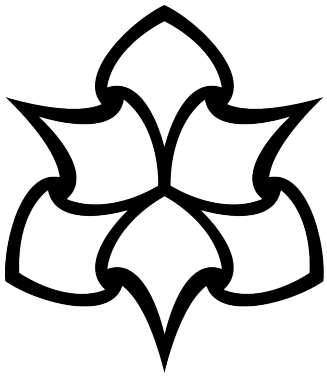

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A framework analysis of the “open paradigm”. Four approaches to openness in the field of design.

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Open design is a term that expresses a plurality of meanings and, according to the literature on the subject, is difficult to define due to due to the variety of its practices and applications. This research study seeks to examine the opening phenomena related to design by imagining a more extensive and articulated area that may be called the “open paradigm” in the field of design. Starting from the analysis of the 20 case studies cited most often in the literature on open design, the research study outlines a framework for the “open paradigm” by identifying four different approaches to openness: OS – Open source approach, CO – Collaborative approach, CR – crowd approach and OM – open manufacturing approach. These approaches are not new to design research, but they are often studied within the confines of their own contexts. The paper explains each approach in written and visual form, to synthetize the different modes of operation in relation to the design process, analyses them as part of a system and concludes by identifying the attributes of each approach in term of dynamics, tools, resources skills and the role of the designer.

Keywords: open paradigm; open design; co-design; crowd design, open manufacturing, design theory

1 Introduction

Since the origin of the design discipline, the notion of “design” has been deeply connected to industry and mass-production (Maldonado, 2003; Dorfles, 1072). According to Celaschi, Formia and Garcia (2010, p. 63) “Design is the culture through which this relationship between art and industry progressively, and not unitarily, takes shape”. Though the connection with the origins remains very strong, the exclusive bond between industry and design has loosened over the years. The design discipline has gradually become more articulated and fragmented into a multiplicity of different sectors of intervention by partially hybridizing its industrial origins (Yee, Jefferies & Tan, 2013) and integrating the participation of different stakeholders into the design process, such as non-designers (Sanders, Brandt & Binder, 2010), professionals from different fields or institutions.

In the last few years, one of the most hybridized areas of design is the one identified with the expression “open design”. As shown by Boisseau, Omhover and Bouchard (2018), the academic literature on open design has grown, and knowledge of this phenomenon has increased both through the definition of the practice and the analysis of case studies.

Literature on the subject agrees that this expression refers predominantly to the open source process applied to the design of physical objects (Van Abel et al., 2011; Menichinelli, 2016). Nevertheless, some authors underline that this area is difficult to define because it embodies many different connotations and related concepts such as co-creation, crowdsourcing, DIY (do-it-yourself), open innovation, and many others (Cruickshank & Atkinson, 2013; Aitamurto, Holland & Hussain, 2015; Boisseau, Omhover & Bouchard, 2018), synthetized by Gasparotto (2019) in three different main features: open source, collaboration, and access.

Related arguments such as: making, open source, collaboration, co-design, open innovation, crowdsourcing, crowdfunding, open manufacturing, and many others, are very common in the literature on open design, to the point that some authors (Aitamurto, Holland & Hussain, 2015; Gasparotto, 2019) have identified this broader area with the expression: “open paradigm in design research” or “open paradigm in the field of design”.

Starting from these considerations, this paper aims to examine an extensive area of intervention that spans the boundary of open design and considers different approaches related to the concept of openness as part of a larger system. Moreover, the research seeks to discover which tools are used, how opening processes operate in the different phases of the design process and what skills and resources are required.

2 Methodology

The first step of the research consists in the identification of the open approaches applied in the design field through a review of the literature and the classification of case studies. We performed a quantitative study by examining the case studies collected in 38 research papers written between 2000 and 2019 on the subject of open design. From a list of 42 total case studies we choose to consider the 20 most often-cited (Appendix 1). Case studies cited more than once in the same article were counted as 1 and case studies describing opposite phenomena, such as for example, patenting or “authorial” design, were excluded.

Selected case studies were analyzed, using qualitative research methods, based on the following questions:

- How does the case study work?
- Why does it appear in the literature on open design?
- What form does it take?
- Which methodologies were applied in the case study?

In the second step of the research we examined the results and identified four main clusters that group together methodologies with common characteristics. Each cluster, also called “approach” in this research study, is described in written and visual form and seen in relation to the design process. Reference was made to Karl Aspelund’s design process (2014), split in the following stages: Inspiration – Ideation – Conceptualization – Exploration/Refinement – Definition/Modelling – Communication – Production. To synthetize and simplify the reading, the different stages of Aspelund’s design process have been grouped in this paper into three macro areas: Conceptualization, Refinement and Production (Figure 1).

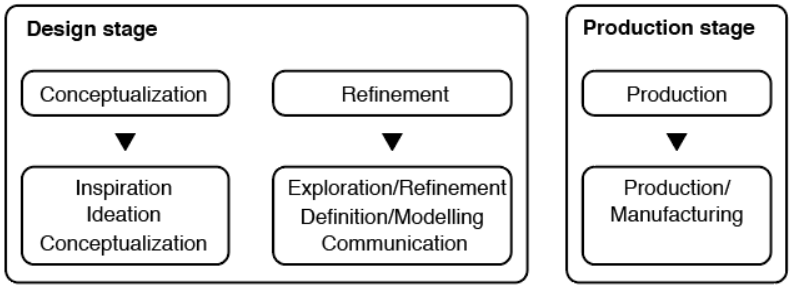

Figure 1. Synthetic representation of Aspelund's design process. Source: Silvia Gasparotto.

Finally, the last part of the research analyzed the “open paradigm” as a system by describing some case studies through a conceptual framework and by identifying the main attributes of each cluster.

3 The “open paradigm” in the design field

By examining Appendix 1 it may be observed that the selected case studies mostly involve web platforms, tools and software that use more than one methodology in the development of their projects. A more in-depth examination shows several similarities between the methodologies themselves. For example, considering common attributes and modes of operation, we noted that co-design and participatory design may be enclosed in a cluster that gathers many other samples of collaborative methodologies. For this reason, and for a simplified interpretation of the phenomenon, the research study proposes to collect and classify (Bailey, 1994) methodologies discovered in the analysis of case studies by gathering them into four subsets (Table 1): OS (Open source approach), CO (Collaborative approach), CR (Crowd approach), OM (Open manufacturing approach).

