Open design for Industry 4.0

Caro Franzato Universidade do Vale do Rio dos Sinos – Unisinos
cfranzato@unisinos.br

L'articolo analizza i cambiamenti del design nello scenario delle tecnologie dell'informazione (IT), dell'Industria 4.0 e della conseguente integrazione dei sistemi di produzione e consumo. Analizza gli effetti delle evoluzioni sociali e tecnologiche sulla pratica disciplinare e, assumendo la rete come il paradigma organizzativo caratteristico del contesto attuale, definisce il concetto di reti di progetto. Attraverso la presentazione di diversi casi, l'articolo descrive l'open design, uno degli approcci più usati nelle reti di progetto, esaminando il contributo che svolge nella quarta rivoluzione industriale. Infine, l'articolo discute i ruoli che il designer assume: designer-imprenditore, specialista della cultura di progetto e metadesigner.

Tecnologie dell'Informazione, Industria 4.0, Reti di Progetto, Open Design, Ecosistemi Creativi

This article analyzes design changes in the scenario of Information Technology (IT), Industry 4.0 and the subsequent integration of production and consumption systems. Taking the network as the organizational paradigm characteristic of current conditions, it defines the concept of design networks and analyzes the effects of social and technological developments on practice. Through the presentation of different cases, it will also describe open design as one of the most common approaches employed in design networks by examining its contribution to the fourth industrial revolution. Finally, this article discusses the roles that the designer takes on: designer-entrepreneur, design culture specialist and metadesigner.

Information Technology, Industry 4.0, Design Networks, Open Design, Creative Ecosystems.

C. Franzato Orcid id 0000-0001-7666-7037

ISSN 2531-9477 [online], ISBN 978-88-85885-00-4 [print]

Design networks: from participatory to open design

Beginning in the 1970s, in a process of mutual influence and inspiration between the emerging information technology (IT) and its socio-economic context, the network has today become an indispensable paradigm for describing an ever-growing number of organizational and professional macroeconomic relations (Castells, 2010).

In a parallel evolution, collaborative relationships in the development of design processes have been multiplied. Especially with the computerization of work environments that took off in the seventies, designers, mainly in Scandinavia, began to interact with communities of workers for the purpose of reconfiguring work spaces, equipment and activities (Bødker, Kensing, and Simonsen 2004; Sanoff, 2007). Participatory design, which developed alongside these activities, can mainly be characterized by ethical principles that allow for genuine participation by the actors involved through mutual learning and social equity (Bødker, Kensing, and Simonsen, 2004). From an operational point of view, however, this is especially characterized by the many collaborative relationships that are intrinsic to and engendered by the process.

In these pioneering cases, design activity takes place *on* information and communication technologies. With the effective computerization of the workplace and the advent of the internet, however, these technologies come to mediate collaborative relationships, i.e., design activities begin to occur *through* them. Thus, opportunities for collaborative relationships increase exponentially and the web of design relationships becomes more dense and intricate. Today the process can occur in different spatiotemporal contexts. As can be seen in matrix 1, proposed by Johansen in his work on groupware (1988), computer-supported cooperative work (CSCW) can occur with the participation of the various actors involved: a) in the same space at the same time (local, synchronous interaction); b) in the same space at different times (local, asynchronous interaction); c) in different spaces at the same time (remote, synchronous interaction); and finally d) in different spaces at different times (remote, asynchronous interaction) [fig. 01].

By necessity we design together in a very broad network of interconnected actors directly and/or indirectly through analog and digital devices, hardware and software. Note that each interface is not neutral but has its *actancialité*, as Bruno Latour shows us (2007). Each link, including those operated by artificial intelligence or simply mechanically, involves a translation process, of the order of language or of the operation itself, such that, from one agent to another, significant transformations or true

CSCW Matrix	Same time (Synchronous)	Different times (Asynchronous)
Same place (Co-located)	Face-to-face interaction (e.g., activities related to on-site meetings, with the physical presence of the participants)	Continuous task (e.g., individual activities in the general workgroup plan, but also activities related to team room communication)
Different place (Remote)	Remote interaction (e.g., activities related to online meetings – video-conferences, calls, instant messaging – or parallel work sessions)	Ongoing communication and coordination (e.g., activity related to project documentation, project management and general communication)

