Title: DIY-Materials. Technological approach of materials for design

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Abstract

In recent years a new class of materials emerged, the DIY- materials, based on the direct experimentation carried out by the designers. In the present paper, the specific class of DIY-materials integrated with technology has been analyzed, with a specific focus on the induced "mutations". Three main categories have been distinguished: Industrial Mutations, Interactive Mutations and Material Mutations.

Keywords: DIY-materials, technological integration, hybrid

Background

The techno-scientific development of the last few years, together with the democratization of the transformation processes of the material, has led the designers to approach the world of materials through research and direct experimentation. Besides, the phenomenon of cross-fertilization, which is the hybridization of knowledge and the intersection of skills that also pertain to other disciplinary fields, has contributed to the generation of unprecedented associations between materials and technologies.

Do-It-Yourself practices have extended from products to materials (Brownell, 2015); in this sense, we talk about DIY-Materials and, therefore, of materials that move away from industrial processes and that are made through self-production processes. Depending on the case, these can maintain the characteristic of artisan products, or the artisan phase can be limited to their conception. In contrast, with subsequent development and engineering phases, they can be made in the context of industrial production. DIY-Materials are not developed and designed with the sole purpose of replacing industrial materials because, if it happens, this will be a long and perhaps even expensive process.

What interests us here is the emergence of this exciting phenomenon, which introduces a new dimension in the relationship between designers, technologies, production processes, sources, and materials. This "new class" of materials collects those examples conceived and produced by the designer, and their development is characterized by a low-cost approach for both resources and production processes. (Rognoli et al., 2015).

In these types of self-made materials, it is possible to find some examples where the hybridization between technology and matter proposes new alternatives to mass consumption. The role of technology, when embedded in the material, improves interactions: active, reactive, analog, or digital (Parisi et al., 2018). Therefore, the usability of the material improves over time. The usability of the material, when considered

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when configuring any artifact or product, enhances the probability that the use expands over time and does not become disposable in the short spam.

According to Karana, Pedgley, and Rognoli, Materials experience' is the experience people have with and through materials (2014). When a design project starts from the material, the chances that the experiences the material sparkle pass through the product increases. This means even more when the material embedded technology sparkles any performative experience or interaction (Giaccardi & Karana, 2015).

The DIY-Materials research introduces new operational paradigms that allow a renewed approach to the culture of the project, at different scales, from that of architecture to that of the industrial product. This approach is based on the collaboration and interaction of different disciplinary skills and configures a new material culture that optimizes performance and systems in a sustainable perspective.

DIY-Materials Kingdoms

DIY-Materials have been classified into five categories (Ayala-Garcia et al., 2017), also called Kingdoms, which are inspired by the first biological classifications of the XVII century (e.g., the work of the Swedish botanist, zoologist, and physician Carolus Linnaeus called Systema Naturae (Linnaeus, 1758). Linnaeus published what became for many years the standard biological classification of elements of earth, known as the Linnaean taxonomy. The kingdoms of DIY-Materials are:

(1) Kingdom Vegetabile: When the primary source for a DIY-Material derives from plants and fungi, we categorize the material under the Kingdom Vegetabile (note that we have maintained the original Linnaean taxonomy where "fungi" was classified in the XXIV Class Cryptogamia).

Materials under this kingdom differ from the others, mainly because they are made through growing or farming techniques. Designers who create materials under this category often collaborate with, for example, farmers and biologists.

(2) Kingdom Animale: It refers to all material sources derived from animals and bacteria. Note that bacteria were not yet discovered when the Linnaean taxonomy was published, but due to its behavior as a living organism, we inserted it into this kingdom. Those materials can be developed either by collaborating with alive organisms or by using parts of the animals, like hair or bones.

(3) Kingdom Lapideum: It contains all DIY-Materials which are made from minerals: stones, sand, ceramics, clay, etc. Many existing cases combine ingredients from other kingdoms, such as wool or cotton fabrics, but in a lower percentage compared with the main constituent. Another feature in this kingdom is its strong link to crafts, probably because these types of materials have a long tradition in our material culture.

