues that the hand, the eye, and the tool (e.g., an interactive pen display) interact just as in any making process (McCullough, 1998). Nevertheless, multi-sensory impressions while designing are multimodal. It can be compared to the development of photos in a dark room: the scent of the chemicals, the feeling of the photo paper, and the sound of the rippling water are all sensory inputs in the making process. Computer technology used in today's businesses and institutes of higher education rarely deals with all the senses and such sensory input (not yet, anyway).

Spatial, distributed and extended cognition and lo-fi prototyping

At the start of a co-design process, several methods can be applied. In this case, lo-fi prototyping was used. When co-designing and developing lo-fi prototypes in the early phase of a design process taking place in an immersive CVE, it is relevant to reflect upon the cognitive aspects that are related to such a process. In the initial stage of a design process, a designer may use pens and paper to create sketches or develop paper prototypes and mock-ups. Prototypes consist of visual, tactile, and sometimes verbal and auditory information. Nevertheless, prototypes give, for instance, shape to ideas and/or thoughts to be communicated and reviewed.

Traditionally, prototype has been an artifact on paper or in material representation. Lo-fi prototyping on paper has potential when it comes to identifying problems or possibilities with a design idea in an early stage of the design process (Retting, 1994). Digital prototyping first emerged with the introduction of computer technology and provided a digital representation of thoughts and ideas on a screen. It is possible to prototype in VR (Evans, 2018). Immersive VR provides an embodied context, where body, space, and artifact can interact, creating new opportunities for the virtual extension of the body during prototyping. This refers to contemporary theories in cognition psychology.

The perception and cognition can be explained as two-folded, i.e., based on pre-experiences and knowledge, as well as on our sensory input when interacting with and in the world. Today, human perception and cognition do not only consider information processes within the brain. There is a relationship between the inner world (the body), the outer world, and our thinking. Barbara Tversky argues that thinking is embodied and spatial. The thinking is part of the bodily experience and reactions (the inner space) relate to the nearby surrounding, and a geographical space (Tversky, Morrison, Franklin & Bryant, 1999). Another theory from the 1990s considers our thinking to be distributed and part of a larger system which includes tools, the surrounding environment, people, and their interactions (Hutchins, 1995).

Theories of distributed cognition are related to design thinking. A designer uses tools and methods to design or "distribute" their ideas to the outer world, making them visible and tangible to themselves and others. These prototypes, models or sketches give access to previous and present ideas, as an external memory, stimulating our memory (van der Lugt, 2005; Purcell & Gero, 1998). Pertinent to this, Andy Clark's theories discuss our thinking as an interaction with tools. Cognition is considered to be an open system, which could be part of a technical system (such as a CVE), then the cognition is extended (Clark, 2001/2003). In VR, the designer is forced to use VR equipment, for instance the headset and hand controls. This experience is explained by Andy Clark (2001/2003), who discusses how cyborgs are a part of humanity, as we interact with a diversity of technology in our everyday lives, such as pens (to write text or draw pictures) and typewriters. There is no clear demarcation between our corporal body and the technology (ibid.). A contemporary example of VR technology becoming an extension of the corporal body and our vision is the FlyVIZ (Ardouin, Lécuyer, Marchal, Riant & Marchand, 2012). It had a setup that allowed the user to see all around themselves like a fly and, for instance, when catching a ball thrown from behind.

An Introspective Study

We conducted an introspective study to investigate if and how immersive VR facilitates the co-design experience. Focus was placed on the ideation and the co-designing of lo-fi prototypes representing museum exhibits in an early phase of the design process that takes place in an immersive CVE. The nature of the introspection was a first-person study. In this case, we as authors observed and reflected upon our actions, thoughts, emotions, and sensations (sensory and bodily perceptual experiences) while co-designing.

More deeply, introspection is more than just observing a phenomenon in the world. Rather, it is a subjective observation of body and mind, based on how we experience the world (Gallagher & Brøsted Sørensen, 2006). This introspective study was based on a reflection that took place during and after the design process. Such a reflection concerns a vast amount of phenomena. In this study, we reflected upon the bodily sensations, as well as feelings, emotions, and design activities that occurred both during and after the co-design process.

To prepare for the introspection study, two commercial immersive CVEs, their software, were tested; Rumii (est. 2016) and Glue (est. 2017). Rumii is like a lo-fi prototype environment with the capabilities of collaborative white boarding, document presentation (2D/3D), sketching (2D/3D), and 3D platonic form making. Rumii was used in this study since it provides 3D platonic form making, while Glue did not at that time.

As a pre-study (pre-test), and to prepare for the introspection and to prepare for some eventual technical challenges, the immersive VR technology and Rumii were integrated into an advanced CAD curriculum at a US midwestern university. To flesh out ideas for co-designing in immersive CVEs, we supervised sixteen industrial design students when they were trying to design, develop, and present ideas and prototypes in Rumii.

Preparing and executing the introspection

Following this orientation with the students, we proceeded to conduct three pilot tests (pre-tests) in the very same CVE in order to advance the technique, explore tools offered by the virtual environment, test recording techniques, and plan a design brief.

In preparation for co-designing in an early phase of the design process, including ideation and early lo-fi prototypes, we (the authors) formulated a design brief based on our design skills in co-design and spatial design with a specific focus on exhibit design and architecture. Both of us (the authors) are educated in spatial design and architecture. One of us has moderate experience in using immersive VR technology, and the other has over ten years of experience. The design brief was a shared premise, dealing with ideation, early prototyping and design of exhibit stands as well as furniture and other artifacts as parts of a larger museum exhibit. The purpose of the brief was to display historical artifacts, such as jewelry and coins, for young children to interact with and learn about history while visiting a museum. Focus was placed on the shapes and colors of stands, furniture, and other artifacts. No details regarding texture and specific materials, for instance, were included. Instead of using traditional tools and methods (such as sketches or cardboard models), platonic building blocks were used, offered by the collaborative virtual environment Rumii, with twenty three (23) virtual geometrical shapes, and combinations of them, including a color palette of twenty two (22) basic colors.

Wireless Oculus Quest headsets and hand controls were used during the design session. The work was done remotely, with one designer in Sweden and the other in midwestern USA.

Figure 1. This picture shows one of the authors with a VR headset and hand controls comparable to the one used while co-designing in an immersive CVE. The bodily movements and actions are mediated with the VR equipment and reflected by avatars in the CVE.

The co-design session continued for one hour (including 5-10 minutes spent dealing with technical problems). The reflection during and after the design session was inspired by the theories of Schön (1983). Through talking out loud during the session, we reflected upon our individual thinking, actions and contributions, as well as on our collective making process. When the session ended, the reflections continued individually, captured by field notes. In addition, the reflections continued during two online meetings, face-to-face, allowing us to compare notes and further reflect upon the design activities that took place, as well as the thoughts, sensations, feelings, and emotions that came up while co-designing within an immersive CVE.

The recordings and field notes were analyzed by highlighting key moments and experiences when co-designing. Keywords were noted, and screenshots from recordings and quotations from the notes were categorized into themes. The themes were as follows: *Visioning the design possibilities*, *Interaction with objects (including the sub-themes Choice of color and shape, Scale of objects, and Moving and changing objects), Interactions between designers and Hearing*, and *3D-audio*.

Reflective Analysis and Discussion

The actions, thoughts, feelings, emotions, and sensory and bodily perceptual experiences that occurred while co-designing early prototypes in an immersive CVE were analyzed through a diversity of theories that emerged while planning the study and analyzing the empirical data. Some of the theories have been applied in previous studies and the theories are common in, for instance, design studies and pedagogy, and concern direct perception and affordance, socio-semiotic, remediation, design fixations, and theories on existentialism and human relations. These theories were applied to reflect upon the key moments and experiences during the co-design session and, to some extent, describe and explain them.

Figure 2. The picture visualises the mediated authors when co-designing on a display box. In the background platonic forms (cube, circles, etcetera) are listed on a white board, beside are colors which can be used to give colour to the platonic forms.

Design fixations

The immersive CVE used in this study provides a menu, which offers an overview of the available 3D platonic forms, i.e., geometrical shapes (materials), and color possibilities. Such platonic forms can be compared to the more abstract forms used during lo-fi paper prototyping.

When entering the CVE, qualities are represented (functions and a visual appearance) that support interactions with and within it, relating to concepts such as familiarity and remediation. The metaphorical likeness with previous media may affect how new media are interpreted and used. For instance, the CVE has avatars and visual similarities which we recognized from previous games and online 3D chats, such as Active Worlds or Second life used in the late 1990s. Moreover, the CVE provides a menu of possible functions, which is comparable to basic modeling software programs. By adding a socio-semiotic viewpoint by Kress and van Leeuwen (2006), it is worth mentioning that the programmer and developer of such a virtual environment bring along their own values, culture, and experiences when inventing such an immersive CVE. In addition, they are influenced by conventions, which can be related to interactive games that are available today, or were previously available since the advent of the 3D gaming industry. The CVE in this study was approached as an "actual" and cultural place due to previous experiences and memories of using other places, such as design studios, similar virtual environments and our previous digital games experiences.

The co-design session started with a dialog around the possible functions offered by the CVE and its design possibilities: "*...all shapes, forms and colors of modeling ideas are discussed togethe*r" (Fieldnotes).

Figure 3. The initial geometrical figure (building block) in the immersive CVE which is in focus of the investigation, at the start of co-designing a lo-fi and digital prototype, representing parts in a museum exhibit.

One of us initiated the co-design process by explaining the menu in closer detail, and choosing a geometrical figure called a "Cube Corner," which was orally and collectively signified as a chair (Figure 3). A blue color was selected, then a symbol (a star) was added to signify the chair as a throne (Figure 4). This can be perceived as a semiotic act, derived from the users' similar cultural context, past experiences of games, and pre-experiences of museum exhibits and exhibit design, among other things. Through this act, this meaning making process, the geometric figures gain meaning for the users and the design makes sense.

Figure 4. The digital prototype in the initial phase of the co-design session. A flat and circular shape was used to express a dais to a throne.

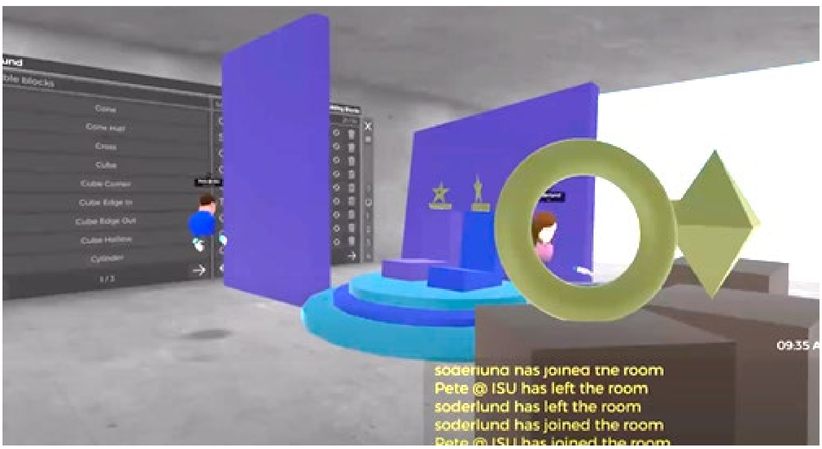

Figure 5. The prototype, at the end of the co-design session.

The co-design session continued with creating a place, a part of an exhibit at a museum that is, and architecturally defining the place by marking the location with circular and flat shapes placed above one another to indicate differences in height and depth. These shapes were expressed and interpreted as a dais to a throne (Figures 4 and 5). As the co-design session continued, the more limited the shapes became in their meanings, which constrained the design options. The findings indicate that the first shape limited the meaning of the subsequent shapes and the manner they could be combined, and ultimately limited the design of the digital lo-fi prototype and outcome of the design session. This phenomenon can be related to the concept of design fixation.

Previous studies indicate that novel ideas are based on old ones. Thinking while designing is not a free or standalone action but, on the contrary, can be fixated on our previous experiences and knowledge of previous forms, shapes, and concepts (Ward, 1995; Purcell & Gero, 1996). There are studies demonstrating that VR may support collaborative creativity, such as the study by Alahuhta, Sivunen & Surakka (2016). However, the co-design process in this study did not necessarily lead to collaborative creativity in the sense that the co-design session generated creative, novel and unique design ideas. Thus, it is relevant to reflect upon whether immersive VR supports collaborative creativity per se, or if it may depend on how knowledgeable a designer is with, for instance, the co-design process, in using immersive VR technology and tools while designing.