01

01
CSCW Matrix (adapted from Johansen, 1988)

deviations occur. Furthermore, each translation process involves a successive process of interpretation, or in other words, further transformations or deviations. According to Lévy «the technique, even the most modern, employs cobbling together, reuse and deviation. It is not possible to utilize it without interpreting, metamorphosing. The being of a proposition, of an image or of a material device, is determined only by the use of them and by the interpretation elaborated by those who get in touch with them» (1992, p. 238, translated by the author).

Thus, contemporary design can and indeed should be read by means of the network paradigm. The expression "design network" refers to the form of design organization that opens innumerable, diverse, dynamic, variable, synergetic and antagonistic relationships within the creative ecosystem. Such a network is elaborated through a specific way of designing: the expression "open design" refers to an open system of processes that flow continuously and unpredictably throughout the ever-changing design network, related to other open systems of processes and to the creative ecosystem as whole. In this understanding, design no longer remains the domain of designers or other professionals traditionally related to the design process, such as engineers or marketers, and instead welcomes all possible interventions that are continually drawn into creative ecosystem.

From an epistemological point of view, the concepts "design network" and "open design" can be understood and investigated with complexity theory. It would be overwhelming to consider these from a purely pragmatic point of view, i.e., by circumscribing the system and tracing its causal relations in order to comprehend its organization and function. A system's openness to exchanges and interactions with other systems and the environment,

in fact, makes it impossible to capture in a framework. It is in constant change, and because we have no control over this, we must accept that its future is uncertain (Morin, 2008; Prigogine, 2014).

The merger of design, production and consumption systems in Industry 4.0

In the essay in which he defines the concept of "industrial design", Maldonado ([1976] 2003, p. 12) states that the goal of design is the coordination, integration and articulation of the factors related to the production of products, and those related to their use and individual or societal consumption. In fact, design is frequently understood as a link between systems of production and consumption.

This conception of design is becoming obsolete at the moment, since the technological revolution anticipated in the previous section no longer presupposes a separation between these two systems. Thus, design will no longer have the prerogative to mediate relationships between the two supposedly separate, closed systems of production and consumption as they begin to overlap, articulate and eventually merge into a single sociotechnical ecosystem that hosts endless actions, interactions, reactions and iterations with as much chaos as organization. It is in this scenario that the possibility of invention and innovation resides.

According to Castells (2010, p. 30), information and knowledge are more than just fuel for the technological revolution, the way fossil fuels were for the industrial revolution. The author states that «what characterizes the current technological revolution is not the centrality of knowledge and information, but the application of such knowledge and information to knowledge generation and information processing/communication devices, in a cumulative feedback loop between innovation and the uses of innovation» (2010, p. 31).

In previous economies, the production system of goods as well as services followed a linear chain, where input and output had different natures. Output from the production system served as input of a new linear input-process-output chain in the consumption system. The latter output was frequently discarded without the possibility of reusing or even recycling it. By contrast, in the information economy, information and knowledge are the input and also the output of the process, in addition to conducting the process as a whole. Output can become input for the same process, allowing cumulative feedback loops and potentially infinite exponential developments.

