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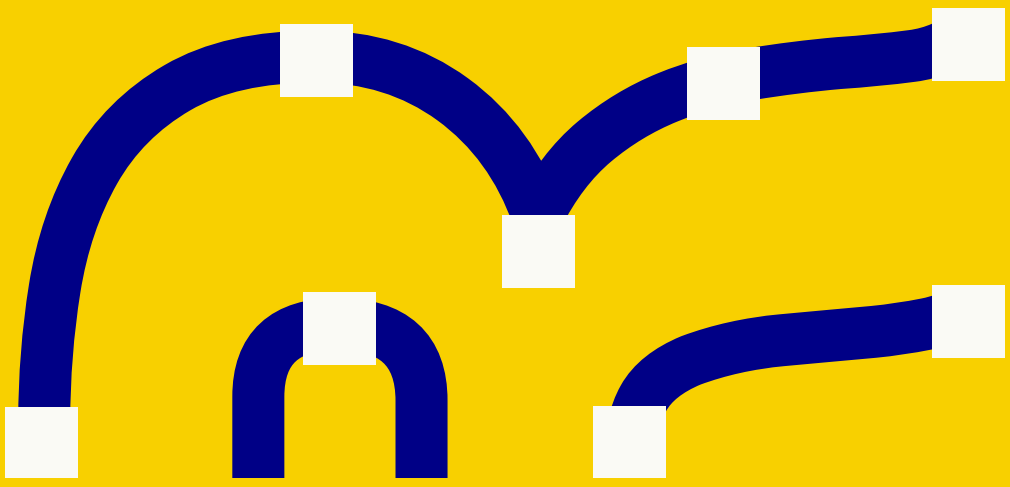

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Exploring collaborative processes between maker laboratories, designers and companies moving from 3rd to 4th industrial revolution

Massimo Bianchini, Venanzio Arquilla, Massimo Menichinelli, Guillermo Gustavo Florez Vazquez

Abstract

The present paper explores the relationship between makerspaces, Fab Labs and other maker laboratories, designers and companies to verify if these subjects are developing collaborative processes and producing a new systemic innovation model in terms of circular economy.

The pioneering stage of the Makers Movement, fostered by techno-evangelists like Chris Anderson and Dale Dougherty (Anderson 2012; Hatch, 2014; Dougherty 2015), is almost over. For more than a decade the impressive growth of maker labs (maker spaces and Fab Labs) has created a hype about their effective role as new production places distinguished by open and peer-to-peer practices. These spaces have multipurpose technologies and multidisciplinary communities (professionals and amateurs) potentially able to materialise almost anything (Gershenfeld, 2005). But today, "anything" means overall materialise experimental prototypes, unique pieces, micro-collection and components that complete products made by other subjects. Economic and technological limits of many maker laboratories (such as basic technologies not easily upgradable because they are undercapitalised) combined with aesthetic, functional and material aspects of artefacts made by makers are still far from being appreciated by the market. In parallel, an increasing number of unemployed or with low wages designers and creative professionals need to transform themselves into self-employees or self-entrepreneurs and are then claiming easier access to the means of production. Finally, SMEs and craftsmen need to digitally transform their products and production processes to intercept a new generation of customers that are evolving into community-market and user innovators (Von Hippel, 2005 and 2016). For these reasons, it can be interesting to investigate if and how these subjects can strategically work together to exceed their limits and develop collaborative production models related to circular economy.

Starting from this assumption, the first part of the paper explores the latest evolution of maker labs, designers and manufacturing companies. A state-of-the-art based on literature review identifies general issues, critical aspects and opportunities about collaborative processes developed by these subjects. The emerging research questions generated a subsequent fieldwork study. The second part shows the results of a study conducted in 2017 on 25 maker labs

located in countries characterised by a high density of these spaces and a consistent presence of designers and manufacturing companies. Sections 1 and 2 of the study describes the maker labs involved analysing their system of relationship with designers and companies. Third and fourth sections analyse the collaborations between maker labs and designers and between maker labs and companies. The last section analyses the projects developed by maker labs involving communities of designers and companies. The whole study aims to reveal if these collaborations can generate sustainable product-services materialised thanks to open and distributed production models. The third and final part analyses the results of the study to define bottlenecks and best practices that inhibit or enable innovation models based on collaboration between makers, designers and companies. The conclusions put these guidelines in the Fourth Industrial Revolution scenario.