Table 1. The four clusters of the “open paradigm”.

Design phase			**Production phase**
OS	**CO**	**CR**	**OM**
Open design	Co - design	Crowdsourcing	Open manufacturing
Open source	Co - creation	Crowdfunding	Open distribution
Open hardware	Participatory design	Open innovation	Open production
Peer production	Design thinking	Decentralized innovation	Distributed manufacturing
	Co - development	Crowd production	Open fabrication
	Co - innovation	Crowd - creativity	Making
	User - creation	Crowd - innovation	DIY
	Community based development	Horizontal innovation	Personal or self - fabrication/production
	Meta - design		

3.1 OS – Open source approach

Open design, open source, open hardware and peer production are considered part of the OS cluster because of their relation to the open source approach. More specifically, the term open design began to appear in scientific literature around the 2000s (Vallance, Kiani & Nayfeh, 2001). Although its official definition is still open to new developments, the most acknowledged meaning of open design indicates those projects that follow the open source model by sharing all the information under a Creative Commons license (Balka, Raasch & Herstatt, 2010; Ciuccarelli, 2008; Van Abel, et al, 2011). Thanks to these agreements, all information related to the project may be used, edited and produced by anyone (Menichinelli, 2014). Open hardware and peer production are also related to the same approach; the first retrieves the dynamics of open source development for hardware, the second enables the creation of a product, a service or common goods by bringing together a self-organized community.

The practice of open source developed as a demonstration of dissent regarding the issues of intellectual property and democratic ethics; the values it expressed were then embraced by the open design philosophy, which expanded its goals to include: the desire to break down barriers between designer and user, the ability to design and manufacture unusual objects that often belong (as symbols) to specific communities, the freedom to design artefacts not limited or regulated by any authority. Other reasons to apply the open source approach in the design of physical objects reside in the advantage of creating a community of people who contribute to implementing a project. Sharing resources, in fact, facilitates the creation and experimentation of solutions to complex problems that may be very difficult to solve with limited human and economic resources (Murty, Paulini & Maher, 2010).

Finally, it should be specified that the OS approach has a horizontal dynamism. Although it is inevitable that a first person/group of people generates the "source project", the process does not develop in a top-down or bottom-up mode, but peer-to-peer. This dynamic, in fact, does not allow for any degree of control over subsequent versions of the project.

The case study most often cited for explaining the OS approach is Rep Rap, which is the first low cost and open source 3d printer built with both open software and open hardware. Another interesting case study to explain the dynamics of open source design is OpenStructures. In this case, the platform enables anyone to upload components designed on the basis of a specified grid – with predetermined dimensions – in order to allow holes and joints to fit together to create new and different open source objects, for example tables, chairs or lamps.

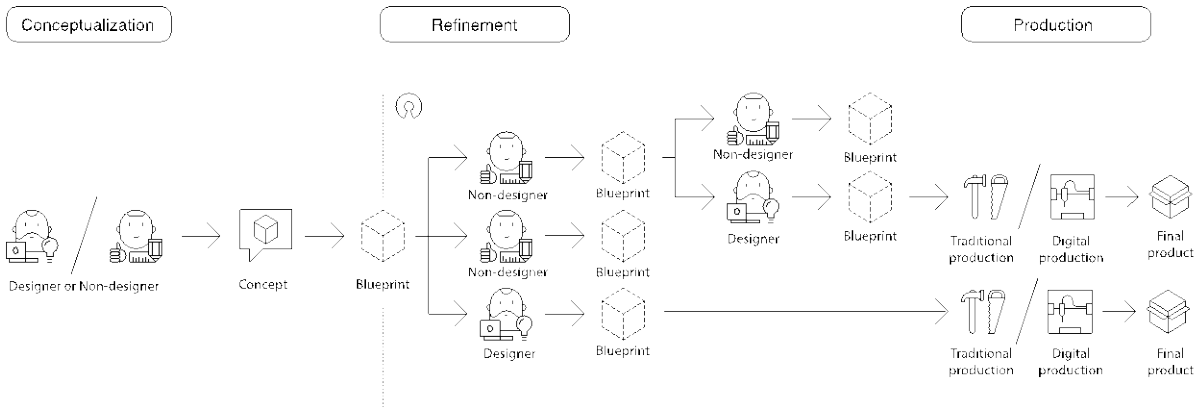

Figure 2. Visual representation of the OS approach. Source: Silvia Gasparotto.

The OS approach (Figure 2), can be started by anyone, designers or non-designers, using any sort of methodology. The process is opened up in the final stage of the conceptualization — when the source file is released as open source — as well as during the production phase (open manufacturing), so that everyone is given the opportunity to build the same artefact or its subsequent version by hand or with digital processing methods.

3.2 CO – Collaborative approach

In the cluster of CO, different methodologies related to the concept of collaboration coexist. The prerequisite of a CO approach lies in the belief that every individual is a bearer of knowledge and competencies that, when shared, will lead to a different – hopefully better – result than one that an individual could achieve alone (Sanders, 2008; Wilkinson & De Angeli, 2014).

There are many nuances that distinguish participatory design, co-design, meta-design, design thinking and the other collaborative methodologies, especially as they involve non-designers in different phases of the design process and in different roles. For example, in participatory design, non-designers are invited to collaborate in the early stages of the design process, but they don't make design decisions (Ehn & Bannon, 2012), whereas in meta-design, non-designers act as designers in a particular environment built by the designers themselves (Fischer & Scharff, 2000).

By analyzing case studies, the involvement of different people in this approach is relate to participation, especially for generating ideas and prototypes (Murphy & Hands, 2012). This involvement can be direct or mediated, open to all phases of the design process, or limited to only some of them. Traditionally within this methodology, the designer combines his classic role as a developer with the role of facilitator (Aguirre, Agudelo & Romm, 2017) within a group of people who work together to achieve a common goal.