Affordance and remediation

Squares, rectangles, spheres and cones were the most dominant choice of shapes during the co-design session. The shapes were moved, placed separately, beside or above each other and squeezed together. The shapes were combined into forms with a given meaning. The initial scale was 1:1, in relation to the size of the avatars (Figures 2-5). When the shapes were enlarged (beyond the 1:1 scale), they were no longer easy to view. To describe these experiences, the concept of affordance may be of interest.

The concept of affordance, in its original definition, has, in many cases, expanded and been applied in several areas, for instance, in interaction design (Norman, 2013) and co-design in VR when for instance Alahuhta, Sivunen & Surakka (2016) highlight seven affordance possibilities (e.g., avatars, co-presence, and multimodal communication) when collaborating in VR. However, it was Gibson (1977) who invented the concept of affordance, based on the ideas of direct perception, referring to perception in action without higher levels of cognitive processing. Originally, affordance designates how an object (fluid or firm) invites a human (an animal) to interact, depending on the relationship between the properties of the body, object, and surrounding environment. Groome (2010) discusses the concept of affordance in relation to the bottom-up processes and the function of the motor cortex, as we interact with the world by grabbing and pulling things. According to Greeno (1994), the concept of affordance may be confusing, whether it refers to properties of an object or to the properties of the one interacting with the object. Nevertheless, if we approach the concept of affordance as originally described, as the interrelation between the body, object and surrounding environment, such an interrelation can be considered to be a prerequisite for interaction.

When it comes to co-designing in immersive CVEs, it is worth discussing if and when the concept of affordance is relevant to use, and if there are other suitable concepts. This introspective study indicates that a direct perception may be a problem, since co-designing in VR indicates a semiotic act, performed in a cultural space. It is likely that the interactions with the 3D platonic forms are based on learned behavior and activities. Besides, the combinations of the platonic forms were based on conventions and pre-experiences and pre-knowledge.

To reuse McCullough's expression digital medium from 1996, co-designing in this immersive CVE was a virtual, yet actual, making-process. The digital materials in this case were geometrical figures preselected by the programmers and developers of the immersive CVE software program. These 3D platonic shapes constrain the design possibilities, i.e., what to design and how to do it. These digital materials are carriers of design qualities since they, for instance, resemble Legos, the familiar interlocking plastic construction toys. Furthermore, the appearance of the CVE in this study resembles previous computer games and online 3D chats from the 1990s. It is worth considering whether this similarity raises ideas (opportunities and obstacles) while co-designing within the virtual environment, or ideas about the functions of the shapes, the design (how to combine the shapes), and how to collaborate (e.g., waiting for your turn to act/interact). This aligns with the theories on immediacy, hypermediacy, and remediation by Bolter and Grusin (2000), and similar theories by Manovich (2001); namely, that previous visual media and technology are used metaphorically when interacting with new media, and conventions are recycled from one media to another, based on pre-experiences and pre-knowledge of similar situations, shapes, and environments. It refers to a cognitive top-down process, opposite to direct perception, and the concept of affordance.

Nevertheless, during the co-design session the perception was split between the virtual and mediated body, and the corporal body and its physical location. For instance, one of the co-designers was physically kneeling on the floor when modifying the floor-level shapes in the virtual environment. The kneeling was confirmed by a sensory input (a pressure on the knees), from the actual oak floor in the room where the corporal body was situated. In such a situation, when the actual and virtual are interrelated, the concept of affordance may be relevant to the exploration of the co-designers' situational awareness, and the interaction between physical space, virtual space, and actual place.

Co-design Interactions

The co-design interactions took place through avatars, mediating the corporal body and its movement via hand-controls, and through 3D audio that mediated speech. The interactions were supported by the facial expressions of the avatars. Initially, in the session, their mouths didn't move, signaling a technical problem with the audio. The interactions consciously stopped due to these technical problems, until they were resolved, and the avatars' mouths started moving with the audio again, supporting the interactions and the co-design session.

Throughout the design session there was, on one hand, a focus on the same aspect of the design during collective testing, evaluation, and negotiation and, on the other hand, a focus on individual creation and evaluation of individual ideas, which then became visible to both parties. As previously mentioned, when co-designing, shapes were pointed at, moved, and shared. Shapes were grabbed by the virtual and mediated hands, and these shapes could be shared between hands to support each other in replacing or resizing a figure or shape. There was a synchronization between the actual hand and the virtual, apart from the fine motor skills.

The perception of this bodily experience via mediated bodies differed. On one hand, there was a sense of a solid body: *"I was conscious of my co-designer, his presence. It does not feel okay to stand above him or inside him."* On the other hand, this experience was also a non-material experience: *"There was fun interchange physically where we moved through each other where the realness wasn't a limitation..."* In this case, the immersive CVE violates Cartesian dualism, with the body of material and the mind of non-material.

However, the corporal body is represented by an avatar. To refer to the ideas of Magritte, such a representation can be explained as an act of a visual thought (Guerlac, 2007), since the avatar is the thought of the designer who made it, as well as the thought of the person who uses it. In that sense, the avatar can be perceived as a part of someone's mind, which may undermine or bypass the corporal resistance to step over, stand above or "move through" each other (or the avatars) while co-designing.

Figure 6. Sharing shapes when co-designing in the immersive virtual environment.

Design relations

A sense of presence in virtual reality has multiple definitions. One definition refers to being at a real place (being there), a place illusion (Slater, 2009). Somebody that is very used to the VR technology may interact within an immersive CVE and not perceive that they are beyond the world instead of at a place, such as being at home or school (Slater & Sanchez-Vives, 2016). In this study, the CVE was perceived as an empty, less real place when being alone within it. Such an experience can be interlinked to a user's moderate experience of using immersive VR technology. However, when co-designing, the experience of the place was different: "*It becomes a different sense of presence when you hold one object in your hand and give it to the other, and you hold it at the same time*" (Field notes).

Such a contact reflects the relationship between oneself and the other, which is discussed by Merleau-Ponty, for instance. In VR and immersive CVEs, this phenomenon can be related with the concept of *co-presence*, as you become aware of the presence of the other, e.g., a team member, while collaborating. The VR technology can support such a co-presence, and facilitate it (Schroeder et al., 2001; Wiederhold, 2003).

Figure 7. At the end of the co-design session. The lo-fi prototypes represent parts of an exhibit design, to display historical artifacts for young children to interact with and learn about history while visiting a city museum.

Here, ideas of existentialism and the theories of Martin Buber (1923/1937) can be relevant, since they highlight the relationships between people. These theories are applied in several disciplines touching on humanities, such as pedagogy. The theories can be applied without regard for religious belief, which is done in this text. Referring to Buber's ideas, the world can be experienced through a filter as we describe, identify, and categorize (objects, people, and the world we act in) based on e.g., previous understanding and knowledge. This is a matter of the so-called "I-and-it relationship", which is a common relationship. In contrast, the "I-and-thou relationship" refers to encountering each other beyond our previous experiences, knowledge, and prejudices, in the space between us. In this case, "I" starts to exist in the presence of "You" (Buber 1923/1937). Such a relationship is not based on confirmations of the previous experiences of the world but, instead, can be compared to an exploration of the same. According to Salvo (2001), an I-and-thou relationship may open up a dialog between collaborators in a co-design process. However, Salvo does not elaborate on how such a relationship may occur, neither when co-designing in "reality" or in VR.

In this study, objects and shapes were shared when giving and receiving 3D platonic forms, such as cubes and spheres, by switching hands virtually: "*Co-creating/designing … was enjoyable and felt very real in terms of you were there with tangible stuff including fun episodes of taking materials and constructions from me and back and forth in a humored fun way.*" (Field notes). This co-exploration and sharing opened up a dialog regarding the design options and possibilities. Furthermore, the spatial audio in this immersive CVE was directional and followed acoustic principles, and automatically lowered the volume of the voice when the avatars were further away from each other and raised the volume when they were nearby: "*Like just hearing an immediate, familiar voice and turning my head and the voice was right by my shoulder …*". (Field notes). During the design session, the spatial audio gave support when it came to understanding how to orientate and navigate in the virtual environment in relation to each other's bodily positions. The sound quality, the volume, and the location of the sound affected how the voices were perceived and, consequently, the identification of a co-designer. "*His voice sounds different compared to the phone. Is it really him? It is softer and maybe fuller (fuller base) than normal.*" (Field notes). The spatial audio affected the sense of embodiment and co-presence in that we could maintain focused attention individually while still sharing the same audio space in the immersive CVE, comparable to acting in a physical design studio working on a project together.

In that sense, spatial audio, co-exploration, and the exchange and sharing of objects between virtual and mediated bodies reinforced an I-and-thou relationship in this immersive CVE since "I" began to exist in the co-design relation to "You."

Final Thoughts and Future Studies

Through an introspective study, this text presents a reflection and analysis of actions, thoughts, emotions, and sensations when generating design ideas and co-designing lo-fi prototypes in an immersive collaborative virtual environment (immersive CVE), in an early phase of a design process. The purpose was to investigate if and how virtual reality (VR) and immersive CVEs can facilitate the co-design experiences and the co-making process. Theories related to direct perception and affordance, socio-semiotic, remediation, design fixations, and existentialism and human relations emerged during the study and analysis of the findings, and were applied to reflect upon the key moments and experiences during the co-design session. The study illustrates possible areas for further studies on co-designing with immersive VR and within immersive CVEs.

Based on the findings, it can be tentatively suggested that the immersive CVE in this study was approached as an "actual" and cultural place due to the co-design inter-activities within it and the designers' previous experiences and knowledge, as well as the resemblance to previous games, virtual environments, or 3D chats. Moreover, it is tentatively suggested that the digital tools, digital materials (platonic 3D shapes), and the place where the co-design activities are taking place in an immersive CVE have metaphorical qualities, which influence the interpretation of shapes, choice of shapes, the combination of shapes, the result of the co-making process (the prototype) and the co-designing experience as a whole. Futhermore, when co-designing virtual lo-fi prototypes in an immersive CVE, the sharing of objects and shapes, such as when they shift hands, as well as the spatial audio, may facilitate the experience of a design relation, an I-and-thou design relationship, when co-designers collaborate from remote places.

Spatial audio, the synchronization with avatars' facial expressions and the audio's possibilities of simulating space, appears to be relevant when co-designing in immersive CVEs. However, avatars and their functionalities and feasibility are not covered in this study, and we suggest that future studies examine these aspects further. Future technology developments might influence the co-design experience in immersive VR, which is also yet to be explored. The study presented in this text is an introspection, small in scope, and further investigations with multiple methods and users are recommended.

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Andrey Pavlenko

Ontological Premises of Technology and design: a Critical Analysis

Annotation

The article aims to analyse the ontological premises of technology and design. The main problem, expressed as a question, is as follows – are man's technical projects arbitrary constructions of his consciousness (thinking), as Günter Ropohl supposed, for example, or 1) *are they predetermined*, as believed Paves Florensky and Martin Heidegger (strong thesis); 2) *are they limited*, as Friedrich Dessauer suggested (weak thesis).

To answer this question, the concept of "ontological Propis" is introduced, with the help of which any objects that are consistent (CO) are designated. Correspondingly, contradictory or non-consistent objects (NCO) are located "outside" the ontological Prescription and are imaginary objects. Most COs exist in the realm of the possible world, and a smaller part exists in the real (empirically given) world. Ignoring the difference between these worlds gives rise to the main temptation of design: the human mind is autonomous and free, and, therefore, "everything can be designed!" The inaplicability of this claim is shown in the form of three limitations of technology and design:

The first limitation: human consciousness (thinking) can design *consistent and only consistent objects.* "Consistency" is the general requirement of the ontological Propis for all possible and real objects.

The second limitation: human consciousness (thinking) can design *those and only those objects that are law-conforming* (Dessauer). Law-conformity is a requirement of the ontological Prescription for real objects.

Third limitation: human consciousness (thinking) can design only those objects that are *human-proportional.* Human proportion is a requirement of the ontological Propis for real objects.