(4) Kingdom Recuperavit: It includes all sources which being considered as waste, yet can be transformed into a valuable resource. They often come from plastic, metal, or organic waste, sometimes as side products of industrial production.

(5) Kingdom Mutantis: It includes the DIY-Materials created utilizing diverse technologies and hybridization of Industrial, Interactive (with the aid of open-sourced electronics) or smart sources [like property changing, energy exchanging, or matter exchanging materials (Ritter, 2007)]. Mixes of different material sources that come from other kingdoms and evolve into a specific material with the aid of technology are also included. This hybridization represents a significant change of paradigm compared with other kingdoms.

Kingdom Mutantis

This article focuses particularly on the Kingdom Mutantis category. It presents a collection of significant case studies applicable to different scales of products, from wearable ones that represent an extension of the corporal and emotional dimension of users to those for the built environment, in which the materials act as urban interfaces.

Therefore, Kingdom Mutantis includes materials of different origins, often coming from another Kingdom, which has evolved with additions of technological elements.

According to the field of biology, mutations play a role in both normal and abnormal biological processes of life, including evolution. Some mutations are hereditary, which means are passed down from a parent to its offspring, while some other mutations occur by the exposure to particular environmental conditions. It is common to see in the fields of biology and genetics how these variations appear by errors or changes of a specific code inside any natural building block. In design, this is likely to happen as mistakes and code changes are infinite sources of innovation. One of the more recognizable characteristics of the designer's way of thinking is to consider errors as part of the process. Learning from them or enhancing something that went "wrong" sometimes could lead to unexpected results. These outcomes will hardly appear by following a linear chain of thoughts and experiments, typical from STEM-related fields. According to Rognoli et al. (2015), imperfection, dynamism, and self-production are three strategies to address a materials experience. In the DIY-Materials theory and this kingdom, in particular, this combination of strategies evidence unique results.

Either by hereditary transmission of material characteristics or by the influence of environmental conditions, in this section, different mutations that are leading to exciting results of DIY-Materials are presented.

Kingdom Mutantis is divided into industrial mutations, interactive mutations, and material mutations.

Industrial Mutations

Hacking, a word with its origins in the German name Hacken. is a fantastic definition to explain the way of intervening, unmounting, or cut into pieces a particular structure or system. Hacking is a word misinterpreted by many as it connects with the illicit behaviors of some software programmers. In the materials domain, the hackers are the same artisans and bricoleurs, who learn by unmounting and transform by changing the core behavior of a machine or a particular tool, to achieve a result. In the words of Stefano Micelli (2011), the real value of an artisan, compared with an industry worker, relies on its capacity to domain its craft. It is a result of constant improvements in its tools and machines (p. 22). Designers who have access to tools and machinery of different kinds, can create improvements and change behaviors of the devices by introducing new techniques. This process leads to achieving new materials and, subsequently, original products with particular languages. Gaetano Pesce was one of the first designers to take advantage of machine errors, and some of its masterpieces are the result of hacking a specific machine to obtain uniqueness and novelty. Pesce highlights a productive scenario in which the factories are open to self-production and serves creativity (Martino, 2007 p. 31). Following his steps, some contemporary designers transform processes to obtain unusual DIY-Material mutations. Oskar Zieta from Poland creates objects with a balloon-like metal material obtained by welding and blowing metal sheets. The designer developed a new technology called FiDU, which stands for the German 'Freie Innen Druck Umformung,' or free inner-pressure deformation. To obtain a shape, one may first cut a pair of one-millimeter thick metal sheets then weld them on the edges. With the aid of water and air pressure at approximately 0,4 bar, the desired shape starts to form. What is interesting about this technique is to see how a solid and robust material like steel can suddenly be perceived as lightweight and crumpled like paper (figure 1 bottom).

Mx3D is another example of a technological mutation. Developed by Joris Laarman from the Netherlands, this hybrid technology combines an industrial multiple axis robot with a welding machine. The resulting material is a printed 3D metal that can be shaped in different ways. Several types of metals can be processed with this technology allowing designers to create different solutions with a particular aesthetic language (figure 1 right). The metal printers originated from the desire to obtain shapes bigger than the box of a standard 3-D printer, and this technological push is allowing the designer and the new team of partners to develop architectural scale projects.