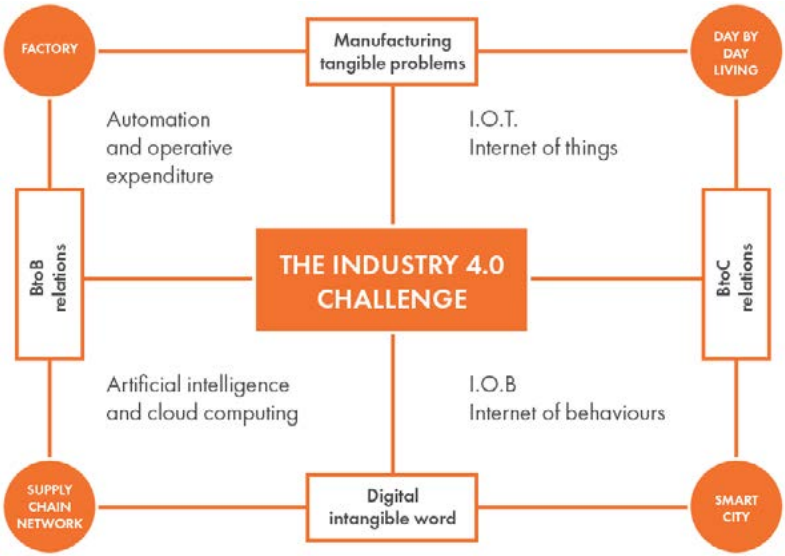
This confluence of input, process and output, no longer in a linear arrangement, removes any sense of separation

between systems of production and consumption. When we have access to a social network, for example, and add a new friend, send a message, post content or "like" someone, we are simultaneously using and producing the network. A social network is not just a series of codes and algorithms developed by a company, it is, above all, millions of users and their relational activities.

One of the main challenges of Industry 4.0 is to overcome this dichotomy between systems of production and consumption, and not just when information and knowledge generate software, but also when they materialize in hardware, such as Celaschi, Di Lucchio and Imbesi demonstrate in the editorial of this issue of MD Journal.

Celaschi (2017, p. 17) outlines the Industry 4.0 playing field [fig. 02], where design interacts with various technologies related to the manufacture of physical products (collaborative robotics, additive manufacturing, cloud manufacturing) or of its computerization (the internet of things, IoT).

What is the position of design on this playing field? This question is important for the discipline if one considers that it has lost its particular function of mediation between systems of production and consumption.



02

02
The Industry 4.0 playing field
(Source: Celaschi, 2017, p. 98)

Cases of Open Design

Systems of production and consumption overlap, articulate and eventually merge into a single creative ecosystem that handles information and knowledge. While it is true that design loses its privileged role of mediation between the two systems, its function as a process can become ever more embedded in collaborative relations hosted by this ecosystem.

De Mul (2011) states that the phrase "everyone is a designer", which periodically resurfaces in design discourse, may be coming true. Today everyone has access to computer-aided design (CAD) software and freeware, and can learn to use it quickly and easily. With these tools, anyone can launch their own design process and share it with others via numerous design websites such as Thingiverse (www.thingiverse.com) or Instructables (www.instructables.com). Moreover, they can even produce their designs through digital fabrication technologies that are already available for home use or in a Fab Lab. Others could find their designs online, and adapt or produce them as needed.

Such logic is not entirely novel. Remember, for example, the 1974 self-design proposals of Enzo Mari. "Autoprogettazione?" was collection of blueprints, «for making easy-to-assemble furniture using rough boards and nails. An elementary technique to teach anyone to look at present production with a critical eye» (2002, p. 1). The designer remarked that «anyone, apart from factories or traders, can use these designs to make them by themselves» (ibid.) and, considering it was an ongoing design process, invited «those who build the furniture, and in particular variations of it, to send photos to his studio at Piazzale Baracca, 10. 20123 Milan» (ibid.). Figure 03 shows one of Mari's 19 designs, a chair that has been produced in many design schools over the last 40 years and, more recently, in several makerspaces as well.

A visionary, Mari anticipated the logic of free software that requires the availability of a program's source code for it to be studied, improved, redistributed and used freely (Free Software Foundation, 2013). In the design field, the term "open" is preferred to the term "free", following an influential metalinguistic trend that makes adjectives out of innovation and science concepts, among others. This terminology is interesting because it aligns with the ecosystem approach used in this article, as it was shown in the first section, where the concept of "open design" was defined.

