Material Designers

Boosting talent towards circular economies

MaDe

MaDe (Material Designers) is a project, co-funded by Creative Europe Programme of The European Union, which aims at boosting talents towards circular economies across Europe. MaDe is a platform, a training program, an award and an event series showcasing and demonstrating the positive impact Material Designers can have across all industry and on the generation of an alternative creative industry aiming at circular economies.

Material Designers are agents of change. They can design, redesign, reform, reuse and redefine materials giving them an entirely new purpose. Increasing the potential of materials, they can go on to research, advise, educate and communicate what materials are and can be in the immediate, near and far future, implementing positive social, economic, political and environmental change across all sectors towards a responsibly designed future.

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Circular Material Fundamentals

1.0

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DIY Recipes: Ingredients, processes & materials qualities

Words by
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1.2

Today there is widespread awareness that the continuous growth of modern societies is driving our planet to collapse. Humans are consuming as if the Earth could have unlimited resources. Since the 1970s, we have set in motion a mechanism by which every year, we consume much more than the Planet can regenerate: the overshoot day, that is the day when we run out of the available resources, always comes earlier. In 2050, continuing like this, it is expected that we will be able to consume the equivalent of the resources of three planets Earth (UN, n.d.). The situation is even more difficult if we think that we have not yet developed efficient reuse and recycling systems.

The current economic model is still mostly linear, following a simple pattern: production -> consumption -> disposal. The idea of managing materials cyclically to increase production efficiency has been known since the early stages of industrialization (Simeone at al., 2019; Fuad-Luke, 2004). More recently, various schools of thought have sought solutions for more efficient management of resources, from cradle-to-cradle design (Braungart & McDonough, 2002), up to biomimicry (Benyus, 2002), which can now be found in the Circular Economy as a holistic framework of good practices. According to Ellen MacArthur Foundation (2012), more recent theories such as performance economy, cradle to cradle, biomimicry and blue economy have contributed to refine further and develop the concept of CE.

One of the first definitions of circular economy says that it is "… an economy designed to be able to regenerate itself. In it, the flows of materials are of two types: the biological ones, capable of being reintegrated into the biosphere, and the technical ones, destined to be revalued without entering the biosphere" (Ellen MacArthur Foundation, 2012). A production system no longer based on the maximization of profits and the hyper-exploitation of natural resources but which re-elaborates all the production phases and follows the five fundamental principles identified by the Ellen MacArthur Foundation: ecodesign, modularity and versatility, renewable energies, ecosystem approach, materials recovery (Ellen MacArthur Foundation, 2012; Weetman, 2017).

Within this new economic model, where the serious and urgent problems of our society must be understood and addressed from a different perspective (Lukens, 2013), design is becoming a fundamental discipline, embracing complexity and facing different variables.

It has been studied that up to 80% of the environmental impact of human products, services and infrastructure are determined in the design phase (Thackara, 2005). The responsibility, therefore, lies mostly with the designers and the design decisions they make, and that shape the processes underlying the products: the use, the materials and the energy needed to make them, how they are managed daily and what happens when they are not needed anymore. Several scholars have recently defined CE as a holistic, restorative and resilient economic model based on innovative projects for the reuse of products and resources, efficient material recovery strategies through closed-loop supply chains and reverse logistics (Sillanpää & Ncibi, 2019; Ghisellini et al., 2016).

Being "circular" is not just a question of reintroducing scrap in the traditional sense of waste into the production cycle, but also to remedy the inefficient use of natural resources, products and materials. It is a question of clearing away the very concept of "waste" and recognizing that everything has a value (Lacy and Rutqvist, 2016).

To this extent, designers need the right training to tackle complex challenges and apply knowledge within multidisciplinary teams in response to the urgent challenge they have to face. One of the significant concerns in implementing the CE principles relates to understanding the flow of materials and the possibilities of reshaping the current state of our society in terms of artefacts and infrastructure. Since the traditional industrial drivers that pushed materials research are no longer valid on all fronts, designers don't have to rely solely on pure science when it comes to material development. In fact, the expansion of the designer's knowledge of materials and processes is fueled by the democratization of technologies, activism and do-it-yourself practices (Anderson, 2014; Bettiol & Micelli, 2014; Tanenbaum et al., 2013).