Conclusion: the activity of the designer is not arbitrary but is significantly limited by the ontological Propis.

Introduction

One could, however, rather tentatively say that the era of "design" was initiated by Rene Descartes, whose maxim Cogito ergo sum[1] (Descartes, 1989), became a kind of slogan of the entire Enlightenment. It was Descartes who formulated his worldview in such a way that now the *"existence of human"* (and the world in general) was made dependent on *"human thinking"*. Both components are important here: firstly, "thinking", and this means that the whole philosophical world that comes after Descartes *will be based on this very thinking* and everything derived from it, up to modern computer programming and modelling; and secondly, "human", and this already means that *all other rational forms – the "realm of ideas", God's intentions, theology (literally "words of (for) God"), and suchlike – are left out of the discussion as "non-human"*. In fact, Descartes proposed not just the "project" of the New Man, but, if you will, the *"project of all projects"*. In a sense, Descartes is the *First Designer* in the European culture of the New Age. He gave an impetus to what later will serve as the basis for the division of all researchers – of course, also, very arbitrary – into two clearly distinguishable groups: the first, which *directly followed Descartes* in this matter and put the works (products, artifacts) of a person in dependence of his "thinking"; and the second, which, *contrary to Descartes*, tried to discover the origins of human projects in the world itself (sometimes in nature itself). To understand why this was so, let us take a step aside and consider some concepts that we will need to elaborate on the matter.

Concept of the "Ontological Propis"

In order to describe these two groups and the premises that became the foundations of their views, as well as to adequately describe the nature of "technology" and "design" and explain their essential features, we need to introduce a new concept. Such a concept would be "ontological propis". By "ontological propis" (hereinafter referred to as "Propis") I will mean a *set of consistent and only consistent objects, both possible (given in theoretical knowledge) and real ones – given in sensory (empirical) knowledge*. To mark the Prescription, I introduce special symbol "⯐". Now let's denote some properties and features of the Propis. To do this, I introduce the corresponding notation. For a better understanding I will compare it with the corresponding symbols and operators in the von Wright model of time (von Wright, 1983), which also employs a "logic of events" rather than a "logic of utterances".

1 Descartes writes about this in the treatise "Discourse on the Method". A critical analysis of this statement can be found in the works of J. Hintikka (1962; 1988), as well as in Pavlenko (2012).

1) The Symbol $\mathbf{S}_f$ denotes complete (**f**ull) space of states of the world. It appears, at a new level, the only analogue of von Wright's operator «p T p» (the event exists and continues to exist) (von Wright, 1983), that characterizes such space of sensuously observable physical events of the world, *when the "sequence of events" is, but there is no meaningful change in events!* The variable "p" in the von Wright's model means "some event in time". Broadly speaking, von Wright allows construction of such model, assuming that we can take the entire set of events, length of *m*, and receive the "number of possible worlds", equal to 2^m (von Wright,1983) insted of (Chalmers,2002).

Disjunction of such "possible worlds" Wright calls "T-tautology" (von Wright 1983). However, regarding this description von Wright makes a disappointing verdict: "... T-tautology does not say anything about the history of the world. It is trivial and therefore logically true" (von Wright, 1983). We see that the expression «~ p T ~ p» ("event does not exist and does not come into existence") does not fit into von Wright's model again. We see that von Wright didn't *know what to do with the phenomenon of the lack of change*. After all, if the world is given entirely and there are no changes in it, therefore, there is no time. I think, here he doesn't notice that his own model readily admits this scenario: : p T p; p T p; p T p ... p_n T p_{n+1} .

2) The Symbol $\boldsymbol{S}_e$ denotes "**e**mpty space of states of the world". It only is the analogue of von Wright's operator ~ p T ~ p, so it characterizes such a "state of the world" events, when *there is no event in the physical world and it doesn't occur.* I call it "empty" and I take the term "space of states of the world" in quotes in order to emphasize the specificity of this expression, because it – by the way, von Wright himself does not indicate to such a feature it somehow – strictly speaking, describes not a real sensuously observed *physical event*, but only some of the possible events, which *is not given* in the space of the actual state of the physical world in the present. For me, it is strange that von Wright did not pay attention on this. After all, he had, in fact, built *a model of temporal physical events (observed) of the world.* The operator ~ p T ~ p simply *falls out* of the sense-perceived physical reality, speaking *only about the possible events.* After all, the variable for the event (~ p) *denotes anything, but not sensuously observable physical event (p).*

3) The Symbol $\mathbf{S}_{h/f}$ denotes "half (partially) complete (**h**emi**f**ull) *space of states of the world".* It is an analogue of von Wright's operator p T ~ p, namely characterizes such state of spaces of the world, when *there is a real event, but it starts to move from the real world to possible one.* Let us note again that von Wright did not share his world events in real and possible.

4) The Symbol $\mathbf{S}_{h/e}$ denotes “half (partially) empty (**h**emi**e**mpty) *space of states of the world*”. It is a distant analogue of von Wright’s operator ~ p T p, videlicet characterizes such a state of the world, when *a possible event starts to become real.*

Operator’s specificity [symbol] is that it denotes the space of all changes *as the set of changes which have been given*, that is to say, “the space of sequences of events” (in Wright’s terminology - “space changes”).

Further, I will outline the main properties of the Propis, which were already described in the previous work Pavlenko (2012), but which I will need again, in connection with the description of the nature of technology and design.

Let’s try to characterize the prescription of world events. I will signify this phenomenon by means of Russian word “Propis”, expressed by the symbol [symbol] :

1) The Propis *is the world of consistent and only consistent objects and events.*

$$\text{(I)}\quad [\text{symbol}] \quad \leftrightarrow S_f \wedge S_e\,,$$

$$\text{moreover, } (p \,\&\, {\sim} p) \notin S_e \vdash (p \,\&\, {\sim} p) \notin S_f$$

2) Consistent objects (events) *can be* implemented in a sensually observable (physical) world.

$$\text{(II)}\quad S_f \subset S_e$$

(3) *Propis* is the sum of all the conjunctions of events observed in sensually observable and possible worlds.

$$\text{(III)}\quad [\text{symbol}] = \sum (S_f \wedge S_{H/f} \wedge S_{H/e} \wedge S_e))$$

(4) Be implemented in the observable world can that and only that, what is consistent:

$$\text{(IV)}\quad S_f \in S_e\,,$$

$$\text{Moreover, } (p \,\&\, {\sim} p) \notin S_f$$

(5) All events in the S_f are elements (lines) of prescribing the sequence of events of this “Propis”:

$$(V) \quad S_f \in \text{※}$$

(6) In S_f there is no real event which does not belong to ※.

(7) In S_e there is no possible event which does not belong to ※.

(8) Accident – is a characteristic of the human knowledge and description of “Propis”, but not the “Propis” as itself.

(9) Changes in the world of events S_f – are *hand-written-samples*.

(10) The line of Propis – is a strict sequence of events in the real or possible world of this recipe.

(11) The Propis, from the temporal point of view, is a set of qualities, united by sequence of events.

From “Ontological Propis to “Technology” and “Design” (The First Limitation of Technology and Design).

Now let’s try to bridge the gap between such an abstract philosophical concept as “ontological Propis” and the concepts of “technology” and “design”. It is reasonable to ask: what can the concept of “Propis” give us in explaining the nature of technology and design? In fact – a lot. As we could see, according to formal expressions (I) and (II), *consistent and only consistent objects can be realized in the world*. Therefore, if we assume that: 1) *the plan always precedes the execution*, and that 2) *the plan is a project (design)*, then we have the right to assert that since *“human design” is a process (product) produced by human thinking*, then, accordingly, the design should also have such a quality as “consistency”. This is the first consequence from the Propis. Having established this, we can now formulate the first problem, which we express explicitly as a question:

> *Are man’s projects just arbitrary constructions of his consciousness (thinking) or are they something more (than just constructions of his consciousness)?*

In a slightly more concise form:

> *Are human projects products of only and only human thinking?*

To answer it, let us draw attention to the fact that thinking is connected, first of all, with the world of "possible objects", and the latter are most directly connected with ontology. Therefore, both "technology" and "design", as long as they discuss the *construction of possible technical objects*, are also related to ontology.

The world of the sensually observable "technical sphere" of human life, turns out to be not the only "world of technology" from this point of view. Meanwhile, many researchers are inclined to see only the positivistic - "materialized" – sphere of technology, which is empirically given. "Opportunity of technology", on the contrary, allows us to talk about "technology" even before "it" – at the stage of a technical project – gets a "materialized" expression, gaining empirical observable forms of a particular technical product – an artifact. In other words, technology (technical artifact) exists in two ways:

1) at the stage of the project (design) as a *possible object*; (fixed in expression (I));

2) at the stage of implementation of a possible object into an *empirically given object* (if we are talking about physical objects). (It is fixed in the expression (II)).

If a technical artifact is impossible in principle, then there are not any reasonable grounds for its implementation in actual reality. This follows directly from expression (IV).

Having understood *the first* – the most general – *restriction* in the field of engineering and design, let us now consider the prerequisites that still give rise to hopes of "unlimited possibilities" of human design.

Anthropocentrism – the Premise of the Main Temptation of Design

From my point of view, as the most representative figure expressing the position of "anthropocentrism" in the philosophy of technology, Günter Ropohl and his explanation of the nature of technology can be considered: "I would like to make it clear to the reader," writes Ropohl, "that for my part I consider invention as a primary, counter-natural product of human consciousness" (Ropohl, 1989, 216). Such an invention is achieved, according to Ropohl, due to "planning, intellectually controlled and future-oriented activities, as well as due to the human ability, in the imagination, to move in space and time, to combine any feature of the available" (Ropohl, 1989, 216).

Polemizing with the representative of the ontological approach (to be discussed below), Dessauer, Ropohl asks a question that he thinks is crucial on the topic under discussion:

"I hardly resist the temptation to refute Dessauer's train of thought with examples from technical practice: perhaps here I would directly fall into a satirical manner of controversy if I would consider, for example, the question of whether front-wheel and rear-wheel drives pre-exist in the Platonic realm of ideas" (Ropohl, 1989, 211.)

According to Ropohl, it is human consciousness that is the source of technical inventions: "Technology is nothing more than overcoming nature through human consciousness" (Ropohl, 1989, 217). Ropohl's position is frank and that is good.

So, asserting that the new is a product of human consciousness, Ropohl, gives an answer to the question: "*where* does the technically new come from?" Claiming that the new arises from the "planning, managing, directing and combining activities of the human mind," Ropohl also answers one very important question: "*How* does the technically new come about?" Ropohl's broad answer to this question can be presented in a laconic form: *technically new is a combination of the available!*

From my point of view, the basis of Ropohl's and his associates' position – unbeknownst to them – is built on the premise according to which there are two realities: the first reality is "nature"; the second reality is "human". If there are no technical devices in nature, then they should be in a person, in his mind. It seems to me that this position is erroneous. And here's why. The basis of this argument is the wrong syllogism:

A) All that does not exist in nature is a human invention

B) "A car drive" is not what exists in nature

C) "A car drive" – is a human invention

Obviously, the conclusion is not true from logic's point of view, due to the violation of the rule of the first figure – "the smaller premise should be an affirmative judgment." Indeed, from the fact that the "car drive" does not exist in nature it does not follow with logical necessity that it is precisely a human invention.

It is this view of the nature of human abilities that gives rise to the main temptation of technology and design: *the conviction of its unrestricted power – the human mind is autonomous and free, so "everything can be designed!"*.

Let us show the unimplementability of these claims, due to the objectively existing limitations of technology and design, not in the possible, but in the real (empirically given) world.

The Main Intrigue in Explaining the Nature of Technology and Design

A discussion of the world of "possible objects" may also take a different and very unexpected, ontological perspective. So, for example, should one understand "possibility" as a kind of "special world of the possible" that exists outside of a person who is aware of this "possibility", or is the sphere of the "possible" limited only by human thinking and consciousness? The two most likely answers to this question have given rise to two most authoritative areas in the philosophy of technology, to which, to one degree or another, most researchers gravitate.

Among the supporters of understanding the "possibility of technology" as a *special world* (be it the world of "ideas", "possible world" as a world of consistent, but still unrealized technical projects, "being" or something like that) are Pavel Florensky, Martin Heidegger, Friedrich Dessauer and some others.