The CO approach relies not only on the creative abilities of the individual, but seeks to use and enhance collective intelligence, imagination and skills that enable people to collaborate, to work and learn together (Levy & Bononno, 1997). Though traditionally, co-design methodologies are used in real communities and in different fields such as architecture, urban planning and, of course, design, most of the case studies gathered in this research paper regard online platforms. Collaborative tools used on platforms such as Quirky.com, OpenIdeo.com, Arduino.cc or GitHub.com are basic but effective. They include forums, chats and private mail-boxes useful to the community for communicating with one another. In analyzing the case studies, it becomes clear that the designer's traditional role as a

facilitator is not always required. This role is not so important for co-design online communities which seem to prefer a rougher rather than an effective qualitative result.

In the CO approach (Figure 3), the design process is shared: a group of people – it does not matter whether they are designers, non-designers or design researchers – collaborate to achieve common goals. The team does not necessarily work together through every phase of the design process: members might participate in a co-design process in just, for example, the conceptualization phase, or the refinement phase.

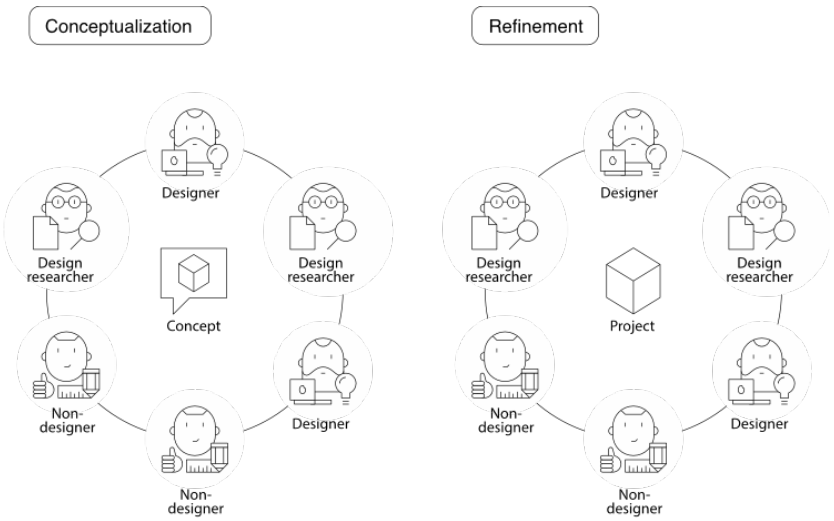

Figure 3. Visual representation of the CO approach. Source: Silvia Gasparotto.

3.3 CR – Crowd approach

The CR approach contains different crowd-related subjects, such as crowdsourcing, open innovation or crowd creativity. The common attribute of this subset is the open access to human, financial or creative resources usually related to innovation. Many different formulations have been used to explain this approach: crowd-based design activity, web-based collective design, or crowdsourcing for design (Hui, Greenberg & Gerber, 2014; Hajiamiri & Korkut, 2015; Xu & Bailey, 2011).

The term "crowd" combined with "sourcing" was first used by Jeff Howe in the magazine "Wired" (2006) and was further explored in the book titled “Crowdsourcing. The participatory value of the crowd as a resource for the future of work” (2008). In 2012, after comparing over forty definitions, Estellés-Arolas and González-Ladrón-de-Guevara of the University of Valencia perfected and expanded Howe's definition. They claimed that people usually respond to the "open call" of a crowdsourcing project to meet a real need, economic gain or social recognition, self-esteem, or developing a personal skill (Estellés-Arolas & De-Guevara, 2012).

Like CO, the CR approach also displays some differences between the methodologies grouped in the cluster. For example, crowdfunding is a collective funding method based on the accumulation of small amounts of money from many different investors. This system is used extensively by designers who want to propose their innovative products on platforms such as Kickstarter or Indiegogo. Open innovation, instead, “is the use of purposive inflows and outflows of knowledge to accelerate innovation.” (Chesbrough, Vanhaverbeke & West, 2006).

The crowd-based activities were made possible by the Internet, and many companies have added a virtual environment to their platforms, where everyone can gather ideas and make suggestions for new products or services (Bayus, 2013). It should be noted that the dynamics through which crowdsourcing in design is made manifest often combine competition and cooperation, so we cannot consider the crowd as just a collaborative community (Baek, Kim, Pahk & Manzini, 2017). Individuals participate in "challenges" or competitions focused on the same goal – for example proposing product innovations on the Quirky platform – from which in the end, however, only one person or a small number of participants will profit. Referring more specifically to the field of design study, the crowd is usually involved in the research and development of products that provide some sort of innovation. For this reason, in most cases competitiveness is equal or even more important than collaboration.

Online platforms that rely on this kind of process can deal with many different subjects: from product to visual communication, from video-making to services, all in search of solutions to problems. They respect a common procedure for the selection of ideas by adopting a competition format: the launch, the submission, the selection and the award ceremony. Examples of platforms that use the CR approach are the above-mentioned Quirky, but also Open Ideo, Zooppa and Javoto.

In the CR approach (Figure 4), in most cases the design process is developed by individuals, but the contest is the same for all participants.

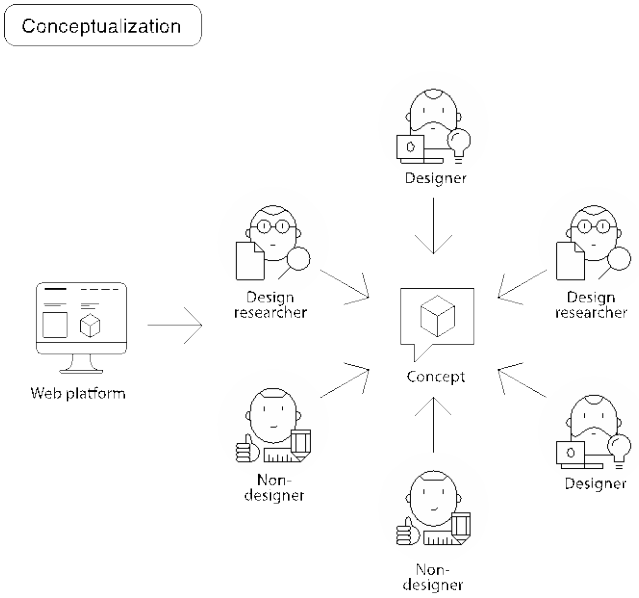

Figure 4. Visual representation of the crowd design CR approach. Source: Silvia Gasparotto.