Mari's proposals are authorial, though they remain open. For technical reasons, the author must centralize the ongoing process and asks interpreters of his designs to send photos to his business address. This case was chosen to

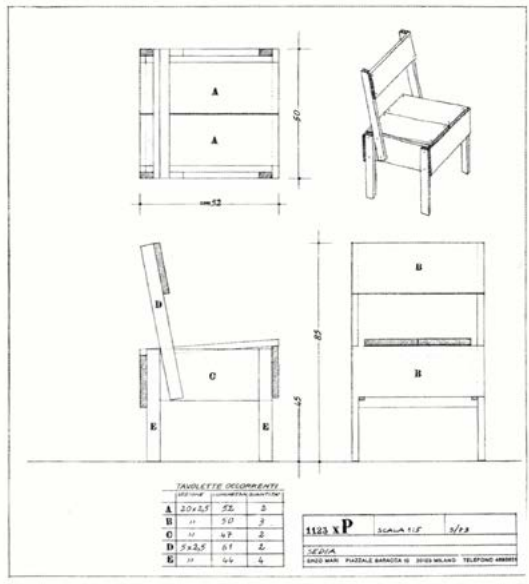
demonstrate that open design was possible even before the IT revolution and the advent of the Internet. The best examples of open design, however, are linked to software development and, in particular, with the work of the Free Software Foundation (www.fsf.org). The development of Linux, Firefox and OpenOffice, for example, are the fruit of open design projects in which a mass of developers driven by a collaborative spirit continuously and effectively participate.

There are also notable examples of this approach beyond the digital sphere. For example, the OpenIDEO platform (www.openideo.com), initiated in 2010 by the IDEO consulting agency, regularly convenes designers and other professionals, challenging them to solve social problems in a specific locations , or effecting people worldwide. The platform allows for the formation of design networks between these various actors and promotes their collaboration throughout design and its implementation.

OpenIDEO is an example of strategic design for social innovation, though it is not directly related to Industry 4.0. Approaching the fourth industrial revolution, in 2009 Fiat Brazil created the design platform FiatMio.cc to develop a concept car using open design [fig. 04]. As related in the project's video presentation, «after years interacting with consumers on the Internet, Fiat decided to listen to people, not only before or after, but during the creation of a car» (Fiat, 2010, no pages). The platform allowed the development of a process involving about 17,000 people from 160 countries who sent more than 11,000 ideas for the design of an urban car. For the needs of this article, however, it must be noted that the platform depends on a mostly centralized design network, as was the case with Enzo Mari. The company's design center, in fact, played a key role in gathering ideas and realizing them in the development of the prototype that was presented at the 2010 São Paulo Motor Show. Another important limitation is that it is a concept car, and not effectively produced or put in use, which prevents a proper investigation into the interface between the systems of production and consumption.

This interface between systems was created with OpenDesk.cc (www.opendesk.cc), a platform that promotes connections between designers, producers and users. As with the above noted cases of Thingiverse and Instructables, this functions as a repository of items to which designers upload their plans, users select products, and with which local carpenters fabricate and deliver products. Thus, the platform favors distributed manufacturing and eliminates a good deal of cost and vastly reduces environmental waste stemming from both

03



03
Enzo Mari, Chair (source: Mari, 2002, p. 52, courtesy by Corraini Edizioni)

business-to-business and consumer distribution. For the scope of this article, however, it must be said that this platform does not favor a true opening of the design process, which remains the domain of designers.
The WikiHouse.cc platform functions in a similar manner by distributing the design and production of housing

units [fig. 05]. This example is directly inspired by the Industry 4.0 concept (Parvin, Reeve, 2016). The design process is open and is developed by a design network composed of architects, engineers, designers, other professionals and volunteers. It is interesting to note that the OpenDesk.cc company and the WikiHouse.cc foundation were both developed by designer-entrepreneurs. As with OpenIDEO, these are initiatives in which the boundaries between design, innovation and entrepreneurship become increasingly tenuous. Merging and overlapping the various systems and processes actually reduces barriers between the different professional disciplines in both function and scope.

These cases were chosen to present a range of open design examples for consideration, from the concept of design networks to the relationship with Industry 4.0. Through these, three issues that characterize open design can be explored. First, it is possible to evaluate the mix of design, production and consumption systems broadly covered in the previous section. Mari, OpenDesk.cc and WikiHouse.cc are revealing in this regard.