In recent years, many initiatives based on DIY practices (Fox, 2014) have flourished around the world. These also concerned professional design and not just the world of amateurs. In fact, the designer took the opportunity to acquire control of the entire design process by developing material artefacts autonomously.

Kotler (1986) defines do-it-yourself as an activity in which individuals employ raw and semi-raw materials and parts to produce, transform, or reconstruct material goods, including those obtained from the natural environment. When designers faced this growing trend related to self-production and focused on the material dimension, a new class of materials was born, known as do-it-yourself materials, DIY-Materials (Rognoli et al. 2015).

The development of DIY-Materials by the designer arises from a personal propensity of the individual towards experimentation, and it grows, changes and improves through experience and the reiteration of a process that evolves through trials and errors (Rognoli et al., 2017). In the self-produced material development where the development ends before the start of the industrial production of the same, in the self-produced materials the specifications are finalized as late as possible, allowing for further refinement and reiteration of experimentation. It is a process of design through making which demonstrates obvious parallels with crafts practice (Yair et al., 1999).

From the analysis of the many case studies and considering the various experiences made at an international level, we can state that it is undoubtedly possible to outline general guidelines that describe the main phases for the development of a DIY material.

The purpose of this chapter is precisely to identify the primary and fundamental steps necessary for a designer to develop a material draft that is configured as a DIY-Material.

Furthermore, we also want to contribute to the definition of the figure of the materials designer, as a new model that is emerging in the professional context.Material designer is a professional able to manage the complex role of materials in the design process, focusing on the right material qualities or properties or even design them, incorporating today also a CE design approach. Facing new materials developments, the material designer is called to face the challenge of tackling the material project as a whole, starting from the selection of the sources and developing a comprehensive strategy in which material drafts are created, designed and improved.

Most of the time, the designer's motivation to undertake a path of material experimentation is attributable to the sensitivity and desire for alternative and more sustainable solutions, with the aim of replacing those used today by industry in an inappropriate way for human health and the environment. The exploration of alternative solutions leads the designers to evaluate new sources, often considering waste or the abundance of natural materials as the starting point of the material development process. This approach stimulates designers to acquire a global and systemic approach to the project, which can also help to reach the tracks of the circular economy and achieve its goals.

03 THE IMPORTANCE OF MATERIAL DRAFTS AND MATERIALS DEMONSTRATORS

Designers have started experimenting with matter from the most disparate sources, by generating increasingly sophisticated material development processes, oriented to the creation of material drafts and shaping material demonstrators. These demonstrators have the purpose of making the superficial and formal qualities of the hypothetical material perceptible and concrete, to further direct the experimentation and give impressions and new ideas. Material demonstrators are obtained quickly and do not require many investments, sophisticated tools or processes. However, they are also beneficial for undertaking actions of speculation and critical design, pushing the designer to create scenarios and visions and foresee their future application.

As argued by scholars (Barati et al., 2016; Parisi et al. 2017) material demonstrators are useful for frame and communicate material knowledge between materials experts, designers and users. The material drafts and the demonstrators offer the designer the opportunity to tinker and learn interrelationships between processing, control and experiential qualities directly, ensuring a broader understanding of the process leading to certain features than a finished, ready-to-use sample can do. Furthermore, demonstrators facilitate communication because they carry evident traces of the process. They tell us where they come from and what their history is because they readily convey information about processing which is difficult to find in standard samples.

Scholars also claimed (Parisi & Rognoli, 2017; Barati et al. 2017), the material drafts and demonstrators are able to support creative thinking and directly orient the design choices. Buchenau and Suri (2000) coined the experiment "Experience prototyping ", which is a form of prototyping that allows both designers, but also users and customers to gain a first-hand appreciation of existing or future conditions through active involvement with prototypes. This approach is used to facilitate various activities during the design process, including understanding, exploiting and communicating the experiential aspects of design and predicting the use of the future artefact.

The propensity of designers to create initial representations of their ideas and insights can be very useful in developing materials in which multiple stakeholders are involved, including materials scientists, engineers, biologists and design researchers (Barati et al., 2017). Despite the approximation that is duly inherent in this approach, creating demonstrators and the material draft is also useful for sharing paths and design purposes for the entire project team, providing them with the opportunity to experiment by making and directly creating new hypotheses, on the appearance and feel of the material and changes in the course of its development.