Another answer, according to which the "possibility of technology" is limited by the bounds of human thinking and consciousness, is, on the contrary, the most influential. As a representative of this trend, I have already cited the point of view of Gunther Ropohl. According to this school of thought, the *"source" and, therefore, the "possibility" of technology is human consciousness and only human consciousness*. Any other ways of reconstructing the occurrence of technical artifacts are considered by them as "metaphysical" and devoid of any basis.

In fairness, it should be noted that other approaches than two mentioned above are not completely absent. Not at all, they exist. Moreover, some of them aim to go beyond the narrow framework of described dichotomy and propose different basis for typology. For example, Carl Mitcham in his work "What is the philosophy of technology?" (1995) proposed to classify approaches in the study of the phenomenon of "technology" on the basis of "engineering – humanitarian". The choice of strategy proposed by Mitcham is quite explainable: first, the word is given to professionals, and then – everyone who wants to state "their opinion on the philosophy of technology" are welcome to do so. Indeed, who, if not professionals, knows the subject of discussion – "technology per se"?! However, despite this approach being natural from the point of view of common sense and professional pragmatism, it is also not free from shortcomings and provokes perplexity.

Heidegger in one of his works on the philosophy of technology (Heidegger, 1962, 5) shrewdly observes that the “essence of technology” in itself is not something “technical”. In fact, if this is true, then specialists can speak out professionally about the “technology” itself, but the “essence of technology” will remain outside the scope of their professional knowledge and skills. In this case and hereinafter, by the “essence” of any object we mean simply the *totality of inalienable attributes, without which the given object cannot be thought of in a complete way*. “Essences”, in our understanding, are not metaphysical or religious “substances”, but “inalienable attributes” of the objects in question.

The ontological approach, according to materialistically and positivist-inclined philosophers of technology, can provoke only bewilderment and healthy sarcasm. However, Mitcham’s approach, brought to its logical conclusion, can itself lead to obvious absurdities. So, for example, one can pose a fully justified question: who is competent in deciding on the need for cloning of human being by means of bioengineering (and discussing this topic in general)? The answer prompted by the position stated above (Mitcham and his supporters) is unequivocal: first of all, bioengineers (after all, they know there is “bioengineering”), and then everyone else inclined so! But does a bioengineer know “what human is”? The reason for the emerging concerns, it seems, is that the essences of the things of the world contain some “additive” not reducible to their “spatio-temporal” explication as objects of our scientific and technical representation in the present period of time. This “additive” does not have to have a religious or metaphysical nature. It can be purely natural – physical, chemical, biological, etc. – but always remain in the realm of not fully known in the present period of time[2]. Having understood this, let us now try to briefly consider the main provisions of the ontological approach in explaining the nature of technology and design.

Ontological Turn in Understanding Technology and Design

One of the first attempts to understand the place of technology in the life of a new European person belongs to J-J. Rousseau (1961). Technical person was also criticized by F. Nietzsche, O. Spengler (1931) etc. However, in addition to general “reflections on technology” in the last quarter of the 19th century and the first quarter of the 20th there is a real boom of analytical research on this issue. A significant proportion of this boom comes from Germany. The most significant works of this period belong to Ernst Kapp (1877), Theodor Bäuerle (1917), Friedrich Dessauer (1928; 1959), Manfred

2 For example, today in physics there is no unambiguous explanation (somewhat harsher – there are no clear explanations at all) of the nature of “dark energy” and “dark matter”.

Schröter (1934) and some others. Researchers are beginning to reflect on the fact that technology cannot be simply reduced to just "material-technical products" – the products of human activity.

But the question – where does a person get knowledge about technical objects, which, in fact, do not exist in empirically given reality? – becomes the main nerve of interest.

Philosophers and engineers began to understand that in order to clarify the nature of technology, it is necessary to establish the ontological basis of its nature. Thus, the philosophers faced the task of answering the question, "how is technology possible"? If they found the answer to this question, then they would penetrate the essence of technology. Historically, the first attempt at such penetration was made by Pavel Florensky in 1917–24, with the analysis of which we will begin our study.

Ontological origins of technology by P. Florensky

In one of his works, Florensky literally says the following: "The whole culture can be interpreted as an activity of the organization of space. In one case, this is the space of our life relations, and then the corresponding activity is called *technology* (italics mine - A.P.). In other cases, this space is a conceivable space, a mental model of reality, and the reality of its organization is called science and philosophy. Finally, the third category of cases lies between the first two. Its space or spaces are visual, like the spaces of technology, and do not allow life interference – like the space of science and philosophy. The organization of such spaces is called art" (Florensky, 2000, 112).

The technology "changes reality to rebuild space". But how can technology rebuild space? We are well accustomed to believing that "technology" can rebuild "house", "bridge", "road", but "space"? It looks incomprehensible and almost mysterious. We also confidently know from school that all the things of the world are "placed" in space: houses, people, air, the ocean. From the largest, Cosmos, to the smallest, particles: everything is "in space"! This self-evident belief, in fact, rests on one single non-obvious cornerstone – the Newtonian understanding of the nature of space: "space is a container" (Newton, 1954, 280–281). Pavel Florensky offers a completely different understanding of space, according to which it is not a container, like a Universe-sized barn in which God places utensils of the Universe. In the understanding of Florensky space is a *force field of activity*. He says that technology – just like science, philosophy and art – forms a "force field" (Florensky, 2000), which distorts space. So how and in what sense can technology – any artifact of it – distort space?

To answer this question satisfactorily, a radical rejection of the self-evidence of Newtonian ideas of space is necessary. In order to switch to another understanding and perception of space, it is necessary to consider an example – some “action in space”. Florensky proposes to consider the “gesture”, an ordinary gesture made, for example, by the human hand. He says: “A gesture forms a space, causing tension in it and thereby distorting it” (Florensky, 2000, 113). That is, the “gesture” as such is the source and cause of the distortion of space. But another approach is also possible, says Florensky: “When the tension in the space *is marked* by the tensions from the gesture in this place (italics mine - A.P.). It was already here, preceding the gesture with its force field. But this distortion of space, invisible and unavailable to sensory experience, became visible to us when it showed itself via force field, assuming in its turn a gesture” (Florensky, 2000, 113). In this case, the “gesture” is no longer the “source” of the distortion of space, but its “consequence”. It is this latter approach that is more “appropriate,” according to Florensky, to explain the essence of technology. We can say that the “technology”, as well as the “gesture” only causes, develops, I would say–- *reveals the distortion of space*. Indeed, the “technical” curvature of space, “was already here, preceding the gesture with its force field” (Florensky, 2000, 113).

Using the concept of “ontological Propis” introduced above, I will say: being is already total and complete, according to Florensky, contains all the Propises of all “gestures”. Human only follows these ontological Propises with more or less precision. Such, in general terms, is the view of Florensky on the ontological basis of technology.

Another, no less interesting, supporter of the ontological explanation of the nature of technology is Martin Heidegger. Consider his approach.

Ontological origins of technology by M. Heidegger

Technology as Machenschaft. Heidegger begins his analysis of the ontological basis of technology in one of his early works, *Beiträge zur Philosophie (Vom Ereignis)* (1925/1989), by analyzing the concept of Machenschaft. The meaning of Machenschaft should not be associated, according to Heidegger, with its common understanding as “trick”, “bad” art or with the concept described by the word “fraud”. That would be oversimplification. According to Heidegger, in relation to the question of being, Machenschaft should be understood as “the way of being” (*eine Art der Wesung des Seins*) (Heidegger, 1989, 126). Machenschaft is not just the work of human hands, it is rather how it is done. Machenschaft, Heidegger says, lets us name something that “something creates from itself” (Sich etwas von selbst macht) and is thus suitable for emerging needs. This Sich-von-selbst-macht came from τέχνη and its semantic field, which, in turn, came from a certain interpretation of φύσις. Today, Sich-von-selbst-macht is itself coming to power domination (Heidegger, 1989, 126). According to Heidegger, Machenschaft was already present in antiquity. But there, while remaining hidden, it never revealed in its entirety its essence, for antiquity was under the influence of ἐντελέχεια. For the first time, Machenschaft, as they say, "comes out of the shadows" in the Middle Ages. The medieval concept of actus obscures the original Greek understanding of the dis-closure of being. Now Machenschaft, according to Heidegger, is more clearly revealed due to the role of the Jewish-Christian understanding of creation and the corresponding idea of God, which contributed to the transformation of understanding of God as "being" (ens) to his understanding as "being creator" (ens creatum) (Heidegger, 1989, 126). And also due to the fact that God, and then the world, were reduced to a causal understanding (Hösle, 1991, 146), according to which God began to be interpreted as "the cause of oneself" – causa sui (Heidegger, 1989, 127). So, Machenschaft, from an ontological point of view, is Sich-von-selbst-macht. The latter concept could be interpreted as "building oneself out of oneself" or, leaving German aside, with the appropriate Russian word, "samosozidanie" (self-creation). Consequently, the Heidegger's Machenschaft is "the self-creation of human". Until the era of the New Time it had never come to domination – *self-conscious self-creation*. Having come to such a state, Machenschaft takes a special form – the subordination of everything to this domination – the form of Gestell. Therefore, Gestell is just a specific manifestation of the Machenschaft!

Technology as Gestell. If Heidegger was interested in the source of technical, technology as a way of being-in-the-world (Dasein) as early as 1925 – and now this can hardly be argued – nevertheless the essence of modern technology, its "global nature", Heidegger, in fact, analyzes in detail only in his work *Die Technik und die Kehre* (Heidegger, 1962), which is based on the report "Gestell", read in 1949, as well as in a number of other post-war works. Heidegger begins his explanation of the essence of modern technology with the question of how does technology relate to its own essence. Indeed, for example, the essence of a tree is not something "wooden", Heidegger notes, therefore, "... neither the essence of technology is something technical". (Heidegger, 1962, 5) At the same time, technology is not something neutral, as many believe, linking its understanding either with technical means or with human activity using these means. This is an instrumental and anthropological definition of technology (Heidegger, 1962, 6). Of course, both of these aspects are present in technology, and such a definition of technology would be correct. However, "correctness", according to Heidegger, should be considered justified only when it leads to the essence and method of its discovery – the truth (Heidegger, 1961, 7). But instrumental definition does not lead us to it. Why? Because, Heidegger answers, we are in the grip of instrumental definition. To free ourselves from its power, we should understand what is "instrumental" in and of itself. After all, any instrument, in essence, is something adapted to achieve a specific goal, for the sake of which something is processed. Here, it is found that an action performed for some purpose is called the cause (Heidegger 1962, 7). This is the "active reason", previously called the *causa efficiens*. It is this type of causality, according to Heidegger, that underlies the instrumental explanation of technology. Turning to the Aristotelian classification of causes, Heidegger says that neither an active reason, nor three others, have ever been understood by Aristotle himself or his contemporaries in the sense that consciousness of the New Time endowed causality with. For Greek consciousness, the reason is not "what is being done with something." The Greeks understood "reason" as – ἀιτίον. But ἀιτία cannot be translated as "causa" or German "Ursache". It should be translated as "ver-an-lassen", which would be close to the Russian "order". And any such *order* is "Her-vor-bringen", that is, "pro-knowledge" or in Greek ποίησις (creativity). But this is how φύσις opens. "Φύσις," says Heidegger, "is also ποίησις in the highest sense" (Heidegger, 1962, 11). Pro-knowledge leads something from concealment to non-concealment. Therefore, "pro-knowledge" is at the same time Ent-bergen – "disclosure", that is, just what the Greeks called ἀλήθεια, and we call it "truth". Therefore, Heidegger concludes, technology is not just an instrument, technology *is a way of disclosing* (Heidegger, 1962, 12). Antique τέχνη, therefore, was associated with the cognition and method of revealing the truth, and not "making something for the sake of some purpose".

However, the ancient understanding of technology is significantly different from its modern "machine" understanding – Kraftmaschinentechnik. Its difference is that the latter type of technology is based on natural sciences. Although the process of alienation of man from nature was lengthy, nonetheless, from Heidegger's point of view, a decisive event was the emergence of the philosophy of Descartes. Descartes identifies the "extension" as the geometric image of space and the "real space", that is, reduces the latter to the former. This gives him the opportunity to consider the whole "nature", "placed in space", simply as an "extended thing" – res extensa. "Behind such a characteristic of natural objectivity," says Heidegger, "is the position expressed in the *cogito sum* formula: being is representation". (Heidegger, 1988, 285) It was this reduction of nature to the "extended thing", which can be mathematically calculated and presented, that was the premise and basis that "made new European machine technology metaphysically possible and with it the new world and its humanity" (Heidegger, 1988, 285).