Second, open design can be placed in the contemporary socio-technical context, thus further defining its relationship with Industry 4.0. In the previous section it was stated that systems of production and consumption are not discretely separated, but are increasingly inter-

04
The Fiat Mio concept car, presented at the São Paulo Motor Show (source: Fiat, 2001. The company uploaded the video under the Creative Commons Attribution 2.0 Generic license).

04

twined, joining in a single socio-technical ecosystem. It is this new ecosystem, which is the creative articulation of production and/or consumption processes, that gives rise to open design. Open design is enabled within it, while also contributing to its configuration and ongoing reconfiguration. If, as we saw in the case of Mari, open design itself is not new, then new collaborative contexts and technologies are propelling its growth and dissemination. As demonstrated in these cases, the logic of this type of platform, which makes all technologies social and promotes their collective and collaborative use, is at the heart of open design's vitality and growth. On this basis it is elaborated to its full potential by means of the virtualization, distribution and automation of the following:

- data collection (big data, crowdsensing and the internet of things).
- Computing (cloud computing, data mining, advanced analytics, machine learning and artificial intelligence).
- Simulation (virtual and augmented reality, gamification).
- Prototyping (Fab Lab Technologies and open-source electronic prototyping platforms, such as Arduino).
- Manufacturing (collaborative robotics, additive manufacturing).

Thirdly and finally, it is important to recognize the value of open design's ethical principles, as promoted by the Free Software Foundation and as can be observed in the cases of Mari, OpenIDEO and WikiHouse.cc. Open design is based on the principle of openness, that is, it guarantees and fosters free access to the design process. Thus, we must also address its political dimensions. According to Thackara (2011), we should place it «in stark contrast to the legacy left by the industrial economy», meaning an economy obsessed with hierarchy and rigid control. However, if it is true that computerization and Industry 4.0 favor flexibility and horizontality in this process, then can we be sure that they are conducive to open design and principles such as actual freedom and autonomy? One of the main activities of Industry 4.0 is the mining of our personal data and the development of algorithms for predicting and influencing our behavior. As Giulio Carlo Argan put it, «Mari is right, everyone should design: in the end, it is the best way to avoid being designed» (cited in Mari, 2002, p. 34, translated by the author).

Final considerations: the designer in Industry 4.0

With computerization has come profound changes to the design process and the forms of organization that elaborate it. This allows open design processes to be developed within large, potentially infinite, design networks that

constantly evolve. This change was noticeable in software design early on, and today, the fourth industrial revolution has already become a reality for the design and production of products and services, and also for the fields of architecture and urbanism.

The term "Industry 4.0" focuses on the computerization of the system of production. However, this article focuses on the progressive fusion of this system with that of consumption, allowed by IT. In the resulting creative ecosystem, through the concepts of design networks and open design, engagement in the design process had expanded beyond the limits of the design profession. It thus becomes important to ask yourself what it means to be a designer when everybody designs. Will the designer´s labor become even more flexible and precarious, and end up just one more profession lost to the gig economy (on the future of the world of work, see the interview to Jamie Woodcock, by Machado, 2017)? Will we design for free, purely as a hobby or for self-fulfillment? There are several clues to the future of the design profession which deserve the most attention from researchers.

The designer-entrepreneur. As demonstrated by the cases of OpenDesk.cc and WikiHouse.cc, together with the flourishing of numerous startups around the world, designers, software developers, architects and engineers are taking advantage of the increasing osmosis between systems of design, production and consumption to create their own businesses. Arquilla, Bianchini and Maffei (2011) show that the skills that the designer used to move into production and consumption systems and to connect them are not only still valid but may become the basis for new business models. Designers today can transform their studio into a workshop for both production and sales, expand their production capacity by connecting with companies that were formerly customers, and extend their capabilities for conducting business through e-commerce. Explicitly evoking the concepts of the open system (2011, p. 9), they suggest the concept of "designer=enterprise" to refer not to a new aspect of professional performance, but to the creation of a new form of organization led by the design process that focuses on the production and distribution of goods, and which acts in the interstices of the creative ecosystem. Serafini (2016) investigates this form of entrepreneurship that can arise by chance as much as by necessity, and identifies in it the hybrid performance of professionals in the creative ecosystem, the main features of which are: the overlap between the roles of designer and entrepreneur that make it difficult if not impossible to clearly distinguish relative