Material drafts are samples that come out directly from the material experimentation phase, focused on understanding the adequacy of the chosen sources and the correct use and dosage of the components. In this phase, the focus is on the sensory qualities of the future materials and those colours and elements to create textures, transparencies and chromatic effects. Material demonstrators are therefore slightly more advanced prototypes, in which the experimentation phase focuses more on the formal potential and feasibility of future processes, experimenting with potential forms and techniques (Rognoli and Ayala-Garcia, 2020).

04 THE MATERIAL DEVELOPMENT PROCESS

We have defined DIY-Materials as materials that arise from an individual or collective self-production activity, often through techniques and processes of the designers' invention, as a result of a tinkering process with materials. DIY-Materials can be new materials with creative use of other substances as material ingredients, or they can be modified or further developed versions of existing materials (Rognoli et al., 2015).

Within the framework of the material experience (Karana et al., 2014), DIY-Materials have been described as carriers of unprecedented and promising material experiences for the future panorama of materials for design. We also investigated their aesthetic potential (Ayala & Rognoli, 2017) and their propensity to become bearers of social innovation (Rognoli et al., 2017). Now, we intend to explain in broad terms how the development path of DIY-Materials takes shape. The main phases of the self-production process can be summarized in four steps:

(I) Taking into consideration the material context in which the designer wants to move and select, choose and study of its source;

(II) Exploring through tinkering, as practical, creative experimentation on materials, fundamental for experiential learning related to the material itself.

(III) Experimenting self-production processes and developing material drafts;

(IV) Evaluating the material drafts that are evaluated and chosen to be transformed into material demonstrators. This further step of experimentation leads to reflection on possible applications or new rounds of experiment.

The Material Designer often begins to conceive the material draft by thinking about a source or selecting the appropriate source (Ayala-Garcia et al., 2017). The choice or the opportunity of the sources guides the experimentation as it directs the material designer on a particular type of ingredients. Then the material designer starts a manipulation process for understanding the properties and qualities of materials, learning the constraints and recognizing their potential (Parisi et al., 2017). Also, as the material draft begins to take shape, material designers start a more systematic process of getting the various potentials of materials and open to imagine material demonstrators. The designers are fully aware of the capabilities and potential of the new material, and tuning becomes significant (Karana et al., 2016). Finally, the designer proposes a vision of what the material can become, its future conditions and possible uses. Imagining through storytelling will help to realize future applications with the material (Celi & Rognoli, 2017). Storytelling will also help communication to make the proposed solution acceptable, and the definition of a potential speculative path provides valid indications for the progress of the project using this material.

At this point, it is essential to point out that this path of material development is not linear, but reiterative as a cyclic process. Even after the imagination phase, the Material Designer can plan to consider new sources or alternative transformation tools and can begin another cycle of material development. Sometimes the cycle starts with a previous tuning result or previous work on a material source.

It is essential to emphasize that the path we illustrate in this chapter responds to the need to provide the primary and fundamental steps useful for a material designer to develop a material draft, although there is no single or consolidated method of dealing with materials developed for the field of design. By following this cycle of four iterative steps, however, it is possible to obtain a potential material draft consistent with the CE approach quickly and effectively.

Each designer then explores, creates and personalized his/her own research path. Having supported the material-focused research of hundreds of students and designers in international contexts, we can suggest guidelines, defining the main shared and helpful steps for a material exploration that could lead to its redesign or reuse in new circular applications.

05 INGREDIENTS SOURCE AND SELECTION

The initial choice of the source for the development of the material is a very delicate phase, which will affect the whole process and future considerations. However, as a free choice, the Materials Designer can consider any source to start from.

Observing the emerging phenomena and the different case studies available (Rognoli et al. 2015), it is easy to note that the selection of a source is usually motivated by the desire to find the answers to the many looming and increasingly evident problems in our planet. For this reason, experiments are very frequently conducted on waste materials, food leftovers or organic, renewable and biodegradable materials. Designers tend to adopt a systemic approach, in order to understand the complexity of the life cycle of the material, and its possible reintegration into new productions, leading to a subsequent industrial symbiosis.