It should, of course, be noted that even Heidegger paid attention to the connection between the essence of technology and natural science. For example, Ortega y Gasset spoke about this connection in his lectures in 1933 (Ortega y Gasset, 1957, 93). However, no one like Heidegger considered it from ontological point of view. What type of non-covertness do we now see? What kind of technology is this from the point of view of its essence?

Everything in the surrounding world is brought into the state of availability by this technology (Bestand) as something intended for delivery for the sake of something. The main feature of modern technology is that this "available state" is not something external to a person as an object opposing him (Gegenstand). Bestand is a way of becoming material of both technology and the person himself, therefore, Bestand as such is invisible. Heidegger asks: who carries out this delivered-ness, making it non-covert? Obviously, a human! (Heidegger, 1962, 17). However, Heidegger observes that as Plato did not create "ideas" in the form of which the essence of being was revealed to a man in antiquity, and likewise[3], modern man does not create "technology" in which something non-covert is revealed. Modern technology is least of all "the work of human hands" (Heidegger, 1962, 18). Each challenge facing a person prepares him for delivered-ness. This preparation sets up a person to bring all reality into available state. It is precisely this verdict (Ausspruch) of being, which instructs a person to focus on self-revealing in bringing everything to the available state that Heidegger uses the term Gestell for (Heidegger, 1962, 19). Everything is delivered that falls into the circle of dissolved space of being: nature, bowels of the earth, space, and finally, human himself. Gestell is not, therefore, neither human activity, nor a simple tool serving such activity. And in these conditions of Gestell's domination, human imagines himself to be the "protagonist" and "creator" of technical civilization. This is where the danger awaits. Indeed, at the "moment" of awareness of one's dominance over the world, a person, in reality, turns out not to see himself in himself, for he himself is in the power of Gestell.

Having considered the ontological approach by explaining the nature of technology by M. Heidegger, let us now turn to the consideration of another, no less interesting, ontological approach proposed by Frederick Dessauer.

Ontological origins of technology by F. Dessauer

In his first work on the philosophy of technology "Technical Culture" Dessauer introduces the concept of "The law of the development of technology" (Entwicklungsgesetz der Technik). The meaning of this concept is reduced by Dessauer to the fact: "that the progress of mankind is generated by the progress of technology, acquiring, thanks to the latter, the quality of striving forward... proportionality – is the greatest, most powerful, fundamental law that characterizes the development of human spiritual culture as a whole[4]". In this work, by the term technology Dessauer means

3 Ortega and Gasset draws attention here to the connection of "technology" and "theory" in the 16th century. (Ortega y Gasset, 1957).

4 Since, unfortunately, I don't have Dessauer's original work "Technishe Kultur" at my disposal, I'm giving a definition of the "law of the development of technology"

not “machine technology”, but all human activity that is performed and is being carried out, which is aimed at the outside world. In this case, technology becomes a kind of art. But what then characterizes the law mentioned above? According to Dessauer, technology is the way in which a particular nation asserts its power and rule over the world. Here the question should be asked emphatically: is there a goal for the development of mankind subordinate to this law? But, before one gets the answer to the question about Dessauer’s understanding of technology, one should start by answering the “first” question: where does the source of technology come from and what is its essence.

The Socratic Source of Technical (Socrates and Technology). According to Dessauer, technology – as something “technical” – is first discovered in Socrates’ speeches. Why, then, was Socrates chosen as the founder of the “technical” by Dessauer? The reasons are as follows. Socrates, by his origin – his mother was a midwife, his father was a stonecutter – and in the manner of his thoughts, was a “born technician.” *Almost all of the examples that Socrates uses to express his own views are borrowed from craft activities, or, simply, from technology.* Here is how Dessauer describes the “genesis” of Socratic technology: “Socrates introduces two serious topics into the discussion: the topic of truth (knowledge) and the topic of good (value). These two functional questions of philosophy form the center of attention of philosophers at all times, as, for example, in the era of I. Kant, two millennia later, in the form of the *famous four questions* (in his “logic”) (my italics - AP)” (Dessauer, 1959, 60). So, Dessauer shows that Socrates does not just talk about the “truth” and “good”, but tries to bind them into something united. How does Socrates manage to unite truth (knowledge) and Good (values)? According to Dessauer, Socratic philosophy created a “model of technology” in which he combined “virtue with knowledge”. In fact, as a technician, Socrates knew very well that any technological product is preceded by “knowledge of a thing” (Dessauer, 1959, 63).

This first condition is necessary, because without its feasibility “the emergence of technology from pre-scientific – primitive knowledge of nature is impossible” (Dessauer, 1959, 63).

The second thing Socrates was sure of was that all technical objects (products) *are determined by human goals.*

From this, in turn*, the third* follows: before the inception of the image of the product, its eidos, its design should be seen in the soul of a person. *In other words, a certain “idea” of this product must pre-exist for all this.*

based on the work by Dessauer’s researcher Klaus Tüchel (1964, 12), in which it is given without abbreviations.

The fourth step involves the very process of implementing the "technical product", due to the combination of concept and action, "guided by the goal". Here, the "work" (das Ergon) becomes the "product" (Organon). The work corresponds to the "goal" (das Ziel), and the instrument corresponds to the "purpose" (der Zweck).

Fifth step. Thanks to the already existing conditions, *the concept* (Phronesis) is carried out not arbitrarily, not by chance, *but in accordance with the already conceived.* And this means, in the language of my work, that the design (technical construction) precedes the manufacturing.

And finally, at *the sixth step*, the purpose (der Zweck) is fulfilled, which in the eyes of the technician acted as a goal, which, in turn, simultaneously is the good for this purpose, which has value, due to which Socrates's teachings entered the world of values and good. *In fact, that is good that achieves the goal!*

Indeed, the above *six steps* of understanding of technical remain valid to this day in explaining the nature of technology. Of course, Socrates could not have imagined the whole variety of forms of manifestation of technology that are revealed to the man of our time. However, his strategy – to connect the idea (as well as the design) with its implementation, the "goal" of the product with its "purpose" was, in Dessauer's opinion, extremely productive.

Among the existing and most common interpretations of technology, Dessauer identifies Ernst Kapp's (1877) concept of "organoprojection" as an example of the wrong move in explaining its nature. According to Kapp, a person "copies in the 'technology' things he saw 'in nature', in biological organisms". According to this approach, the "technical" already exists in the material nature and man only copies it. According to Dessauer, this is the influence of biologism.

So, to consider technology as a technologically oriented design, which asserts itself in a product, means to explain, in Dessauer's opinion, its essence. Here we come to the distinction between understanding "the goal" (das Ziel) and "the purpose" (der Zweck), which is of great importance in explaining the nature of technology in Dessauer's conception.

The difference between der Zweck and das Ziel. Even the most superficial approach to the history of mankind indicates that man has always been a creator, inventor, designer (die Gestalter) and in this sense has always been a "technician". In fact, a person, first of all, studies his subject. In this, he acts as a Homo Investigator. By exploring, a person offers new solutions to problems. "A man," says Dessauer, "is also Homo inventor, the constructing creature." But Homo faber is also a making or producing man. He transfers his forms from the inner world to the outer. *The soul projects* *its formed representations and images onto nature*. These mental forms of representations have a threefold character:1) they are extracted from nature; 2) they are brought from non-availability to availability; 3) they are connected in patterns.

Indeed, any technical thing – for example, a "medical pill", indicates its demand by society. What is requested by society has its purpose. So, what is the difference between "purpose" (der Zweck) and "goal" (das Ziel)? Understanding the differences between them will bring us even closer to understanding the essence of technology. The very first difference, that literally springs to mind, is that a person is able to consciously set goals and strive for a goal. But the device (das Gerät) cannot! *The device is capable, being unconscious, of only fulfilling its purpose*. Dessauer gives a very revealing argument in favor of this. For example, a microscope fulfills its purpose when it makes very small objects visible in good resolution. However, before the microscope and its purpose were realized, the goal of the inventor, designer and manufacturer of the microscope should already exist. "The goal precedes the purpose!" – this is the main thesis of Dessauer in his discussion of the question of the temporal sequence of the relationship "purpose and goal". So, Dessauer captures a significant result for him - there is a temporary asymmetry between the "goal" and the "purpose": first the "goal" arises, which leads to the birth of what has the "purpose". Here, in this temporary gap, the most inexplicable point in the appearance of technology arises: how are ideas implemented in things? According to Dessauer, psychology (constructive imagination) alone, as suggested by G. Ropohl (1989, 216) later, is not enough and neither is anthropology alone. Here, according to Dessauer, a metaphysical basis is necessary.

And here we come to the most innermost in Dessauer's philosophy of technology – to the question of the "origin of technology". What no researcher can disagree with is the fact that prior to the act of invention technical objects *were non-existent*. They simply did not exist in the available world. For example, in the world there was no "microscope" before its invention. There was no "rear and front-weel drive", which G. Ropohl (1989, 211) speaks of. What follows from this? Does the emergence of these devices (contraptions) - their invention – mean there was some "successful" play of the human imagination? If we answer this question affirmative, then we will find ourselves in the realm of consciousness, which is the realm of the psyche. Therefore, the source of technology, ultimately, is psychology!? Is it so? Dessauer takes, from my point of view, an original step that overcomes the "psychological reduction" of the nature of technology. He finds in a technical product feature that does not depend on the psyche, or anything human in general. Dessauer (1959, 63) discovers that: "... the quality of an object existing as a microscope was already in space, otherwise it could not have been invented". What does "the quality of an existing object already existed in space" mean? This means that the *being of the world* in which the microscope arose *was already originally arranged in such* *a way* that it contained - even before any act of invention - "the ability to increase (decrease) the optical size of the objects contained in it" (Dessauer, 1959, 63).

If we use the concept of Propis proposed above (Pavlenko 2003; 2003b), then we are obviously forced to admit that Dessauer has come close to a similar understanding of the structure of being: "microscope", as the quality of the being of the world described above, was already contained in being, was literally pre-scribed in it.

However, the following point turns out to be extremely important here: what in existence itself allows the existence of a certain kind of qualities and what prohibits them? Neither Florensky nor Heidegger find such a formulation of the question. So, what allows technology in the present world?

"Consistency" alone, which was stated in expressions (IV) and (V) in the first section of this article, is no longer enough, because we are dealing not only with the world of possible (theoretical), but also with real (physical) objects. And for the feasibility of real (physical) objects, physical limitations are actually required, which Dessauer will talk about in other context.

In the context of the topic under discussion – the connection between technology and design – this means that any design projects *are predetermined,* as Florensky and Heidegger believed. The predetermination of the possible and real worlds of technology can be considered as a "strong thesis": *any technical artifact is predetermined in the world of the possible, and, therefore, in the real world.*

Dessauer makes it possible to soften the "strong thesis", giving this imperative the form of a "weak thesis": *technical design and technical artifacts are limited.*

The Second Limitation of Technology and Design

Law-conformity of technology

As early as his first work "Philosophy of Technology" Dessauer brings up the "justification of technology" by emphasizing its "nature-conformity": "technology has never been in conflict with the laws of nature, on the contrary, it always conformed to them... the human spirit always resonated with the laws of nature and yet it is not technology itself" (Dessauer, 1928, 4). So, we see that technology complies with the laws of nature both as a product, since it does not contain contradictions, and also as an idea, since human thinking "contains" the same laws as nature itself.

Indeed, by doing this Dessauer addresses one of the most serious issues related to the foundations of technology, which has not lost its depth to the present: *Why is technology complementary to the laws of nature?* The same question can be expressed in other words: *Why does such a technology turn out to be consistent with precisely such laws of nature?*

To answer this question, Dessauer clearly formulates his ontological position:

> *... all technical objects that were invented "did not exist" before, they were not available before that. There was no microscope prior to its invention. But the quality of an object existing in this precise way as a microscope, was already in space – otherwise it could not have been invented. (Dessauer, 1959, 71)*

This thesis of Dessauer's is easily read by the consciousness brought up in anthropic argumentation. In both the first and second cases, we find a correlation. In the second case (in the case with the anthropic principle), the correlation of the properties and qualities of the observer with the properties and qualities of the physical Universe, and in the first case (in the case of technology's law-conformity) of the properties and qualities of technical objects with the laws and characteristics of nature: "There are no technical objects (creatures) contradicting natural laws or external to them" (Dessauer, 1959, 71).