Theme: Innovation
Keywords: maker laboratories, designers, manufacturing SMEs, distributed production, collaborative processes, circular economy

1. Collaboration between maker laboratories, designers and companies. A (first) state-of-the-art

1.1 The context

In the last decade, the growth of the Maker Movement and its "maker laboratories" such as Fab Labs, makerspaces, hackerspaces and all other sort of community-based fabrication spaces can be considered as a tangible evidence of a socio-technical transformation process that economists and sociologists have defined "The Great Transformation" (Polanyi, 2001; Brynjolfsson and McAfee, 2014). It is a paradigmatic change, which involves the structure of our productive systems, enabled by a transformation of the nature of work influencing the design and materialisation of product service systems, their market and relation with the human user. In this emerging context, it is plausible to think that figures such as makers or user and free innovators (Von Hippel et al., 2011; Von Hippel, 2016) are examples of a growing process of hybridization between individuals and democratized technologies for design, materialization, communication and distribution of artefacts, also adopting a clear post-humanistic

perspective (Braidotti, 2007). Many scholars chronologically placed makers and maker labs on the most advanced limit of the Third Industrial Revolution (Anderson, 2011 and 2013), two paradigmatic symbols of this age. Makers have been described as independent innovators able to concentrate on a personal-collaborative dimension design skills, scientific-technological skills, entrepreneurial skills, and communication-dissemination skills. Maker labs have been defined as enabling spaces for these new figures, and like other (micro) places such as homes, offices, gardens, they can be considered as atoms or minimal units of a sharing and circular economy model that "will allow people to monetize everything from their empty house to their car." (World Economic Forum, 2016, p.4). Makers can also be viewed as an intergenerational class of independent innovators – far removed from the concept of (urban) creative classes developed in the 2000s (Florida, 2002 and 2017) – which can emerge autonomously thanks to the fact that they can (more) easily access, possess or build the means of production, at least the ones with require less resources and are openly shared as open source hardware. This statement could sanction the possible return of the primacy of the individual to capital or the transformation of individuals from "simple" consumers of products to new consumers of processes (communication, manufacturing,...). In that sense, the extraordinary and growing concentration of economic, social and technological power held by the champions of the Third Industrial Revolution cannot be ignored. On the other hand, the rapid theorization of the transition from the Third to Fourth Industrial Revolution (Schawb, 2016) seems to bring back in the field of production of goods and services new and technologically advanced forms of supremacy by economic-financial capital. Forms of production that are developing through the computerization and robotisation of work, progressively disabling individuals with less creative and technological skills (Frey and Osborne 2013; Acemoglu and Restrepo, 2016) and introducing new forms of collaboration between human and non-human agents. The technological convergence between (big) data production and digitalization of products and production fostered by the Fourth Industrial Revolution logic is considered so pervasive that could influence the upgrading of Society, from Industry 4.0 to Society 4.0 (Floridi, 2014). The whole Maker Movement has then a role in this transition thanks to its efforts in democratizing digitalization of production with open and sharing processes.

1.2 The Maker movement: entering the second phase

Within this framework, the evangelistic and pioneering stage of the Maker Movement, fostered by techno-evangelists like Chris Anderson and Dale Dougherty (Anderson 2012; Hatch, 2014; Dougherty 2015), can arguably consider almost over. For example, signs of this transition can be found in the crisis of 3D Robotics, the drone business founded by Chris Anderson (Mac 2016), or in the bankruptcy of TechShop (Woods 2017). The impressive and fast growth of maker labs, maker spaces and Fab Labs[1], this defines a hype about their effective role as new production places characterised by open and peer-to-peer practices. Maker labs are and remain single spaces with factories or craft workshops. They have multipurpose technologies and multidisciplinary communities (professionals and amateurs) potentially able to materialise "almost anything" (Gershenfeld, 2005). But today, "anything" means overall materialise experimental prototypes, unique pieces, micro-collection and components that complete products made by other subjects. Economic and technological limits of many maker laboratories (basic technologies not easily upgradable because they are undercapitalized) combined with aesthetic, functional and material aspects of artefacts made by makers are still far from being appreciated by the market. In parallel, an increasing number of unemployed or with low wages designers and creative professionals need to transform themselves into self-employees or self-entrepreneurs and are then claiming easier access to the means of production. Finally, companies (mainly SMEs and craftsmen) need to digitally transform their products and production processes to intercept a new generation of customers that are evolving into community-users and user or free innovators (Von Hippel, 2005 and 2016).