An important task is to understand the different sources available based on this new materiality, which has been classified by various scholars in different ways (Thompson, 2013; Lee, 2015; Pellizzari & Genovesi, 2017; Solanki, 2018; Franklin & Till, 2019). Ayala-Garcia (2019) introduced the classification of kingdoms, a precise system for identifying a potential source for DIY-Materials. This classification refers explicitly to the kingdoms of life proposed by Linnaeus in his Systema Naturae (1735) and divides the different sources that can be obtained from natural or industrial resources (Rognoli & Ayala-Garcia, 2020; Ayala-Garcia et al., 2017).

THE KINGDOMS

→ Kingdom vegetabile: the primary source of this kingdom comes from plants and fungi. The self-produced material drafts that belong to this kingdom are also made through growing or cultivation techniques.

→ Kingdom Animale: includes sources derived from animals and bacteria. The development of self-produced material drafts often takes place in collaboration with live organisms or using ingredients of animal origin, such as hair or bones.

→ Kingdom Lapideum: the sources include minerals: stones, sand, pottery, clay

→ Kingdom Recuperavit: includes all sources which, although mostly considered waste, can be turned into a valuable resource.

→ Kingdom Mutantis: includes different sources related with technologies and hybridization with interactive elements (with the help of open-source electronics) or intelligent sources, such as the transfer of ownership, the exchange of energy or the exchange of materials.

Once the material designer has identified a source and has a reference in the classification of kingdoms, the main and significant characteristics of these sources can be researched: aesthetic aspects or intrinsic properties will influence the entire design process. The availability of the source also becomes a crucial element of the whole process, as it is essential

to have a sufficient quantity to carry out the experiments and to think in terms of material flows for a circular economy.

Within this phase the designer should try to know the material origin and its life cycle as thoroughly as possible, thus letting the experimentation follow according to sustainability requirements. The fundamental rules of the material flow in a CE, as Ellen Mc Arthur Foundation explicitly stated, want the starting source to be returned in its original cycle, keeping it natural and biodegradable if from organic origin, while recyclable if from a synthetic origin. From an aesthetic point of view, the primary source may still be visible, influencing technical characteristics and supporting the storytelling of the novel developed material.

In some recipes formulated by professional designers participating to Made project, the original material can be fragmented, becoming a filler to be aggregated with binders to create a new one, as we can see in the work Eggshell Ceramic by Laura van de Wijdeven. Here the eggshell, according to the size of fragmentation, gives different colors and textures to the final material. The grain size of the filler not only affects the aesthetics of the new samples but also different technical properties such as brittleness, elasticity, hardness and weight. The important thing to remember when using the starting material as a filler is the fact of inserting it in the recipe only when well dehydrated, in order to prevent the formation of mold. There can also be a choice to further separate the matter, in the case of a composite material, or to re-use the starting material as it is, experimenting more with assembly methods and already winking at possible applications as shown in the project PosiBalls by Andrés Ramírez, where the action of sea waves has already transformed the residue of Posidonia algae into soft spheres.

06 MATERIAL TINKERING

Once the material has evolved and the designer sees a potential, a new phase of optimization and tuning occurs. The main question (with infinite answers) regards the possible processes through which the designer wants to develop the new material. Depending on the designer's knowledge and interdisciplinary approach, a vast range of possibilities will, at this point, shape new material samples at each new cycle of experimentation in a reiterative process of discovery. Taking precise notes of the recipes and tested processes is crucial to replicate the experiments and their outcomes. Any sample obtained, even the failed ones, will contribute to build a refined knowledge of the starting material and how it can be transformed; as stated by the designer Rosie Broadhead (author of the project Magnesium Bikini) "Through experimentation and developing these magnesium composite materials, I was able to understand its function and properties". This reiterative learning enables the designer to master the recipe/process better at each new attempt, with a trial and error cognitive process, almost in a sort of Darwinian selection of the best suitable solution (Rognoli et al., 2017).

Even in this phase, learning from one's own mistakes is essential. To give a common example, with moist organic matter, at the basis of many bioplastic recipes, problems such as breakages in the drying phase or the presence of mold over time should be expected on the agenda. Using small tricks like working with always well-dried compounds, paying attention to the correct ratio of liquid ingredients or the inclusion of vinegar in the recipe, may help manage mold in moisty recipes. Cracks or deformation of the sample due to the contraction of the material during the drying phase can also occur easily, in this case hygroscopic fillers or fibers could help to reinforce the basic recipe. Depending on the percentage and granulometry of the added filler its function will be purely aesthetic or structural. A conscious exploration of different features, textures, colours, composition, or a combination of material samples will enhance the material, affirming its identity and eliciting a particular material experience.