Sebastian Straatsma evokes the work of Gaetano Pesce of the serie diversificata (op. cit.) with objects composed with material errors and mixes produced by altering a machine called abstract (figure 1 left). The idea of Pesce to research the new typologies of construction and new production instruments where imperfections make an accountable value has been a topic of inspiration for some designers, especially when the "errors" provide uniqueness. These unique shapes, colors, and finishes are complicated to obtain with controlled standard manufacturing processes.

Interactive Mutations

Thanks to the integration of disciplines and theories between Computer Sciences and Design with the contributions of Bill Moggridge and Bill Verplank in the eighties, the idea of interaction became relevant in the field of design as it highlighted the importance to focus on behavior (Cooper et al. 2007 p.xxviii). Ezio Manzini connected this idea of behavior with the materials also in the same decade (Manzini, 1986 p. 44). Still, equal to what happened with Moggridge and Verplank's theories, almost a decade passed before their concepts were understood. The field of interaction design provided essential tools to intervene in the behavior of materials by programming and controlling properties and qualities. The advent of open-source circuit boards, which started with Wiring, Arduino, or Raspberry some years ago, allowed designers to control materials behavior and activate interactions between people and the material. It is still a material design approach facing an embryonic stage. Some technological advancements may happen before these circuits, and computational capabilities could be embedded in the material. However, different designers are manipulating properties with the aid of these tools and envisioning alternative futures.

Karmen Franinović from Croatia and her research team experiments on the threshold between the mechanics, chemical and electronics. The results are materials that illuminate, sound, and move when electric currents pass through. Membrane structures called Electroactive Polymers suggest a new kind of responsive behavior thanks to the soft and organic movement (figure 2 left). Franinović calls these materials enactive, which explores notions of agency, materiality, and interactivity altogether.

Magnetic fabrics is a project undertaken by the designer Lilian Dedio. Arranging magnetic components in various patterns inside a textile, the material gains life with the aid of media and electronics (figure 2 bottom). When the magnet reacts to a stimulus, the textile begins to move to create dynamic behavior. The visible part of magnets over the textile creates a unique aesthetic language that changes over and over when the entire material is in movement.

Anna Vallgårda, Linnéa Nilsson, Mika Satomi and Linda Worbin from Denmark experiment with a type of materials they call computational composites. These materials are the result of blending any standard material with a computational layer, which shows some desirable properties that can be controlled by the matching of both sources of the composite. In the project IRE möbel footstool, Vallgårda, and her team developed a woven cotton textile embedded conductive thread on one side, and a color print pigment with thermochromic ink on the other (figure 2 right). The conductive threads are resistive enough to heat up when current is let through, enabling a color change in the print through controlling the current.

Material Mutations

Material hybrids and composites are one of the four categories of so-called engineering materials. Inside this category, it is possible to find a whole universe of materials composed of two principal elements with specific properties or characteristics to add to the composite: The matrix and the reinforcements. Sometimes they can include a third element called the core. The development of composite aims to obtain an improved material with augmented properties compared with the original matrix material (Cornish, 1987 p. 135). Recently designers have embarked on similar quests for hybridization and compositions of two or more elements. Probably the aim is not one of the engineers seeking for exceptional performance, it is also research on sensorial improvements. These mutations resulting from the mix of two or more base materials, different from composites, evolve into new material languages capable of envisioning future applications challenging to imagine before.

Martin Pohlman, Julian Schwarze, and Johannes Wöhrlin from Germany have developed during their studies at the materials design institute in Offenbach, a material called Paralightskin (figure 3 right). This hybrid material combines the performative properties of silicone with the haptic and visually appealing characteristics of leather. Parametrically designed and cut, the leather adapts to the shape of the composite, and the silicone pops up in different open spaces to provide visual feedback as a response to touch and pressure.

Elisa Strozyk from Germany experimented with a wood veneer of 0.6 mm, laser cutting it, and manually arranged the pieces over a support cotton fabric. The result is a flexible wooden surface with appealing aesthetics and tactile experience. Wooden Textiles are in the boundaries between hard and soft. They have the familiarity and appearance of natural materials but, at the same time, surprise, as the wood can move and form in unexpected ways (figure 3 left).