At first glance, both the anthropic correlation in cosmology (physics) and the correlation of technical objects to the laws of nature look like a banal tautology. Indeed, what other devices (technical products) are possible apart from those consistent with nature? However, following the logic of the latest multi-world theory in cosmology (Linde, 1990), we could argue as follows: in our world, where we are observers and creators of technology, it cannot be different, but in those worlds without us and where laws are different – perhaps there are other observers with other technical products. Dessauer, in his author's version, gives a philosophical explanation of this conformity of technology to the laws of nature: "This causal nature-conforming process is directed towards the realization of the goal, it is determined by completion or teleologically." (Dessauer, 1959, 71–72).

At the same time, Dessauer admits that in the inorganic sciences (physics, chemistry) the final outcome is not obvious. On the contrary, in the organic sciences a final outcome (Zug) is found, which is aimed at the integrity of living organisms. Technical products have the same integrity. The first or main characteristic of a technical object is its "strict integrity" (in der strengen Bindung) since it serves its purpose (Zweck), in accordance with the laws of nature (Dessauer, 1959, 71). We see that both living objects and technical objects – unlike inorganic nature – have one common universal feature – their existence is subordinate to the goal. It is no coincidence that Dessauer finds support from Kant, who allowed for the "Technica-naturalis" of living beings, thanks to the goal-setting. Speaking about the law-conformity of technology, Dessauer notes another significant feature of this correlation: a technical invention is more than just "applied natural science". Every invention gives, in relation to a simple sum of knowledge – even known laws of nature – *an excess increment*. So, for example, a watch is "something more than a flat combination, than just a sum of hands, pendulums, wheels, springs". The fact is that watches, possessing the integrity of watches, fulfill their purpose (Zweck) – *to show time*, which serves some goal (Ziel). But! Each watch detail cannot do this individually. Here we are dealing with a non-additive sum of parts. "The measurement of time," says Dessauer, "is the excess Mehr-als-Summe of the parts". A holistic structure, a finally ordered unity is first embodied in a watch". (Dessauer, 1959, 86.)

Law-abidance of technology

The connection of technology with the laws of nature is manifested not only by the fact that technology, "by definition", is consistent with the laws of nature, "observes" them and is determined by them in its forms. The simplest example is the whole technical field of "material resistance". However, not only because of this technology is associated with the laws of nature. Technology, at its source – *at the stage of the birth of a technical product* (device, tool, contraption) – is subject to the laws of nature. And here's exactly how. Let's take, for example, the invention of the wheel, which does not exist in nature as just the "wheel" created by human. According to Dessauer, the very way the wheel acts is strictly determined by the laws of nature, which means that "the laws of nature are always given in their availability" (Dessauer, 1959, 78). This means that any technical inventions of a person cannot be "arbitrary", that "exuberance of human imagination" is by no means infinite, but is necessarily subject to these laws! *All these findings are directly related to design.*

Law-possibility of technology

From the fixed nature of the subordination of technology to the laws of nature, essentially one more important consequence follows: in nature that is not filled with technical inventions of a human, *the possibility of strictly law-conforming technical inventions initially exists*:

"This unambiguity of the clearly rounded shape of the wheel is the solution to its realized essence, as allowing (Lösung) to exist as 'this precise being' (Sosein) or as the former philosophers said, its Quidditas, its 'substance', was also given, it 'expected', so to speak, its inventor" (Dessauer, 1959, 79).

From the words of Dessauer it can be seen that the "substance" of the wheel, consistent with the laws of nature, was contained in being itself as an "opportunity". The "Sosein" of the wheel, its "definite form", was predetermined. Not being valid, this "substance" was already here, however, without existence in the available (empirical) world.

Ontological status of technology

Dessauer then asks the question: can we say that since something does not manifest itself, then it does not exist? If we recognize the "existence" of the unmanifested, then where does it exist? According to Dessauer, in this case *the "technical" does not exist in the realm of the real, but in the realm of the possible!* But this is half a step. The possibility differs from the reality exactly by this – it is not real[5]. How does Dessauer address this problem? He says that in this area it (the invention – Lösungsform) was "not some indefinite, arbitrarily given, but fixed in its existential certainty and qualitative givenness" (Dessauer, 1959, 79). That is why it is possible to discover an invention (inventive idea). Essentially, Dessauer recognizes the existence of pre-given forms that do not contradict laws and are abiding them. He calls this type of "pre-given forms" "predetermined objects" (prästabilierte Objecte). Moreover, after the discovery of the "predetermined object", *each technician creates his own approach* to the "ideal form" (Lösungsform), which is revealed to him in the process of invention. The concept of "predetermined invention" was considered for the first time by Dessauer in his work "Philosophy of Technology" in 1927, and before Dessauer, A. Du Bois-Reymond discussed the existence of this form, as mentioned by Dessauer himself, in *Erfindung und Erfinder* (1910). However, even with such an argument, the question remains open: is "invention" – "discovery"? For de Bois-Reymond, yes. Dessauer is less categorical in answer to this question. For example, the discovery of America, cosmic rays and the like is the discovery of what already existed in the given world – reality until the very moment of discovery. The invention is more complicated. According to Dessauer, de Bois-Reymond is wrong. And here's why. Yes, invention is also a discovery, but, says Dessauer, "not in the space of the real, but in the space of the possible" (Dessauer 1959, p. 82). In order to untangle this problem of the "real – possible", Dessauer introduces the idea of several worlds.

First of all, *Dessauer indicates the world which determines the ways and forms of decisions*. This world establishes and limits the technology, which, hence, is defined according to the principle: "unthinkable, therefore, impossible." That is why the "perpetum mobile" is ontologically impossible. Dessauer also calls it the "vast supramundane realm" – this is a world of

5 Plato, after all, had a realm of true existence. Dessauer does not recognize the existence of this realm.

hidden, not yet realized images, which acquire real existence only via human activity. It is a world that can become born.

We see that Dessauer admits something completely unthinkable for the philosopher of the 20th century – the existence of an implicit area, which at the same time *coexists* with the explicit one, which is given to us in sensations and thinking. In this case, it turns out that the *inventing human in almost a photographic sense develops "images" of the implicit world in the explicit* (Dessauer, 1959, 84). In fact, Dessauer here describes what I refer to as the "ontological Propis". But in order to bring forms and images from the "nonexistence of the available world" into the "existence of the available world", "human innate formative abilities, which are the basis of what is happening technically in history", are necessary. This is a world of human abilities and actions. In fact, according to Dessauer: "...the hidden state of the 'fourth world' of pre-existing and realized forms is a possible basis of technology" (Dessauer, 1959, 84–85.)

But here again an unpleasant question may arise: why does what a human needs – in the sense of technical necessity – have to have an appropriate form in this "special supramundane realm" of forms and images? Indeed, "perpetual mobile" or physicochemical devices with an efficiency of 90–95% or more – for space exploration or for energy supply of its needs – would come in extremely handy today. Dessauer gives a negative answer to this question: technology is possible only as a "compositional symmetry" of these two worlds. "It is possible, perhaps, only as a structural similarity. The dictionary of the language of human needs and desires should ideally correspond to the dictionary of feasible forms, with possibly underlying this – one-to-one correspondence of words" (Dessauer, 1959, 85). The conclusion is astounding: *a technical person perfectly matches the natural world in which he lives!* But, in this case, we see that the anthropic cosmological principle (ACP) is also involved in technology. This is essentially the philosophical discovery of Dessauer.

Third Limitation of Technology and Design

When a human imagines, invents, comes up with something, he almost never reflects on the fact that it is "he" who imagines, invents, comes up with. "Thinking", "imagination" and "invention" are perceived by man as a *natural process*. Aristotle would say, as that which is "inherent to human". In this case, we will agree to mean "human" as generic creature, and not specific individual.

And here we come close to the question of the relationship of "human proportion" of human technical inventions and design. Design by its very nature – *the ability to construct something suitable (human-sized) for a human* – is focused on such results, which, ultimately, should be *used by* *human (convenient for human).* Although for objectivity it should be noted that design can also be understood in two ways.

In a *broad sense* – like any (including genetically programmed) *construction* aimed at meeting the needs *of any living creature* (we can talk about the "design" of the anthill, the "design" of a bee hive, the "design" of a bird's nest, etc.).

In the *narrow sense* – as a human design, as a *conscious design and engineering* aimed at meeting the needs of a human as a *generic creature*. Since design, like any human projection, is closely related to his consciousness (thinking)[6], new problems arise in explaining the nature of design (in general, human projective ability).

Challenges in Explaining Engineering and Design

If, hypothetically, we accept the point of view of Ropohl and his associates that "the creation of technological projects and design are products of human and only human thinking and consciousness", we will be forced to state, even within this approach, several insurmountable difficulties that also appear in the form of restrictions imposed on the design of technology, but not from the "outside" – from the ontology side – but from the "inside" of the anthropocentric approach itself. We express these limitations in the form of the following problems:

The first problem. *Human information (information given to a human as a generic creature) may turn out to be "finite information".* What do I mean by this? The following:

"Finite Information" $_{Df.}$ – is a set of *data* that is *detected and recorded by human and only by human*, based on the analysis of the observed Universe.

It follows that there may be information that goes beyond the "finite information" – it is contained in the Universe itself, but is inaccessible for human (for example, at the moment, in a given time period). It turns out that human engineering design is limited by the presence of "finite information".

The second problem. Human consciousness may turn out to be *"finite consciousness"*. (FC). Let's define FC:

"Finite Consciousness" $_{Df.}$ - *this is the totality of knowledge that is generated by human and only by human, based on the analysis of only and*

6 On the design of thinking itself, see Kees (2011).

only data that has already arrived in consciousness from the surrounding Universe.

It follows that there may be knowledge that goes beyond the “finite consciousness” – it is “contained” in the Universe itself (generated by data contained in the Universe), but inaccessible to human, has not been revealed to human (for example, at the moment or at this period of time). It turns out that human design is limited by the very fact of the existence of a “finite consciousness”.

Conclusions

In this article I demonstrated that the activities of a technical designer *are not arbitrary* but, at least depend on the three limitations described above.

It was found that human *consciousness (thinking) can design those and only those objects that are human-proportioned*. However, “human proportion” is such a given that it itself cannot 1) be either arbitrarily chosen by a person, nor 2) be arbitrarily constructed. Figuratively speaking: human can be a “designer of objects” in the world he designs, but he cannot be a *“designer of design itself”* (the very ability to design and construct). And this means that the technology constructed by human and the very ability of such construction (design) are *given to human*. They are *prescribed* both in the most general form (consistency) and in special cases (law-conformity, limits of human consciousness and available information, etc.) in our Universe. Therefore, the original scheme of evolution of the design subject proposed in Ceschin and Gaziulusoy (2016, 143) naturally needs to be continued – the establishment of “sustainability” not only in relation to human and the technosphere, but also in relation to human and the Cosmos (Universe)[7] – the cosmosphere.

If we allow the validity of the already cited multi-world interpretation in the model of the chaotic Universe by Andrei Linde (1990), then we can say: in our world, where we are observers and creators of technology, technology (design) cannot be different, but in the worlds where we do not exist, and the laws differ from those in our world – maybe, there exist other observers with different technical products and different design.

In other words, we cannot, at least hypothetically, deny the possibility of the existence of “technology” and “design”, which are not anthropomorphic and therefore not human-proportioned. In this case, *we could*, so far,

7 The simplest example of the demand and necessity of such a “space design” is pollution of near-Earth space by the waste of human “conquest” of space. This problem is already becoming very acute Drolshagen, Kaschny, Drolshagen, Kretschmer & Poppe 2017.

however, purely hypothetically, *talk about the possibility of a multi-world understanding of technology and design*.