From the beginning, the growth of the maker labs was accompanied by a series of reflections focused not only on the ability of these spaces to enable independent user innovators and maker communities, but also on their economic, technological, social and environmental sustainability (Troxler and Schweikert 2010; Wolf and Troxler, 2016; Kothala, 2015; Maldini; 2016). Many maker labs have been created and/or sustained thanks to or by public funds, or with personal financial resources or with poorly planned business models. The majority of them are economically undercapitalised and characterised by fragile business models (Clapaud, 2016).

1 The first Fab Lab was created in 2003; at the time of writing the total number of Fab Labs is now estimated at around 1,200 spaces (source: FabLabs.io)

In this sense, the recent bankrupt of TechShop (Woods, 2017), a commercial franchising of maker facilities roughly ten times larger than common Fab Labs or maker spaces, or the crisis of 3D Robotics (Mac 2016), reveal the problem of economic sustainability for the maker economy, in which they previously considered stars and relevant success cases. The business models of maker labs are based on a diversified mix of activities for different stakeholder groups: education, materialization of artefacts (prototyping and digital fabrication services), research and consultancy (pilot projects, research programmes), cultural events, communication. It is a volume of activities basically managed by very few people, which aims to stimulate the creation of a community-market made by professional and amateur users (Bianchini e Maffei, 2016) and (try to) collaborate with bodies, institutions and companies.

For many maker labs, the creation of "one's own makers' community", possibly composed of a large number of Makers Pro, user, free and citizen innovators (Eskelinen et al., 2015; von Hippel, 2016) and indie designers, represents one of the most important objectives. Makers' communities are made by undercapitalised individuals and professionals, people that can generally guarantee a low and discontinuous level of economic exchange with maker labs. Nevertheless, the existence and presence of a (basically) high skilled makers' community is fundamental for the maker labs. This aspect is crucial to increase the innovation potential of maker labs, their design and operational capabilities, their reputation and role within the international makers' community. In this way, these labs can become more innovative and attractive. In many cases, the creation and development of a local makers' community require maker labs to lower their barriers to access the space: investment in technology, organization of initiatives and events dedicated to the community, more favourable economic conditions for the use of machines. These conditions can lead maker labs to interact with the makers' community establishing a peer-to-peer collaborative and reciprocal logic. On the one hand, the maker labs support their communities to develop activities and experimental projects that can also lead to entrepreneurial initiatives. On the other hand, makers' communities can support the maker labs to organise activities aims at generating economies for these spaces: educational events, but also an extended growing participation in competitive research activities collaborating with bodies and institutions, and sometimes companies. The recent involvement of many European maker labs in competitive European research and projects (e.g.

H2020 CAPS project like MAKE-IT[2], OpenCare[3], OpenMaker[4], Digital DIY[5]; Creative Europe projects like Made@EU[6] and Interreg programmes like FabLabNet[7]) demonstrates this aspect. In particular, some of these projects work specifically to enables the growth and governance of the Maker movement in different directions: development of social innovation practices; stimulation of open source and digital maker practices and open design engaging citizens and institution; brings together mainstream manufacturers and makers in ecosystems, built to enable cross-boundary partnerships for innovation; creating a new distributed market for makers and designers[8].

1.3 Maker labs and companies

The relationship between maker labs and enterprises is different: it is less straightforward and can be influenced by territorial and political variables. In fact, maker labs can interact in many ways with companies, ranging from big corporations to local SMEs and craftsmen, to no interaction at all. As a starting point, there are several companies offering software and hardware for digital fabrication processes that are very "close" to the Maker movement and maker labs (either because they are their markets or because the companies themselves originated from them), supporting people and spaces providing them cost-effective technologies and/or tools or sponsoring their initiatives: examples can be found in Sparkfun[9], Adafruit[10] or WASP[11]. Established companies typically turn to maker labs as service for prototyping, or in other cases to organise activities such as workshops and hackathons having a double purpose: identify new ideas and/or talents to be integrated into their businesses. In France, companies like Airbus and Renault created their internal maker