Part of the material's identity is related to its behaviors when it becomes a solid volume or a hollow shape, accordingly, exploring volumes and shapes is fundamental for the development of the material. It is a refined step that requires knowledge about the many ways industry and crafts shape, join, and finish things. The different demonstrators and studies of various processing techniques bring the material closer to its possible applications.

Moreover, once the material development has reached a mature stage, it is of great help to perform necessary characterization tests. Any macroscopic techniques such as mechanical testing, thermal analysis, or density calculation will allow the designer to obtain advanced information about the obtained material. Manzini suggested that new materials don't necessarily come from research centers and laboratories (1986, p. 42), this is especially true for DIY-Materials, however, once a certain level of definition has been reached, laboratory tests could confirm the designer's first rough tests and be supportive in presenting the project to the market.

07 MATERIALS ENVISIONING

The experimentation process will produce various material draft samples; during their aesthetical and technical evaluation the designer will probably start making speculations on its applicability. The material drafts, as well as speculative artefacts, create the possibility of thinking about them and can be defined as generators of possible worlds. The designer today is increasingly inclined to look at material samples as a set of properties and qualities to be explored. Material samples can be defined as speculative since they are like drafts, still open and available for experimentation; they allow the materials designer to conceive and imagine alternatives, starting from a material that is not entirely imaginary but has roots in reality and that can evolve into meaningful and preferable material experiences. Material drafts can be speculative also trying to anticipate and create scenarios and visions of future and new material scenarios. In this phase, the timeline in which to place one's project depends on the feasibility glimpsed in the samples and by the designer's choices, in some cases going closer to speculative design (e.g., Digital Lichen by Davide Piscitelli).

Furthermore, it is also possible to speculate on the past. Materials can also look to the past to shape new possibilities for the future. Here storytelling can play an important part in the project's description: being at the very heart of human cognition, interactions and cultures (Beckman & Barry, 2009), the field of design uses storytelling as a tool to describe the creative process. When it comes to materials development, some designers adopt this technique to tell how they achieve a particular material. Unlike traditional material science, where material development is often explained based on performance, Material Designers through envisioning can show experiential qualities and physical characteristics emerged during the process, recording, with different media, the project's main steps and evolutions. Regardless of the trajectory, the material project will take a valuable set of available samples may help build up a story. The storytelling can also focus on how this material will open doors to new applications, in contrast with the current state of product development and mass consumption, highlighting the drivers and motivations behind the project, the sources of inspiration, tools developed, and tests performed.

08 CONCLUSIONS

As we said in the introduction to this chapter, the designers have demonstrated their will to find alternative ways of developing materials for design. They highlighted how they too could play a role in the process of generating new material solutions, applying creativity and collaborating with multidisciplinary teams. The most interesting contribution is related to the identification of alternative sources, and the ability to understand in advance their potential both from an expressive and functional point of view, considering the environmental issue as a requirement.

With this work, we wanted to try to identify the primary and fundamental steps necessary for a designer to develop a material project that is configured as a DIY-Material. Furthermore, we aspired to contribute to the definition of the figure of the materials designer, intended as a model that is emerging in the professional context.

In recent years the materials designer has been compared to an alchemist (Lee, 2015) able to transform components to obtain a more precious element. Materials designer was also considered as a chef with the sensitivity to find authentic ingredients, to mix them originally and to elaborate real recipes. The culinary metaphor (Humier, 2012; Dunne, 2018) is now widely recognized and used in the field of DIY-Materials and in fact, we talk about DIY recipes precisely to indicate how the designer can design the procedure, understood as a sequence of steps, to obtain the final material. The concept of the recipe is also useful to recall the fact that, as happens with ingredients in cooking recipes, even materials can be modified, customized and improved. Each has its own essential cookbook, and the recipes can be handed down.

In this chapter we have tried to outline the main phases that all DIY recipes have in common, emphasizing the role of the materials designer as a figure who is also able to manage the complexity of the circular approach.

To conclude, we want to underline that also during the development of the Made project, it was essential to recognize the creativity of the designers in choosing of primary sources, their imagination in designing the procedure and therefore the recipe, and the efficiency in communicating, supported by the storytelling of the entire DIY-Material project.

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