3.4 OM – Open manufacturing approach

The last approach of the “open paradigm” (OM) refers to the opening of the production stage of the design process. Open manufacturing, distributed manufacture or more generally "opening of production" (Seravalli, 2014) therefore refer to a type of production that is no longer isolated in sites or districts with a high concentration of industries but is widespread and disseminated across the territory. This approach suggests that the production system is on the verge of a sea change, of a magnitude similar to the transformation of communication

systems since the 1970s, when the network shifted from a centralized to a decentralized model, and later to a distributed system (Baran, 1964).

This production structure can be represented, in the “open paradigm”, by Fab Labs, desktop manufacturing tools and micro-factories (Bianchini & Maffei, 2013). These labs are provided with digital and traditional manufacturing machines and tools used for experimenting, producing and prototyping objects (Figure 5). The advantage of that approach is to produce goods at zero distance and to facilitate synergies between global design projects and local economic development “[...] in which local economies operate as separate, adaptive units linked within ever-wider networks of exchange at the local, regional, or global level" (Manzini, 2015, p. 20).

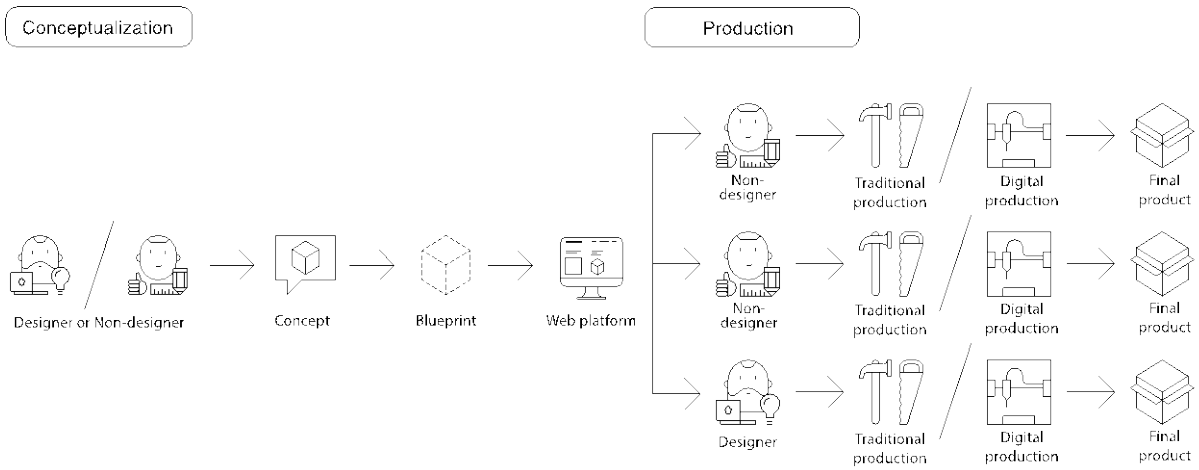

Figure 5. Visual representation of the OM approach. Source: Silvia Gasparotto.

Although open manufacturing is represented by examples such as Fab Labs and desktop manufacturing, it cannot yet be defined as a real production system. Most of the production machines and tools used in this approach are not yet sufficiently developed for mass production, in terms of manufacturing time and product quality, but in recent years research has made significant progress in the development of technologies. For example, Carbon has developed a 3d printer that uses a Continuous Liquid Interface Production (CLIP) process to produce 3d-printed objects faster and with a high level of quality in both the material and the finishing. The strength of Carbon’s machines is such that the company's payoff states: “Stop prototyping. Start producing.” Another company that uses the OM approach as a real production system is Open Desk, which designed furniture that can be downloaded as a blueprint and manufactured by CNC machines. Their platform also provides a global map where you can find the nearest Fab Lab.

The relative affordability and ease of access to these manufacturing machines opened a great debate in the design community, because in recent years it supported activities such as “making” and DIY (do it yourself), where the role of the designer is threatened by the possibility of opening the production phase to, potentially, everyone.

The term “maker” began to enter the lexicon of followers, and subsequently common parlance, after Dale Dougherty published a series of software guidelines in "Make" magazine in 2005, and after the publication that same year, in the same journal, of “The Maker's Bill of

Rights", which described the main aspects of the "Maker's" philosophy. The word "maker" does not allude to just a "social type", but speaks, in general, about a movement (Walter-Hermann, 2013). Commonly, the maker is someone who combines the skill of the craftsman with inventive thinking and the ability to use technology. His nature is more closely linked to the practice of making rather than designing, and the process through which the maker develops projects is usually by trial and error.

DIY is also a phenomenon related to the OM approach, but while "making" is mainly linked to digital production, DIY can also be related to traditional and craft production. Today, this practice has expanded thanks to the abundance of tutorials that may be found online, the so-called "instructional videos". A motivation that drives people to divulge their recipes and working methods may be found in their desire to share their skills with others. Some researchers, for example, recognize the as-yet unexplored potential for self-teaching inherent in this instrument (Hartley, 2012; Burgess & Green, 2009).

In design this phenomenon has created two different positions: one in favour and one against. The pro-DIY is summed up by Ellen Lupton (2006) in The DIY Debate: "By encouraging the public to use design tools intelligently, we will ultimately increase the general understanding of professional work, as well as raise the level of design across society". The opposite position is supported by Lawrie Heller in an interview granted to Lupton and published in the same book: assuming that everyone can be a designer through DIY diminishes the authority and respect for real designers.

The debate has not yet concluded and the issue regarding professionals and amateurs in the design field, which has been raised many times over the years (Kuznetsov & Paulos, 2010), will probably remain unresolved.

4 Analysis of the "open paradigm" in the design field

As suggested by Anderson in the manifesto "More is different" (Anderson, 1972), the description of a system changes if you look at it "brick by brick", or if you consider the entire wall, so in this chapter the four approaches of the "open paradigm" will be considered unitarily.

Firstly, it becomes clear that three of the four approaches in the "open paradigm" are related primarily to the design stage of the design process, whereas the fourth is associated with the production stage. Nevertheless, OS is considered fully accomplished when open source objects are produced with OM tools, whereas CO and CR can also be used with the traditional/closed mass production system.