2 http://make-it.io/
3 http://opencare.cc/
4 http://openmaker.eu/
5 http://www.didiy.eu
6 https://madeat.eu/
7 http://www.interreg-central.eu/Content.Node/FabLabNet.html
8 The Distributed Design Market Platform project (2017–2021) funded by EU in the Creative Europe Platform call works to create a European Commercial platform for independent designers and makers.
9 https://www.sparkfun.com/
10 https://www.adafruit.com/
11 http://www.wasproject.it/w/en/

spaces and are even establishing a network called Fab&co among these business-oriented internal spaces (Chevrier 2015). In Italy, a context characterized by the presence of local production systems based on manufacturing and SMEs, the maker labs have been started typically by private individuals or groups of them. Later, the labs started to network in regional clusters, sometimes with the help of regional institutions, in order to develop local collaborative systems capable of providing innovation services to local companies. An example can be found in the Mak-ER[12] network and in the Fab Lab Toscana[13] Initiative. Furthermore, companies also seek collaborations based not only on the development of products of services, but also for the support of strategic values: for example, large corporations such as Chevron have built partnerships with Fab Foundation (the foundation that emerged from the Center for Bits and Atoms at MIT in order to support the global Fab Lab network) in non-profit initiatives[14].

1.4 Collaboration between maker labs, designers and companies

The interactions between maker laboratories and enterprises take then several forms, pointing to a potential rich ecosystem of initiatives beyond the typical depiction of the Maker movement as just about DIY projects or manufacturing of only Maker products. Starting from this setting, maker labs can become an emerging "third party" in the traditional relationship between designers and companies, because digital technology and digital making are enabling an increasing population of indie creative professionals to act as designer-enterprises (Bianchini and Maffei, 2012). This connection is explored in few pieces of research that investigate, within the Maker movement, the working condition of makers and designers and how Maker initiatives improve their entrepreneurship attitudes and organizations while still being part of the movement. On one side, makers and designers (at least in Italy) are increasingly trying to transform their making activities into their main professional practice, but for only a part of them, this is possible (Menichinelli et al. 2017). This is not an easy task, and several archetypal trajectories are possible for the dynam-

12 http://www.mak-er.it/
13 http://www.fablabtoscana.it/
14 https://www.chevron.com/stories/fab-foundation

ic transition from makers to social enterprises and social entrepreneurs (Langley et al. 2017). Besides these contributions, the interactions between maker laboratories, designers and companies have been analysed only in very few cases. A preliminary and explorative search, conducted on scientific database (ISI Web of Knowledge and Scopus Elsevier) using a combination of research keywords ("fab labs", "makerspaces", "designers", "manufacturing", "SMEs", "Industry", "collaboration"), evidences a general lack of scientific literature (and knowledge) investigating the relationship between maker labs, designers and companies. There is a tiny number of scientific publications that cross at least two key research words. The most relevant topics are related to the potential of digital fabrication and peer-production in the maker communities, in the field of social innovation and in educational contexts. For these reasons, we decide to investigates *if* and *how* these three kinds of subjects are strategically working together in order to exceed their limits and develop collaborative production models related to the circular economy.

2. The analysis of collaborative processes between maker labs, designers and companies

2.1 Research Methodology

In the previous part, we defined in general terms who are the makers, how they interact with the maker labs, and how they are holding the emerging socio-technical challenges generating independent and peer-to-peer innovation. The purpose of exploring the role of makers from Third to Fourth Industrial Revolution is crucial towards a better understanding of how the phenomenon of maker spaces is evolving, specifically with companies and designer. In the previous part, we also tried to define the general nature of collaborative processes between makers, designers and maker labs, and between companies and maker labs, to better focus the basis and way of work of digital fabrication spaces. After that, we planned to develop and conduct an inquiry on a selected group of international maker spaces that will represent as the first prototype of a general survey should on a global scale. To have a better understanding of how maker labs are working or collaborating with designers and small, medium and large-scale enterprises in an international context, we decided to set up an online survey. The initial goal was to test a small-scale model of the survey to identify, circumscribe and analyse the first

range of activities that makerspaces have been doing for a couple of years. In particular, we aim to identify maker labs ways of working and how they had managed the projects developed collaborating with industry and companies, to know more about different ways of design, prototyping and materializing artefacts. Moreover, how they operate, the services they offer, and other activities that to stimulate the collaboration with designers and companies. The list of possible maker labs was made analysing that one with greater relevance or that have developed interesting projects and collaborated with companies. The first reference was based on the list of fablbas.io website (the global list of Fab Labs), where all the global laboratories are listed by country. One of the points to consider was to choose the countries that have more approved laboratories; this means that they are opening or developing many spaces like these because they have had positive results and they have generated impact on the economy, innovation or development of the region where they have been established. After that, an investigation was made to find best case studies through the fab lab´s webpage or social media, and see a general view of their way of working, some examples of projects and collaborations were founded, and according to this, the survey was formulated. The final selection takes into account the most important countries (US, Italy, and France); countries that have important international labs (super-nodes, e.g. Holland and Spain); countries that have important systems of design and large-scale industry (US, Germany and France) or small-medium industry (Italy and Spain), and finally countries characterized by a strong service-design sector (UK, the Netherlands).