05

skills; the strengthening of horizontal relationships with various stakeholders in the ecosystem and network organization; the plurality of ends that motivate this hybrid profile, continuously redirecting and resulting in its field of endeavor.

The design culture specialist. «Design, when everybody designs: an introduction to design for social innovation» is the title of the latest book by Ezio Manzini (2015). The author asserts the existence of a diffuse design method that is practiced, sometimes informally and unselfconsciously, by cultural activists and grassroots organizations engaged in social innovation. In these diffuse design networks, professional designers distinguished themselves as design culture experts: on the one hand, their process competence can lead to alternative views and proposals with great innovation potential; on the other, they have an important role in promoting design, enabling people to design and facilitating their professional practices. The OpenIDEO case exemplifies this quality. Challenges posed via the platform are engaged with not only by designers, but by many professionals and volunteers from various fields who are moved by a sense of social responsibility. The designers at the IDEO Consulting Agency

05
The WikiHouse built at the Hub Westminster photographed by Andy Roberts (source: Wikipedia, 2012. The authors of wikipedia uploaded the video under the Creative Commons Attribution 2.0 Generic license)

offer their design culture and professional experience to structure the platform and provide design methodologies and tools. The WikiHouse.cc and FiatMio.cc platforms operate in a similar manner, demonstrating that the role of designer as design culture specialist can be easily transferred from the area of social innovation to Industry 4.0.

The metadesigner. As we have seen, the transformation is profound. These new means of organizing the design process together with the embrace of open design demand an equally profound critical examination. Bentz and Franzato (2017) claim that only through a metadesign process, that is a second order process of reflecting on this everyday professional activity from removed and critical distance can the designer be aware of these changes and work to direct them. Moreover, a displacement from the level of design to the level of metadesign appears necessary for designing design platforms (Avital, 2011) and the so-called "metaproducts" (Córdoba Rubino, Hazenberg, and Huisman, 2011), that are the products reciprocally connected in the IoT.

REFERENCES

Johansen Robert, *GroupWare: Computer Support for Business Teams,* New York, The Free Press, **1988**, pp. 256.

Lévy Pierre, *As tecnologias da inteligência: o futuro do pensamento na era da informática,* Lisboa, Instituto Piaget, **1992**, pp. 220.

Mari Enzo, *Autoprogettazione?,* Mantova, Corraini, **2002**, pp. 60.

Bødker Keld, Kensing Finn and Simonsen Jesper, *Participatory IT design: designing for business and workplace realities,* Cambridge, MIT Press, **2004,** pp. 337.

Authors of Free Software Foundation, *The free software definition,* **2005**. https://www.gnu.org/philosophy/free-sw.html [July 14, 2017].

Latour Bruno, *Reassembling the Social: An Introduction to Actor-Network-Theory,* Oxford, Oxford University Press, **2007**, pp. 330.

Sanoff Henry, "Editorial of the special issue on participatory design", *Design Studies,* v. 28, n. 3, **2007,** pp. 213–215.

Morin Edgar, *On Compexity,* Cresskill, Hampton Press, **2008,** pp. 127.

Castells Manuel, *The rise of the network society,* Maden-Oxford, Wiley-Blackwell, **2010**, pp. 597.

Authors of Fiat, *A Common Day in Fiat Mio's Future,* **2010.** https://www.youtube.com/watch?v=aCPrg2TQui0&list=PL5FED4D80C03D0EA0 [October, 12, 2017].