Conclusions

The DIY approach to materials, therefore, together with technological integration, allows designers to re-seize the cultural, sensorial and communicative dimensions of the material, to intervene in the realization processes and to manage the "immaterial" technological aspect.

Through direct experimentation on materials, designers are encouraged to use technological elements, to integrate them with different types of sources and to prefigure in this way new scenarios, not possible to imagine following a conventional design method.

The spread of this type of approach and the constant growth of this type of materials is generating a new material culture in which language becomes increasingly complex. In particular, the DIY-Materials, belonging to Kingdom Mutantis category, show an ever stronger hybridization between matter and technology. The combination and the technological integration make these types of materials reactive to the environment and therefore smart.

A material that embedded technology is very different than a technology product, created specifically to fulfill a very specific task and whose parts are easily distinguishable.

The design of a DIY-Materials of the Kingdom Mutantis category expands the possibilities of designing and prefiguring new worlds, with new types of uses, interaction and desires.

References

Antonelli, P. (2008). *Design and the elastic mind*, Museum of Modern Art, New York.

Ayala-Garcia, C., Rognoli V. (2017). "The new materials aesthetics. DIY Materials as triggers of new sensorial experiences." *The Design Journal*, volume 20, 2017 - Issue sup1: Design for Next: Proceedings of the 12th European Academy of Design Conference, Sapienza University of Rome, 12-14 April 2017, edited by Loredana Di Lucchio, Lorenzo Imbesi, Paul Atkinson,

ISBN 978-1-138-09023-1, pp. S375-S389

Ayala-Garcia, C., Rognoli, V., Karana, E. (2017). "Five Kingdoms of DIY Materials for Design." *In Alive. Active. Adaptive: Proceedings of International Conference on Experiential Knowledgeand Emerging Materials* (EKSIG 2017), June 19-20, Delft, the Netherlands, pp. 222-234.

Brownell, B. (2015). "DIY Design Makers Are Taking on Materials. Retrieved" available at https://www.architectmagazine.com/technology/diy-design-makers-are-taking-on-materials_o

Cooper, A., Reimann, R., Cronin, D. (2007). *About Face 3: The Essentials of Interaction Design.* Indianapolis, Indiana: Wiley.

Cornish, E. H. (1987). *Materials and the designer*. Cambridge: Cambridge University Press.

Giaccardi, E., Karana, E. (2015). "Foundations of Materials Experience: An Approach for HCI." *CHI'15 Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 2447-2456).

Karana, E., Pedgley, O., Rognoli, V., (2014). *Materials Experience: Fundamentals of Materials and Design*. Amsterdam: Elsevier.

Linnaeus, C. (1758). *Systema naturae per regna tria naturae: secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis* (in Latin) (10th ed.). Stockholm: Laurentius Salvius.

Martino (2007). *Gaetano Pesce. Materia e differenza.* Milano. Marsilio.

Manzini, E. (1986). *La materia dell'invenzione*. Milano: Arcadia.

Micelli, S. (2011). *Futuro artigiano: l'innovazione nelle mani degli italiani*. Venezia: Marsilio.

Parisi S., Spallazzo D., Ferraro V., Ferrara M., Ceconello M., Ayala-Garcia C., Rognoli V. (2018). "Mapping ICS Materials: Interactive, Connected, and Smart Materials." In: *Karwowski, Waldemar, Ahram, Tareq (Eds.). Intelligent Human Systems Integration, Proceedings of the 1st International Conference on Intelligent Human Systems Integration* (IHSI 2018): Integrating People and Intell gent Systems, January 7-9, 2018, Dubai, United Arab Emirates, Volume 722 of the Advances in Intelligent Systems and Computing series, ISBN 978-3-319-73888-8. pp.1-7

Ritter, A. (2007). *Smart materials in architecture, interior architecture and design.* Basel: Bikhäuser.

Rognoli, V., Bianchini, M., Maffei, S., Karana, E., (2015). *DIY Materials. Materials and Design*, 86 (2015), 692-702.