2.2 Survey structure

The online survey was integrated with a total of 25 questions, some of them to open for general data and some others more specific and closed by check-list. For international Fab Labs in general, it was made in English language, and was applied through Google Forms; the link was sent by email with a personal request to each fabrication laboratory, and explaining them the objectives of the survey. The survey has been divided in five sections (see Table 1).

A total of 25 International Fab Labs and maker spaces has been selected and contacted intake part of the survey. 14 of 25 maker labs answered the survey (56%) in five months (May to August 2017) after three e-mails recall.

Section 1. General info about the Fab Lab / makerspace	Questions about History of the lab, employees and capabilities, equipment, activities and services.
Section 2. Fab Lab / makerspace system of relationship	Questions about skills of the lab community, network of relationship with designers, companies and other subjects.
Section 3. Relationship and collaboration with companies	Questions about companies that collaborated with the lab (sector, size, ...), kind and scope of the collaborations, and critical aspects and/or new opportunities related to collaborations.
Section 4. Relationship and collaboration with designers	Questions about designers that collaborated with the lab (disciplines, skills, ...), kind and scope of the collaborations, and critical aspects and/or new opportunities related to collaborations.
Section 5. Collaboration with companies and designers	Questions about projects that bring maker labs companies and designers together: kind of projects and outputs (e.g. distribution on the market), economic support received to stimulate the collaboration with companies and designers, critical aspects and/or ne w opportunities related to these collaborations.

Table 1. Sections and questions of the survey (general topics)

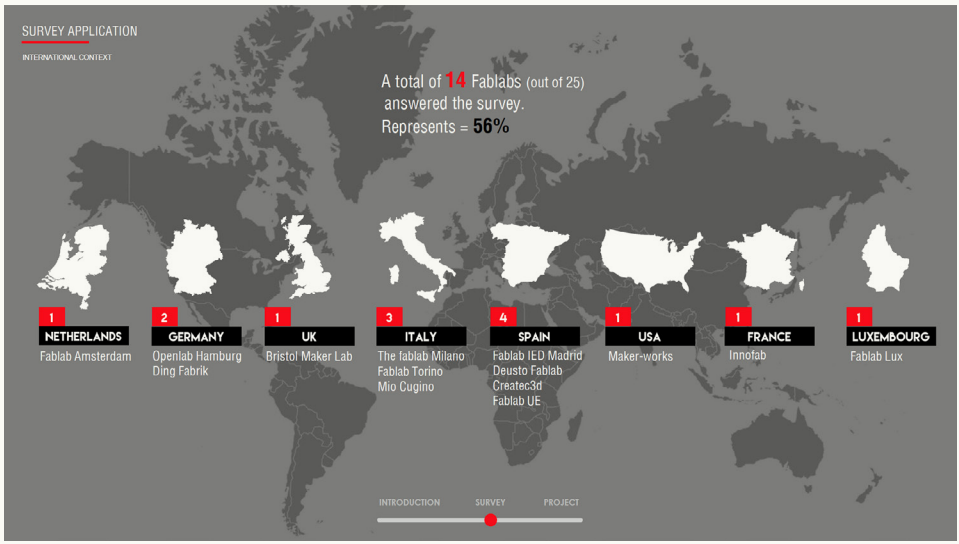
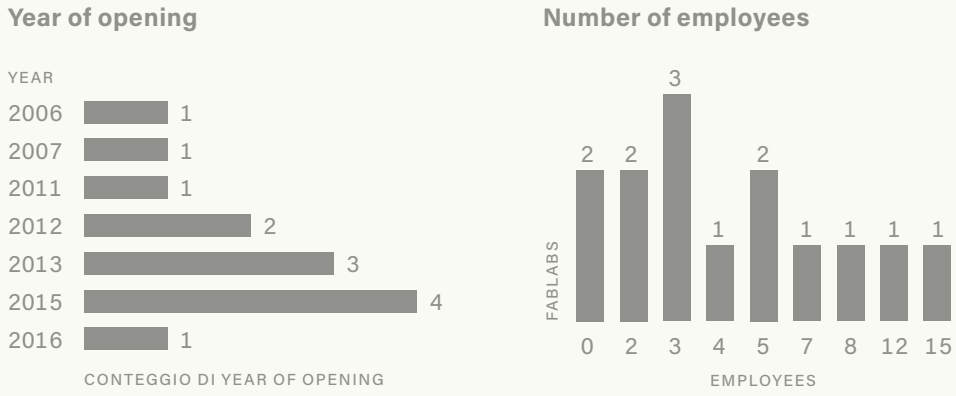