Authors of Fiat, *Project Fiat Mio Making of - Episode 16 - The Fiat Mio's Future,* **2011.** https://www.youtube.com/watch?v=kNde6XwFXAw&index=2&list=PL5FED4D80C03D0EA0 [October, 12, 2017].

Arquilla Venanzio, Bianchini Massimo, Maffei Stefano, "Designer=Enterprise. A new policy for the next generation of Italian designers", *Proceedings of the 2011 Tsinghua International Design Management Symposium,* Hong Kong, DMI, **2011.** https://www.academia.edu/7549731/Designer_Enterprise_A_new_policy_for_the_next_generation_of_Italian_designers [July 14, 2017].

Avital Michel, “The generative bedrock of open design”, no pages, in van Abel Bas, Klaassen Roel, Evers Lucas and Troxler Peter (eds.), *Open Design Now. Why Design Cannot Remain Exclusive,* Amsterdam, BIS, **2011**. http://opendesignnow.org/ [July 14, 2017]

Córdoba Rubino Sara, Hazenberg Wimer and Huisman Menno, *Meta products. Meaningful design for our connected world,* Amsterdam, BIS, 2011, **2011.** https://www.metaproducts.nl/ [July 14, 2017]

de Mul Jos, “Redesigning design”, no pages, in van Abel Bas, Klaassen Roel, Evers Lucas and Troxler Peter (eds.), *Open Design Now. Why Design Cannot Remain Exclusive,* Amsterdam, BIS, **2011**. http://opendesignnow.org/ [July 14, 2017]

Thackara John, “Into the open”, no pages, in van Abel Bas, Klaassen Roel, Evers Lucas and Troxler Peter (eds.), *Open Design Now. Why Design Cannot Remain Exclusive,* Amsterdam, BIS, **2011**. http://opendesignnow.org/ [July 14, 2017]

Authors of Wikipedia, *Wikihouse The Hub Westminster,* **2012**. https://commons.wikimedia.org/wiki/File:Wikihouse_The_Hub_Westminster.jpg [July 14, 2017].

Maldonado Tomás, *Disegno Industriale: un riesame,* Milano, Feltrinelli, **2013**, pp. 126.

Parvin Alastair and Reeve Andy, *Scaling the Citizen Sector. A White Paper on the role of digital innovation in tackling the UK housing crisis,* **2014.** https://medium.com/@AlastairParvin/scaling-the-citizen-sector-20a20dbb7a4c [July 14, 2017].

Prigogine Ilya, *La fine delle certezze. Il tempo, il caos e le leggi della natura,* Torino, Bollati Boringhieri, **2014,** pp. 189.

Manzini Ezio, *Design, when everybody designs: an introduction to design for social innovation*, Cambridge, MA, MIT Press, **2015**, pp. 241.

Serafini Pagnussat Thaís, *Design e empreendedorismo: a atuação mutante do designer nos ecossistemas criativos,* São Leopoldo, Unisinos, **2016,** http://www.repositorio.jesuita.org.br/handle/UNISINOS/5362, pp. 98 [October, 12, 2017].

Bentz Ione and Franzato Carlo, “The relationship between Strategic Design and Metadesign as defined by the levels of knowledge of design”, *Strategic Design Research Journal,* v. 10, n. 2, **2017**, pp. 134-143. http://revistas.unisinos.br/index.php/sdrj/article/view/sdrj.2017.102.06 [September 22, 2017].

Celaschi Flaviano, “Advanced design driven approaches for 4.0 Industry framework. Human centered dimension in fourth digital-industrial revolution”, *Strategic Design Research Journal,* v. 10, n. 2, **2017**, pp. 97-104. http://revistas.unisinos.br/index.php/sdrj/article/view/sdrj.2017.102.02 [September 22, 2017].

Machado Ricardo, “Interview with Jamie Woodcock: Against the reductionist euphemism, the struggle for a just flexibilization”, *IHU Online,* n. 503, **2017.** http://www.ihuonline.unisinos.br/artigo/6841-against-the-reductionist-euphemism-the-struggle-for-a-just-flexibilization [October, 12, 2017].