This means that there is often an alternation between opening and closing both in the design and manufacturing stages (Table 2.). Of the four approaches, the one that seems to be more completely "open" is the OS one: the project becomes as fluid and widespread as its production. OM instead can be used as production or prototyping tools with a closed design stage as well (carried out by a single designer). CO and CR are always open in the design stage, but they can be closed in the manufacturing stage of the design process.

Table 2. Open and closed conditions in the design process.

	Conceptualization	Refinement	Manufacturing
OS	Open	Open	Open
CO	Open	Open	Open or closed
CR	Open	Open	Closed
OM	Open or closed	Open or closed	Open

Secondly, from the analysis of the case studies we can observe how, despite the pre-eminence of one process over the others, the dynamics are hybridized by using more than one approach for the development of the projects. For example, in the case of the Quirky platform, despite the predominance of CR, in many projects there are a series of CO sub-processes based on discussions in the chat rooms and private email boxes present in the platform. This tool makes it possible for the community to contribute in various ways to the development of the project (Figure 6).

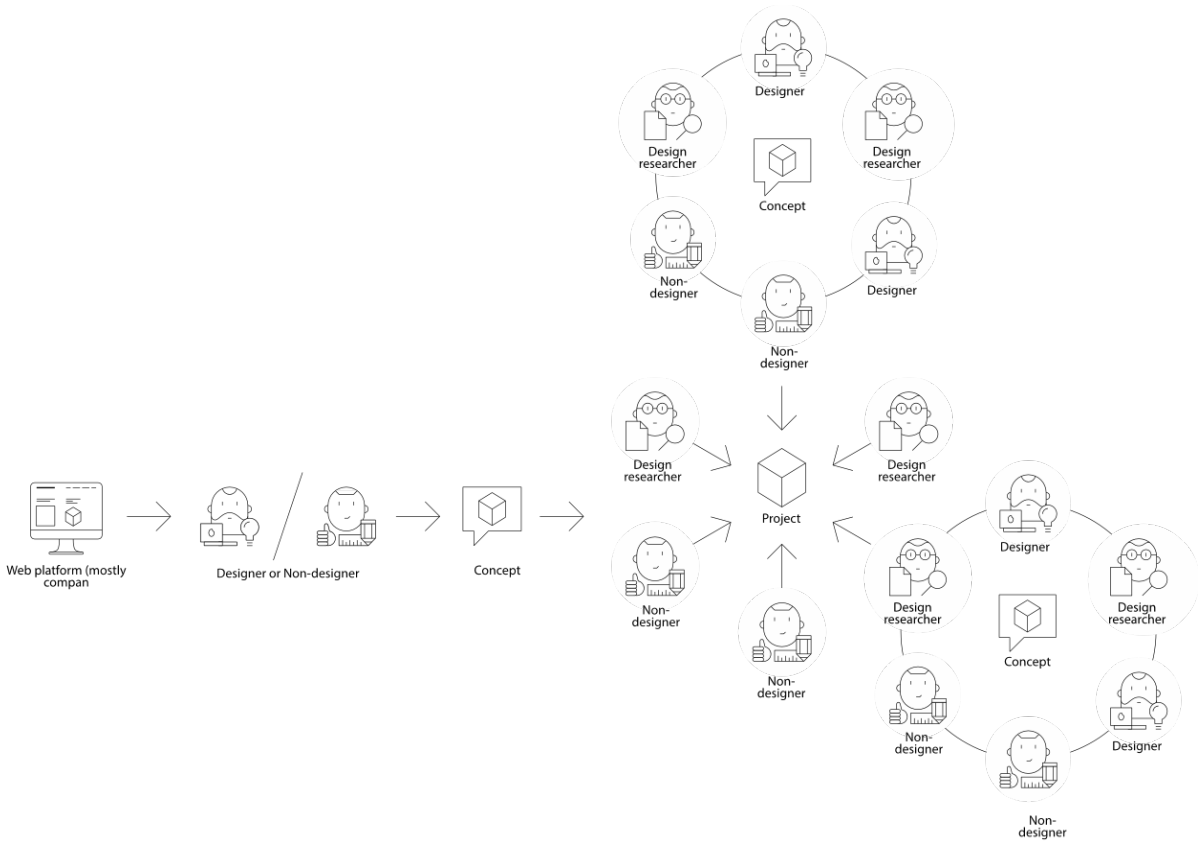

Figure 6. Approaches of openness used by Quirky. Source: Silvia Gasparotto.

A further example could be Thingiverse.com (Figure 7), where the OM approach achieved by 3d printing is complemented by OS and CO, because all files are under the Creative Commons license and because the platform provides tools such as the “remix” or “comment” buttons, to create different versions of the same original blueprint and to facilitate collaboration.

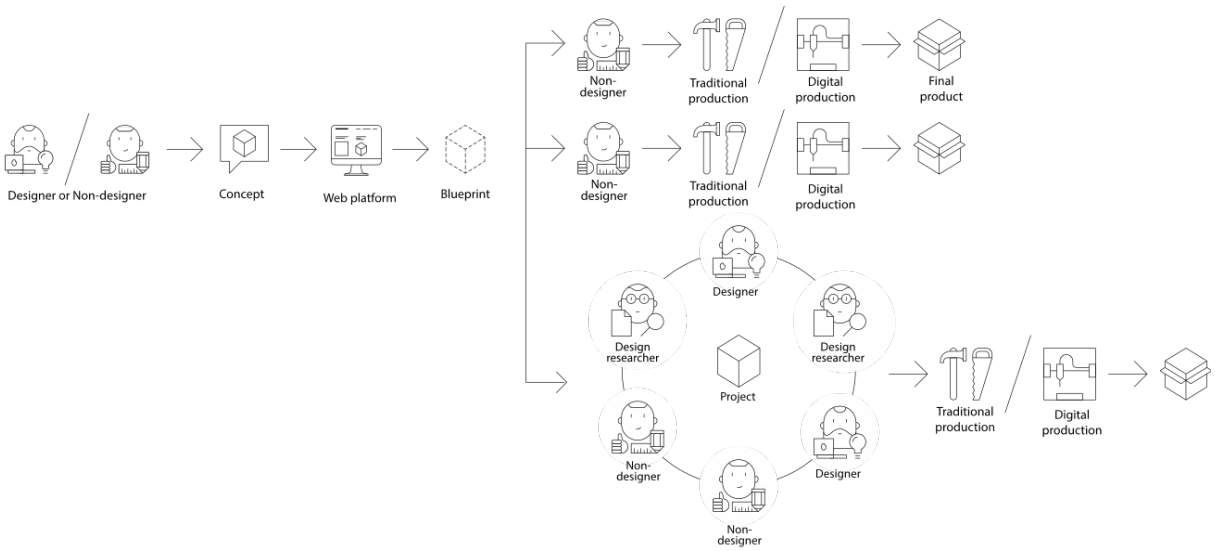

Figure 7. Approaches of openness used by Thingiverse. Source: Silvia Gasparotto.