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IV
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Greg Andonian

The CAVES of Global Identity: From Critical to Creative Thinking

Introduction

The Global Identity evolved around *"CAVE"* encounters of acquiring knowledge that eventually shaped the condition of the universal mind. It related firstly to reflective and critical thinking, secondly to imaginative and projective spirituality, thirdly to innovative and creative vision, and fourthly to artificial intelligence and systems thinking. The art of reasoning, the pursuit of passion, the craft of technology, and the cybernetic control embodied the mythology, the mystery, the magic, and the message and meaning of human inventiveness. Universal values, divine purpose, ethical means, and freedoms and responsibilities were sought in the quest for a sensible destiny for entire humanity.

The philosophical discourses on existence and essence advanced various realms of human reasoning: among them were idealism, moralism, and realism – to name a few. The challenge has been to determine how to harmonize novel ideas avoiding conflicts, devise honorable plans embodying society's aspirations and appropriate creative minds respecting everything living. The inalienable human rights for shelter, nutrition, and productive work are juxtaposed against the responsibilities of authorities regarding how to exercise control in order to achieve a balance between human need, social aspiration and professional duty.

The "Caves"

Existentialism was the modus operandi of Pre-tech society on the Aegean shores until the 5th century BC. The absence of choice negated decision-making and, hence, tradition dictated logical reasoning. This paralleled the rhythm of social, cultural, and professional life. Mythology glorified itself as the imaginative realm of human endeavor. And science in abstraction resorted to reductive thinking; its attempt to understand nature was zeroing in on the atomic structure of matter. However, the essence of life and its surrounding ethical and political issues were deemed irrelevant.

Then, Greek philosophy changed the focus of humanity. It did provoke debate on human logic. From analysis to synthesis, it adopted deductive and inductive reasoning. The concept of the mind was challenged regarding thought provoking and thoughtful making of art, architecture and city planning. It questioned man's ideas about himself regarding his belief system, social order and political agenda. Human logic impacted on society's ways of critical thinking and means of creative dwelling; it attempted to define the realm of being.

From critical reflection and imaginative spirituality to creative vision, the human condition evolved in "cave" experiences that characterized the global identity. These experiences questioned the humanity's value judgment, revealed man's innate aspiration for immortality, and exposed humanity's most cherished dreams for infinite creativity. Thus, ***the first "cave"*** – defined by Plato and which embodied his idealism– aspired to invent a new code of conduct. It challenged humanity to construct universal links with the cosmos. It attempted to establish an ideal social relationship by enacting the rule of law for the common good. And it pursued to appropriate ethical means for desired ends. It debated the schism between human perception and reality, form and matter, and image and representation, also defying pre-Socratic existentialism. It sought freedom of choice and eternal values. This "cave" was a fictional invention – a reflection on mind, a product of reason, and an abstract notion critical to prevailing ideas – favoring mind over body and man over nature.

The Platonic view of the cosmos was indeed manifested in the "cave." It narrated a scenario where a shared world-view – an "ideal" human community, with common values and understanding – was presumed established among the chained prisoners of the "cave" who faced the wall as the immutable board of knowledge. (The wall reflected images of visitors, projected by a distinct light source coming from the entry door behind.) Their vision was limited to the wall screen and blurred because of proximity. For them, shadows were the only "reality" to debate in a valiant attempt to comprehend the larger whole outside. Indeed, the prisoners made "sense" among themselves; they offered critical commentary on the ghostly presence of the visitors and linked the audible whispers to shadow movements. They engaged in interpretation. Then, when a prisoner was released on a limited time pass to see the wonderful, to experience the glorious and to witness the brave world outside, upon his return to his former chained status, he felt as if transformed into an outcast. He could no longer make "sense" with the rest of his comrade prisoners. Their shared worldview had vanished. Now he knew about the real world outside, and the rest knew only its shadows; hence, they no longer measured up. This Platonic pursuit of universal truth has aspired many to view the cosmos as the ultimate destiny of humankind. Higher order, cosmic beauty and divine harmony were what man had to seek in this "cave" beyond human desires and value systems. Accordingly, even though man had to aspire for a meaningful role in society, find his own individual place in the state setting and pursue fulfillment of his dreams with the help of the city establishment – he should never abandon the search for the universal truth. Indeed, man had to seek asymmetrical solution in design, in a subdued form, to enhance freedom of self-expression in art, architecture and urban planning. Plato's idealism attempted to prevent the corruption of the human soul. The eternal future with its values and relationships was deemed more important for humanity than earthly achievements.

If Socratic moralism had to prevail in these "cave" experiences, then individual goals, objectives and aspirations had to become suspect. Consequently, the pursuit of happiness through earthy possessions had to be ultimately questioned. The end state of mind had to be challenged in advance since man always aspired to seek power to subjugate the weak for personal gains, tended to accumulate wealth to control minds for political advantage, and attempted to build fame to dictate his terms of reference. The Socratic moralism was built upon the notion that every human end-goal was eventually attainable, but argued about human sacrifice, resources commitment, and environmental cost. In advance, the end value had to be critically tested against its perceived worthiness. Indeed, if the past had any message to humankind, it did reveal the fact that man never knew how to govern himself – man neither understood how to satisfy his desires without inflicting suffering, nor was he able to control his instincts without causing pain. In addition, man's tools and inventions were always used inhumanely, causing demise of individual rights, decline of moral responsibilities and decay of professional respects.

If Aristotelian realism had to exercise its reasoning in the "cave", then man's present situation regarding possibility thinking had to prevail. It had to advance tasks for the establishment to provide health care, education and employment for the citizens, and maintain law and order in the country. The state had a "god given" mandate to protect itself against the various named "enemies" within and without, and the responsibility to enhance safety for all. Eventually, the state needed its citizens for her "defense" – hence city-plans and architectural solutions had adopted symmetry in design for ease of access and control. Buildings thus embodied monumental scales in form and expression to command authority and ultimate control.

Indeed, the trials and tribulations of the dwellers of this "cave" embodied, first of all, the Platonic vision of universal truths and ideal relationships; secondly, they advanced Socratic reflection upon human intentions and moral aspirations; and, thirdly, they articulated the Aristotelian ethical mission for the realism of goals and objectives. The ideal, moral and ethical values were defined through abductive, inductive and deductive reasoning – a prescription for the "perfect man" to carry responsible tasks for the citizenship, with genuine authority and sincere commitment. This "cave" was the final manifesting triumph of mind over mythology. Man aspired to be in control of his situation.

The second "cave" is defined by Holy Sepulcher and articulated in early Christian existential narratives pertaining to eternity. It enhanced individual spirituality and advanced metaphysical aspirations, dictating its own code of conduct where reason was suspended to absolute authority. It filled the gap between wonder and doubt – advanced a surreal spiritual entity devoid of human critical thought and self-awareness. Paradoxically, submission of the self to the will of God-almighty brought man to the centerfold of divine interest, ignoring the existence of nature and the world outside. God-man-earth cosmology was emulating a mystery from this "cave", where spirit triumphed over body. This "cave" was real, not fictional, but inaccessible to human inquiry and incomprehensible to the human mind. Man could not offer critical commentary on this divine "transfiguration." Hence, the schism between mind and belief evolved, expanding into the realm of existence and experience. Man became numb – senseless and emotionless. He was gazing at the skies with imaginative spirituality for connection, but the messages were yet to come.

When the gate of the last Platonic School of antiquity was closed in Athens by a decree of Byzantine Emperor Justinian, the Christ "cave" then was the only option available for the pursuit of knowledge. From 5th to 15th century, this "cave" was the ultimate challenge for academic curiosity. To dwell in God's mind was the purpose of "visiting" there. Many attempted to reflect upon and project through this "mystery box" without success. Deciphering the puzzle that God could enter the "cave" physically "dead" and leave spiritually "alive" defied human imagination of the era. Could man not use the model for himself? Man was faced with an unprecedented dilemma: to believe in what "happened" in the Christ "cave" – as a manifestation of divine intervention – or to reject it as untrue. Was there any recourse for the "may be" interpretation regarding the mystery inside?

Amongst the notable "visitors" of the "cave" of this millennium were St. Augustine, St. Gregory of Narek and Dante. Indeed, in the City of God, St. Augustine distinguishes man's divine aspirations as the forum for spiritual dwelling, as opposed to in the City of Man mind-body inhabiting man's consciousness. This advanced a duality between man's existential experience and essence. The philosophical question stipulated was not why mind-body should be enduring finite suffering on earth for the "promise" of eternal spiritual existence in the "heaven", but how the mind-body could endure suffering. In contrast to the Buddhist manifesto that life is suffering on earth and man's desires are the prime cause for it, in the Christian belief, there existed possibilities of eternal suffering in the "hell" yet to come if man pursued worldly aspirations here and now. This debate on "hell" and "heaven", now and then – referring to earth and cosmos – led nowhere. St. Gregory of Narek, a 10th century Armenian Church philosopher, in his Conversations with God asks for an audience with divine wisdom and attempts to engage in a dialogue. Upfront, he accepts man's imperfection, but argues whether it was man's making. If the divine code of conduct for man after 10 centuries of preaching couldn't be put in practice, then what's the point? Maybe God's expectations were too high for man to deliver. Man needed help but not hurt, guide but not guilt, and lead but not let. Christ, the Son of God, couldn't dwell in this "cave" for more than three days, but man feels trapped in it for a millennium and can't find a way out.

Humanity's ongoing conflict with divinity originally stemmed from the description of the latter regarding the "perfect man" as God's agent, defined by the metaphor of this "cave." It requested man's conscious denial of his worldly experiences during his temporary existence on earth. In lieu, through the fellowship with the Sacred Book, pretentious spiritual "training" was mandated for his "immortal" mission to cosmos. This conflict, regarding the character instruction of man on earth for a cosmic thereafter endeavor, is the very theme that Dante entertains in his Divine Comedy. His visionary visits to "heaven" and "hell" aspire to reconcile the differences among the dwellers of both extremes and, in doing so, attempt to establish a "genuine" understanding between universe and earth, including God and man.

In the 15th century, it was Martin Luther's translation of the Bible from Latin and, subsequently, Gutenberg's spread through the invention of his printing machine that the truth about divinity was revealed at last. Man's "immortality" was assured through God's grace alone, but not by good deeds as stipulated before. Now man was free to read and individually interpret the holy texts, work for himself and reclaim the knowledge that was left off at the close of antiquity about a millennium ago. This heralded the opening of ***the third "cave"*** and the beginning of a new time and space for man to rethink his position on issues pertaining to the physical world around, experience reality independent of preconceived ideas, and question the very essence of being. Science and technology, rekindled by works of Leonardo da Vinci, Raphael and Michelangelo, once again promoted great trust in self-knowledge. Newton advanced the foundation of mechanics from cogs and clocks to steam machines. The industrial revolution reshaped the global landscape from countryside to city-ports. Maxwell's theories on electromagnetism were utilized in the design of the dynamo and the electric light bulb; they transformed night inhabitation and work ethics. From Einstein's imaginative theories on space, time, light and gravity to studies of sub-atomic particles, man evolved to tab nuclear power. Indeed, now man was thinking holistically. From unity of cosmos to the structure of matter, man was articulating the theory of everything. Matter transforming into wave-motion was under intense study. Chaos theory was unfolding into predictable order. And man was able to fly and land on the moon; space settlements were in the works.

Man's reasoning has evolved, too. Cartesian space devised by Descartes became the technical space for measurement. Within this concept, everything had a relative value, as opposed to an absolute one. His analytical problem-solving methods, in particular, his "divide and sub-divide until one understands" rule, became one of the bases of scientific reasoning. Copernicus and Galileo redefined the earth's relative position regarding the sun and cosmos. Darwin placed man in nature relative to other species. And Freud redefined the human psyche as being instinctive and irrational. Marx envisioned a classless society, Nietzsche declared that "God was dead" and hence man was in charge, and Peirce formulated American ideals in pragmatism. The concept of the world was being drastically redefined…

Architecture, as an important embodiment of human aspirations, transformed itself from the medieval, mystical and introverted spatial experiences to more open, utilitarian and life-sustaining narratives. Man, now was building for himself, expanding for progress and appropriating new technologies. Architecture negated ornamentation and styles of the past and became in tune with human social and basic needs. Functional determinism, pattern language and spatial behavior were the metaphors for these initial designers. Reinforced concrete, steel and glass, and plastics brought new sensibilities to the experiential dimension and the expressive essence of architecture. New building typologies and city morphologies evolved that shaped the scope of modern built environments. New government buildings and transportation structures, education and health institutions, sports and arts centers, shopping malls and theater complexes, office towers and production plants and, lastly, housing units – defined the modern life-space.