The same combination may be seen in almost every case study collected by this research study (Table 3). For example, Rep-Rap is a mixture of OS, CO and OM and Open Ideo involves both CO and CR.

Table 3.

Case study	**"Open paradigm" approaches**
Rep Rap	OS + CO + OM
Arduino	OS + CO + OM
Fab Lab Network	OM + OS + CO
Instructables	OM + OS + CO
Openmoko	OS + OM + CO
Quirky	CR + CO
Thingiverse	OM + OS + CO
OpenIdeo	CR + CO
Innocentive	CR + CO
Linux	OS + CO
Local Motors	OS + OM + CO
Open Source Ecology	OS + OM + CO
Wiki House	OS + OM + CO
Autoprogettazione - Enzo Mari	OS + OM
Github	OS + OM + CO
Kickstarter	CR + CO
Open Structure	OS + OM + CO
Ponoko	OM
Shapeways	OM
Threadless	OM + CR + CO

Finally, for a unitary comprehension of the "open paradigm", it was useful to collect and synthetize some of the main attributes of each approach (Table 4) in order to understand which tools, resources and skills are used most, and how the designer behaves.

Table 4. Main attributes of the four approaches of the "open paradigm" in the design field.

	OD	**CO**	**CR**	**OM**
Dynamics	Use of the open source approach in the development of physical objects	Use of different methods of collaboration for developing projects.	Different methodologies that involve the crowd in design activities	The production of physical objects by a Fab Lab, desktop manufacturing or micro-factories
Tools	Computer with 3d/CAD programs, Fab Lab, 3d printers and other open manufacturing machines	Collaborative tools (mostly associated with an online platform) such as chats, forums, private mailboxes	Platforms that enable design challenges	3d printers, laser cutting, Fab Labs and other networked production tools
Resources	Web platform, Online communities	Web platform, Online communities	Web platform, Online communities	Different materials (eg. Plastic filament for 3d printer, wood, etc), and different production machines
Design skills	Sketching, three-dimensional modelling ability and CAD, prototyping, testing	Sketching, conceptualizing	Sketching, conceptualizing, modelling, CAD, prototyping, testing	Sketching, 3d modelling, CAD
Other skills	Programming	–	–	Use manufacturing machinery (both manually and digitally).
Design facilitation	Not required	Sometimes required, especially in real experiences	Not required	Sometimes required for helping to develop and prototype ideas.
Designer role	The designer could be the initiator of the project, but also one of the developers	The designer, when required can be the facilitator of a co-design process or he could be just a simple member of the group	The designer is usually one of the participants in the challenge, sometimes could also be the developer of another's idea	The designer helps with the development of the 3d/2d model and the production of the object or produces the object directly himself

In particular, it becomes clear that, although many design skills are necessary, the role of the designer is not always required. The established role of designers, non-designers and companies is blurred: in this area of intervention designers who voluntarily offer their skills, resources and projects, coexist with non-designers who possess particular design skills, inventors, engineers, makers and independent producers. This leads, especially in OS and OM, to the fabrication of many objects (Carelli, Bianchini & Arquilla, 2014) which sometimes have relevant functional and aesthetic attributes, but often seem to be nothing more than prototypes. The problem concerning the aesthetics of the product in the "open paradigm" is

of fundamental importance. Openness to non-designers and access to new digital production technologies facilitate free experimentation and prototyping that lead to results that are often precarious in both appearance and usability. Indeed, Vincenzo Cristallo (2015) stated that, in these areas, we have moved from the "aesthetic of beauty" to a new category, defined as the "aesthetics of experimentation" based on trial and error rather than on design culture. The role of the designer seems to diminish in importance in CO and CR as well: in the first case because the common dynamics of the different collaborative methodologies are not always applied in online platforms, preferring a more generic and spontaneous form of collaboration, and in the second case because to do his work, the designer must participate in a challenge with many others designer and non-designers, without the certainty that the project he developed will, in the end, be realized.

5 Conclusion

This research study was born from the necessity to better understand a comprehensive field, not yet fully detailed, that brings together openness and design. The very expression “open design”, which better qualifies this field, carries within it a variety of different meanings and related arguments.

Starting from the lack of agreement observed in both the literature and the case studies, the goal of this paper was to identify and define a broader area of intervention for design that can be called “open paradigm” in the field of design.

Dennett (2013, see introduction) argues that one of the most important “thinking tools” is the “scaffolding”: “You can shingle a roof, paint a house, or fix a chimney with the help of just a ladder, moving it and climbing, getting access to only a small part of the job at a time, but it’s often a lot easier in the end to take the time at the beginning to erect some sturdy staging that will allow you to move swiftly and safely around the whole project." This research study seeks to build the above-mentioned scaffolding – or categorization – from which to start exploring a field that is still “under construction”.

Following a review of the literature and the analysis of the case studies, four different approaches to openness have been found in both the design and the manufacturing stages: OS – Open source approach, CO – Collaborative approach, CR – crowd approach and OM – open manufacturing approach. These clusters are very different from each other and relate to different stages of the design process.

In identifying and describing the four different approaches of the “open paradigm”, the research has determined that the established way of doing design and the traditional role of the designer have changed in this particular field. Though the tools remain approximately the same, the “open” approach to design is not grounded in the design culture. This leads to a lack of planning and anticipation, an essential element for the design discipline. At the same time the role of the designer becomes marginal.

Although the design discipline has many obstacles to overcome, there are also many promising aspects to making the “open paradigm” a productive environment for developing innovative projects. For example, design should be able to connect different areas of knowledge, rework and synthesize new concepts, theories and discoveries, bring greater value to the design culture and finally create interdisciplinary networks that can meet the new tangible and intangible needs of people.

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Appendix 1

Case study	Rep	Website	Brief description[1]	Why is it cited in an open design paper?	What form does it take?	Which methodologies have been applied in the case study?
Rep Rap	13	www.reprap.org	"RepRap takes the form of a free desktop 3D printer capable of printing plastic objects. Since many parts of RepRap are made of plastic and RepRap prints those parts, RepRap self-replicates by making a kit of itself - a kit that anyone can assemble given time and materials."	Rep rap is the most cited case study in literature on open design. It uses the open source process for the development of replicable 3d printing.	Web Platform	Open design, Co-design, open manufacturing, open distribution, DIY, personal or self-fabrication, open source, distributed manufacturing, open production, open hardware peer production
Arduino	8	www.arduino.cc	"Arduino is an open-source electronics platform based on easy-to-use hardware and software. It's intended for anyone making interactive projects."	Arduino is cited in the literature because it is an open source tool for prototyping open design objects.	Tool	Open design, co-design, co-creation, open manufacturing, open distribution, DIY, personal or self-fabrication, open source, distributed manufacturing, open production, open hardware peer production
Fab Lab Network	7	www.fablabs.io	"A Fab Lab is a technical prototyping platform for innovation and invention, providing stimulus for local entrepreneurship. A Fab Lab is also a platform for learning and innovation: a place to play, to create, to learn, to mentor, to invent."	The Fab Lab network provides manual and digital production tools for prototyping and manufacturing physical objects.	Set of tools	Open design, co-design, co-creation, open manufacturing, personal or self-fabrication, open distribution, DIY, open source, distributed manufacturing, open production, open hardware

[1] Descriptions are taken from the websites. All websites were last accessed on September 25, 2018

Instructables	5	www.instructables.com	"Instructables is a platform for you to share what you make through words, photos, video and files. From a one step recipe to a 100 step jet engine build, everyone has something to share. Join the biggest DIY community on the web."	Instructables is mostly cited because it is a platform for sharing DIY "recopies".	Web Platform	Open manufacturing, open design, Co-design, open distribution, DIY, personal or self-fabrication, distributed manufacturing, open production, open hardware peer production, meta-design, user-creation
Openmoko	5	www.openmoko.com	"Openmoko™ is a project dedicated to delivering mobile phones with an open source software stack. Openmoko was formerly associated with Openmoko Inc, but is now simply a gathering of people with the shared goal to "Free The Phone"."	Openmoko is an open source cell phone.	Web Platform	Open design, open manufacturing, open distribution, DIY, open source, distributed manufacturing, open production, open hardware
Quirky	5	www.quirky.com	"Quirky is a free community-led invention platform that brings real people’s ideas to life. Invention is hard. It requires a diverse set of skills, and it costs a lot of money. Everyday people have brilliant ideas but no way to see them become real products. Quirky makes inventing and selling products possible by pairing inventors with product designers and big manufacturing companies that can bring their ideas to life."	Quirky is a platform that enables open innovation on physical objects.	Web Platform	Co-design, co-creation, crowdsourcing, meta-design, design thinking, co-development, co-innovation, user-creation, community based development, crowd production, crowd-creativity, crowd-innovation, horizontal innovation

Thingiverse	5	www.thingiverse.com	"MakerBot's Thingiverse is a thriving design community for discovering, making, and sharing 3D printable things. As the world's largest 3D printing community, we believe that everyone should be encouraged to create and remix 3D things, no matter their technical expertise or previous experience."		Web Platform	Open design, co-design, co-creation, open manufacturing, open distribution DIY, personal or self-fabrication, open source, distributed manufacturing, open production, open hardware peer production
OpenIdeo	5	www.openideo.com	"Founded in 2010, OpenIDEO—IDEO's open innovation practice — enables people worldwide to come together and build solutions for today's toughest societal problems. Online and around the globe, OpenIDEO works with world-class partners to convene diverse communities that collectively develop ideas and accelerate social innovation. OpenIDEO's platform expands on the power of crowdsourcing, equipping participants with resources, connections, and design tools to create real impact."	OpenIdeo is an innovation platform that works on an important world challenge. It gives the community the possibility to participate and offer its contribution.	Web Platform	Co-design, co-creation, crowdsourcing, meta-design, design thinking, co-development, co-innovation, user-creation, community based development, crowd production, crowd-creativity, crowd-innovation, horizontal innovation
Innocentive	4	www.innocentive.com	"Distributed in a previously unsearchable crowd are insights, flashes of genius and ideas that would never have been evident from job applications, resumes or consulting brochures. InnoCentive provides the network, methodology, platform, and expert support needed for the innovative	InnoCentive is mostly cited because of its crowd based innovation system on high level challenges.	Web Platform	Crowdsourcing, co-development, co-innovation, user-creation, crowd production, crowd-creativity, crowd-innovation

			potential of this connected world to be fully realised."			
Linux	4	www.linux.org	"Linux is the best-known and most-used open source operating system."	Linux is the most famous open source software.	Software	Open design, open distribution, open source, peer production
Local Motors	4	www.localmotors.com	"Local Motors is a ground mobility company focused on shaping the future for the better. Founded in 2007 with a belief in open collaboration and co-creation, Local Motors began low volume vehicle manufacturing of open-source designs using multiple micro-factories."	Local Motors is a company that works with open source and crowdsource processes to improve and innovate the world of vehicles.	Web Platform	Open design, co-design, open manufacturing, open distribution, DIY, personal or self-fabrication, open source, distributed manufacturing, open production, open hardware peer production
Open Source Ecology	4	www.opensourceecology.org	"We’re developing open source industrial machines that can be made for a fraction of commercial costs, and sharing our designs online for free. The goal of Open Source Ecology is to create an open source economy – an efficient economy which increases innovation by open collaboration."	Open source ecology shares open source blueprints and instructions for building industrial machines	Web Platform	Open design, co-design, open manufacturing, open distribution, DIY, personal or self-fabrication, open source, distributed manufacturing, open production, open hardware peer production