The 20th century "civilized" man brought upon himself terrible calamities. World Wars I and II devastated Europe, staging the forum for genocide and holocaust. Science and technology as tools of design and construction became means of destruction and ethnic cleansing. Displacement and dislocation, loss of history and memory, and distorted culture and obfuscated facts resulted in significant upheavals in social structures and great discontinuities in man's life. People in governments had yet to learn how to become human in restoring global justice by not resorting to sovereignty as an inappropriate shield for hiding crimes against humanity. Forced inaction on the disoriented prolonged the memory of suffering and the agony of injustice that haunted many.

Cybernetic control, artificial intelligence and systems thinking presently define the realm of ***the fourth "cave"*** at the threshold of the new millennium. Indeed, this "cave" is evolving to become everybody's place. It has incorporated the global, universal and omnipresent. Here, man is the creator of his virtual reality and the inventor of his cyberspace. In it, novel ideas not only exist, but they are in action. And man appears to be in control of his situation. In this "cave" man has created a new illusive reality outside his existence. So far, this reality is experiential – what you feel is what you get. There, the "self" is a relative thing, which is in the domain of flux – constantly transforming itself from being to novel becoming. It embodies man's creative vision to connect with all, at will and at all times, in order to make sense. This aspect of the "cave" is advancing to project itself as the magical realm of infinite possibilities. This open dwelling is considered fundamental to the notion of human rights, respects and responsibilities, as it will continue to shape the future human condition.

Using the millennium life cycle of the former two "cave" models, man at this point could assume that he is exactly halfway through in the latter two "caves" of dwelling experiences. Accordingly, there remains indeed another full five centuries of life span to evolve, during which man will have many survival challenges to confront. Global man will have to raise serious questions about his mode of innovative thinking, ways of intelligent planning, and means of creative making. Will man eventually devise a global economic union whose government will advance global education, bring social justice and mediate amongst nations to cooperate on issues of pollution and waste, natural environment and industrial development, management of renewable and non-renewable resources, preservation of agricultural land, and controlling ever-present overpopulation? Will man be in control of the earth to enhance his survival? Will he be able to bring order, harmony and balance to his mind, spirit and body? Will man play a crucial role in the healing of nature and healthy environment building? What will his value system be regarding priorities? If man's history will continue to be a history of selfish competition, inflicting suffering and cruelty on masses, then social, economic and ethnic conflicts will propagate further global tension. Humanity will lose even more of its scarce dignity. Man's tools of advancement will become tools of utter disintegration, subjugation and manipulation. Controlled misery will prevail globally. Eventually, earth will become a dumping site for the ones who could flee this cesspool and settle in outer space. The rest will falter around, in cyclical disarray, and eventually perish. Then, man will question, in his final moments of reflection, whether he has learned anything from these "caves" experiences.

Reflections on the Future of Architecture

The Global condition of mind, embodied in four distinct "cave" scenarios, posits criticality on experiences and exposures of contemporary hi-tech in constructing a plausible global civilizational identity. Attempts of **first "cave"** visionaries to devise a politically astute, socially cohesive and individually competent **"perfect intellectual man"** – on grounds of idealism, moralism and realism – did not materialize. Democracy lost its essence to the Roman Imperial Court as an oppressive model for human condition. Even the highly developed human mind failed humanity, as man could not solve his challenges intellectually. In the **second "cave"**, God revealed his code of conduct for the salvation of the **"perfect spiritual man"** reserved for the heavens. Divinity lost its essence to dogma as the corrupt model for human condition, as religious strife failed humanity, and man could no longer handle his earthy miseries spiritually. Functional determinism became the modus operandi for theoretically testing the endurance of the **"perfect social man"** in challenging social-cultural, economic-political, and psychological-environmental experiments that humanity interfaced in the **"third cave"** scenario, where the means always justified the ends regardless of the untenable human sacrifice. And, lastly, in the **transitional fourth "cave"**, advances in science and technology hold the promise of defining the **"perfect hi-tech man"** as the product of prosthetics; it attempts to prepare human beings for future productive work, social interaction and creative entertainment. If instrumental reasoning will dictate the condition of mind as it relates to being and becoming, then man will seek technological solutions for his genetic defects, spiritual emptiness and intellectual ineptness. Where the mind's reason and God's passion "failed" humanity, and defunct social experiments yielded ultimate misery, will hi-technology succeed in assuring a sensible destiny for entire humankind?

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Authors

Greg Andonion is professor of architecture at Carleton University in Ottawa, Canada. He has been the founding editor of the RAIC Journal Electric Architect, organized-chaired and edited 50 international symposiums on the Future of Architecture in North America and Europe, and published numerous technical and philosophical papers on Architecture. He is member of the Academy of Arts, Science and Engineering (IIAS).

Ariel Aravot graduated from the Ceramics and Glass Department, the Bezalel Academy of Arts and Design, Jerusalem, in 2020. He completed an internship at the Kayla Talmy's Ceramic Studio in Yuvalim, studied at the Royal Danish Academy of Fine Arts (Denmark) and at the Glass Factory in Orrefors Park (Sweden) in 2019. Specializing in glass blowing, his solo exhibit "In Dialogue" is presented at the Mizgaga Glazier Museum, Nahsholim in 2020/21.

Shujun Ban is an experienced design teacher, working since 2004 in the Department of Product Design, School of Arts and Design, Qingdao University of Technology. Currently, she is a visiting researcher at the Politecnico di Milano for one year. She is a Web Media operator for self-created media brand "Second Air" from 2015 till now. She is the co-editor of #18 of "PAD. Pages on Arts and Design" scientific journal, dedicated to Women's Making.

Pete Evans AIA IDSA is an assistant professor in the Industrial Design department at Iowa State University with over 25 years of industry experience. Pete Evan´s teaching, scholarship and research involve mixed reality (VR and AR) simulation, prototyping, design and communication. He also founded and coordinates the FLEx (Forward Learning Experience) - a mobile design & STEM outreach program.

Marinella Ferrara (PhD) is associate professor of Industrial Design at the Politecnico di Milano. She teaches Product Design and is the Head of MADEC, the Material Design Culture Research Centre in the Design Department. Her research aims to clarify the relationship between design and technology in history and contemporary. Her fields of expertise include other topics, such as design & gender issues, history of design, today making & crafting, design for territory, and the design evolution in Mediterranean aeras.

Mervi Friman (PhD), has worked in administration and research duties at HAMK University of Applied Sciences (Hamk) over 20 years. Nowadays, as a Research Manager, her interests focus on higher education pedagogy and policy, ethics in teaching, learning and research, sustainable development issues in the activities of universities. She has an active role in national and international higher education networks.

Teresa Frodyma received her PhD (2005) in fine arts science from Academy of Fine Arts, granted Ministry of Culture and National Heritage Sholarship in 1991, 2008; specialist in lithography, intaglio print and graphic design; curator of numerous exhibitions; organizer of graphic workshops.

Ewa Grabska received her PhD in mathematics from the Jagiellonian University, and DSc in computer science from the Polish Academy of Sciences, and the title of professor from the President of Poland. Since 2008, she has been a professor at the Jagiellonian University. Her research areas include CAD, graph transformations, visual communication, and computer games.

Iwona Grabska-Gradzińska completed studies in Computers and Polish. Interests embraces both the computer science and humanities – linguistics, visual perception, recognition and reasoning. Works with visual aspects of human/computer communication, aided design and reasoning, as well as computer-aided linguistic text analysis; participates in a project of literary text linguistic analysis. Research assistant in Department of Games Technology of the Jagiellonian University in Kraków, Poland.

Özlem Karakul is an Associate Professor in Faculty of Fine Arts in Selçuk University in Konya; teaches on interior design, conservation of historic settlements, restoration and reuse of traditional buildings. She received B.Arch (1998), M.Sc. in Restoration (2002) and a PhD in Restoration (2011) in Department of Architecture from Middle East Technical University, Turkey. Her main research interests are relations of tangible and intangible cultural heritage, holistic conservation of historic environments, traditional craftsmanship in vernacular architecture of Anatolia and new buildings in historic settings.

Eero Kallio serves as a General Staff Officer in the Finnish Navy. His research interest focuses on the connection between knowledge and skills. During the past two decades he has been working with varied educational and operational design tasks.

Arto Mutanen received his PhD degree in theoretical philosophy from the university of Helsinki. He is Adjunct Professor at the Finnish National Defence University and researcher at the Finnish Naval Academy.

Doctor of Arts **Mirja Niemelä** works as principal lecturer and design teacher at Häme University of Applied Sciences (Hamk). Niemelä teaches design methods such as service design, design thinking and sustainable design. Her background is originally in ceramic design, which she is also teaching at Hamk. Her professional interests are design methods, ceramic design and materials, interdisciplinary collaboration, project work and sustainable design.

Tarkko Oksala is a practicing designer, researcher and teacher in architecture. He is professor (IIAS). He was the central figure in founding the computer-aided design (CAD) lab at Aalto University (former HUT) in 1968 in Finland and later the leader of the post-graduate program in the Department of Architecture. He has received with his teams several prizes in design competitions and written over one hundred papers on design and technology in leading conference venues and publication series. He is co-editor of the book “Knowledge-Based Systems in Architecture”. Today his interest is directed on the promotion of electro-mediative design, art and architecture.

Tufan Orel, PhD is a consultant in design management. He formerly participated as a freelance researcher-consultant at the French National Computer Science Institute (INRIA, Sophia-Antipolis, Nice). He was the co-editor of the International Review, Sciences and Technology of Design (Europia Publishing). He also worked as a researcher in sociology (CEAQ - University de Paris V, René Descartes) and lectured on the history of science at an engineering school for many years (Université de Technology de Compiègne- UTC.).

Andrey Pavlenko is philosopher, specialist in philosophy of science, epistemology and formal ontology. Leading Researcher at the Institute of Philosophy of the Russian Academy of Sciences. Graduated from the Faculty of Philosophy, Moscow State University (1985). Doctor of Philosophy, Professor. Author of 12 monographs and over 200 articles. The main achievements: 1) proved that each empirical theory has a "stage of empirical weightlessness "(1988); 2) discovered a "vicious circle" in the intersubjective justification of knowledge (2010); 3) Discovered the "psematical paradox" in the semantic of G. Frege (2018).

Antony Radford is an Emeritus Professor in the School of Architecture and Built Environment in the University of Adelaide, Australia. He is co-author of several books including Digital Design: A Critical Introduction, Understanding Sustainable Architecture and The Elements of Modern Architecture: Understanding Contemporary Buildings. His recent writing focuses on the concept of responsive cohesion in design, architecture and urban design.

Hiltrud Schinzel is restorer (Magister Artium, Academy of Fine Arts, Vienna, Austria), art historian (PhD, Ruhr University Bochum, Germany) and artist. Artistic media drawing and painting on paper. Research focussed on mediation of arts and sciences, aesthetics. Main book publication: Touching Vision – Essays on Restoration Theory and the Perception of Art, Brussels, 2004 and 2008.

Doctor of Arts **Pirjo Seddiki** is working as a principal lecturer in Häme University of Applied Sciences, Finland. Seddiki has made her doctoral research on aesthetic values and art education in Aalto University (Helsinki). She has written about philosophy of art, applied arts, visual culture, fashion design, methodology of design research and is interested in developing sustainable design education, culture and environment.

Carina Söderlund has a PhD in Innovation and Design. She is a design researcher, focusing on Information Design and Visual Management in work places; and visual communication, technical information and visual rhetoric in work place contexts. She is well experienced in case study and participatory research and has developed methods for collective and collaborative research and design. Carina is also a trained designer in spatial design, and nowadays she works as a senior lecturer at Mälardalen University in Sweden.

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The testimony of the persistence of craft heritage in some cultures, in design practices and in recent craft sensibility of consumers, can help us better understand today's design reality. Meanwhile, it also sheds light on the choice of this special theme – craft, technology, design – for this book. What is more, this theme has brought together a group of scholars, researchers, designers and artisans, allowing them to exchange their points of view and their expertise, and hence find new solutions for the major design challenges of today.

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