Wiki House	4	www.wikihouse.cc	"WikiHouse is an open source project to reinvent the way we make homes. It is being developed by architects, designers, engineers, inventors, manufacturers and builders, collaborating to develop the best, simplest, most sustainable, high-performance building technologies, which anyone can use and improve."	Wikihouse shares open source blueprints and instructions to build affordable houses.	Web Platform	Open design, Co-design, participatory design, open manufacturing, open distribution, DIY, personal or self-fabrication, open source, distributed manufacturing, open production, open hardware peer production
Autoprogettazione - Enzo Mari	3	www.corraini.com/it/catalogo/scheda_libro/62/Autoprogettazione	"Autoprogettazione" was an exhibit and later a book written by Enzo Mari and edited in 1974. He gives anyone instructions for manufacturing and assembling simple wood furniture.	Autoprogettazione is one of the first open design and DIY experiments.	Book	Open design, open manufacturing, open distribution, DIY, personal or self-fabrication, open production
Github	3	www.github.com	"GitHub is a development platform inspired by the way you work. From open source to business, you can host and review code, manage projects, and build software alongside millions of other developers."	GitHub is a platform for sharing open source projects (both hardware and software) and tracing the "forking".	Web Platform	Open design, co-design, co-creation, open manufacturing, open distribution, DIY, personal or self-fabrication, open source, distributed manufacturing, open production, open hardware peer production
Kickstarter	3	www.kickstarter.com	"Kickstarter helps artists, musicians, filmmakers, designers, and other creators find the resources and support they need to make their ideas a reality. To date, tens of thousands of creative projects — big and small — have come to life with the support of the Kickstarter community."	Kickstarter is a crowdfunding platform.	Web Platform	Crowdfunding

Open Structure	3	www.openstructures.net	"The OS (OpenStructures) project explores the possibility of a modular construction model where everyone designs for everyone on the basis of one shared geometrical grid. It initiates a kind of collaborative Meccano to which everybody can contribute parts, components and structures."	Open structure is a platform that shares modular components, based on a grid, for the assembly of physical objects.	Web Platform	Open design, co-design, co-creation, open manufacturing, open distribution, DIY, personal or self-fabrication, open source, distributed manufacturing, open production, open hardware peer production
Ponoko	3	www.ponoko.com	"Ponoko provides laser cutting & engraving services to turn your designs into custom products. You select from 99+ beautiful materials, download our design template, add your design to it, then upload it to get an instant online quote to make your design real."	Ponoko is a service that enables the self-production (DYI) of objects thanks to rapid prototyping machines.	Web Platform	Open manufacturing, open distribution, DIY, personal or self-fabrication, distributed manufacturing, open production
Shapeways	3	www.shapeways.com	"Shapeways has set out to redefine product creation. It is a platform that enables the full creator experience through design, making, and selling--born out of its consumer 3D printing service, the largest in the world."	Shapeways is a platform for designing, manufacturing and selling 3d-printed objects.	Web Platform	Open manufacturing, open distribution, DIY, personal or self-fabrication, distributed manufacturing, open production
Threadless	3	www.threadless.com	"What started as a t-shirt company has since expanded into a full lineup of apparel, accessories, home decor, and now footwear canvases."	Threadless is one of the first companies to enable accessory customization.	Web Platform	Open manufacturing, open distribution, DIY, personal or self-fabrication, distributed manufacturing, open production

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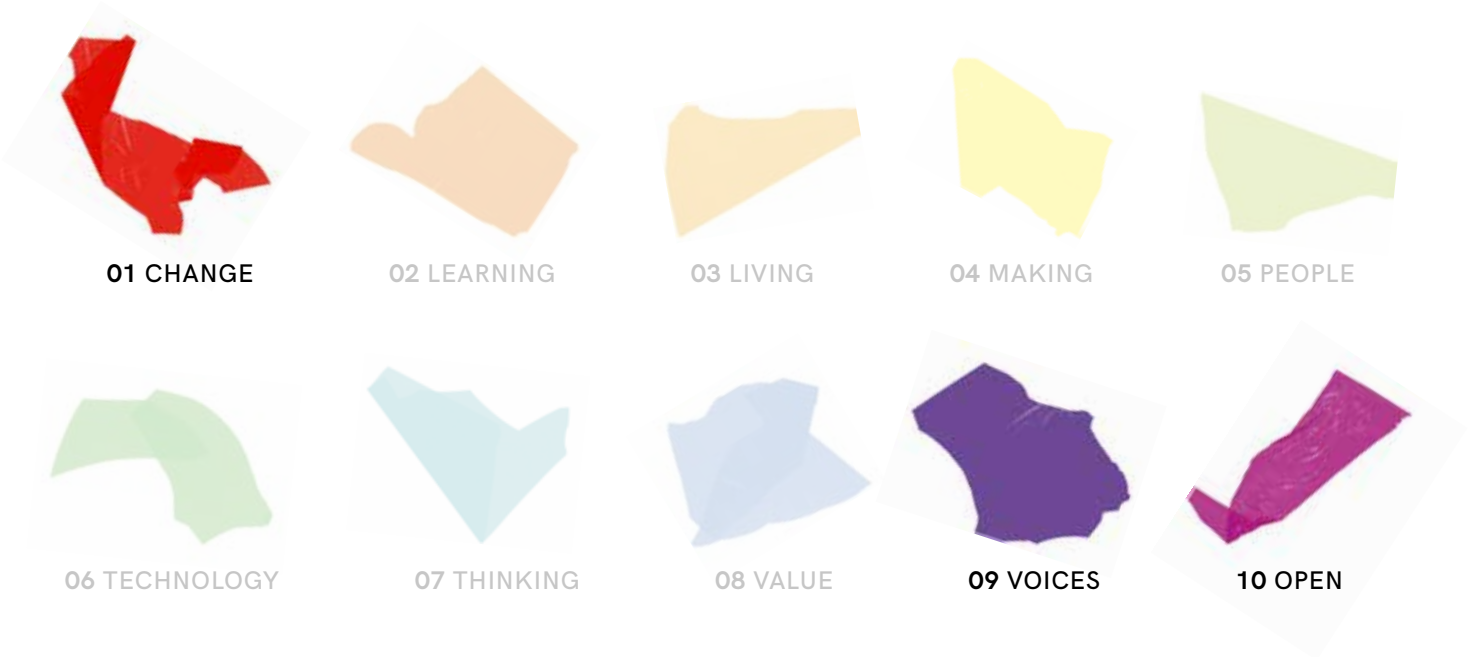

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