Figure 1. Map of the 14 Fab Lab / Makerspaces involved in the survey



Figures 2a and 2b. Year of opening and number of employees of the Fab Labs involved in the survey

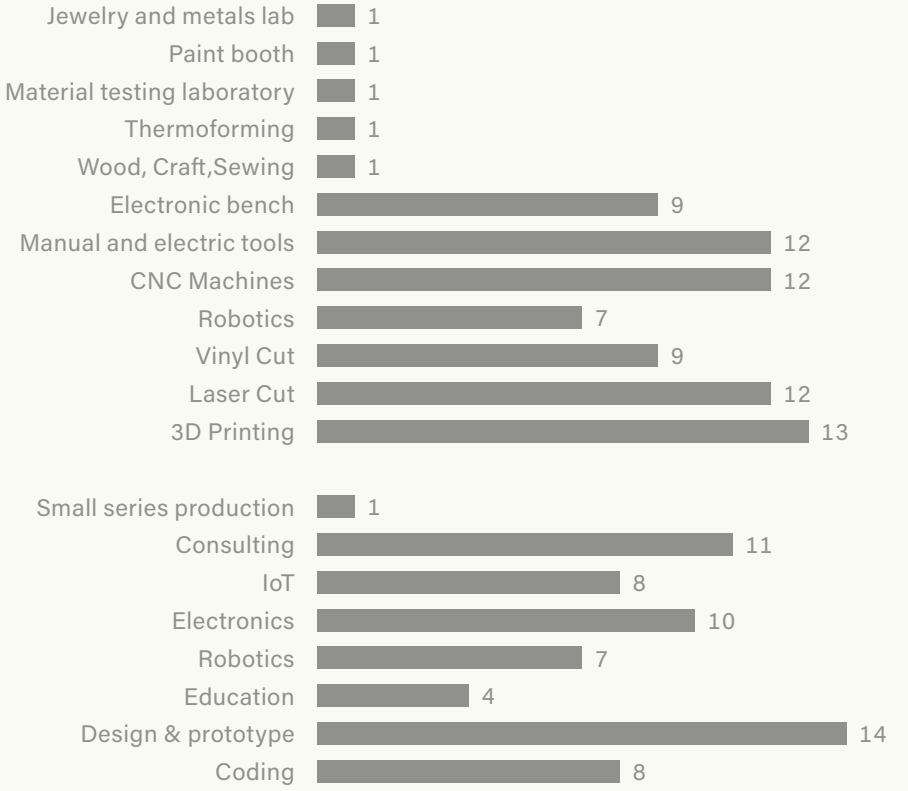
Other 11 maker labs involved that not answered the survey[15]. Possible reasons for the non-participation of these labs could be a lack of interest in the theme of the survey or a lack of time to participate.

2.3 General information about the Fab Lab / makerspace (Section 1)

In Europe, the maker movement and the establishment of fabrication laboratories began earlier than in other countries, for example, within the maker spaces that answered, we can observe that there are one establish since 2006 and 2007, following by one in the year 2011. Just like in other countries, we identify that between 2013 and 2015 was the hype period in which more Fab Labs and maker spaces started to appear, in this case, we can observe from the survey, that in 2015 there were established four of these. The Fab lab is typically small system with few employees. They are a community-based system where the population of participants is larger than the employed one. Looking at the numbers emerged from the survey in two of these maker spaces there are not employees[16] because rather they are more like enthusiast volunteers, people who love to make

15 Fablab Berlin (Germany), Protospace (Holland); Artilect (France), Makerversity (UK), OpenDot and Makers Modena (Italy), Artisans Asylum, NYC Resistor and TechShop (US)

16 Fablab Torino, Dinkfabrik.



Figures 3a and 3b. Technical equipment and skills/expertise of the Fab Labs involved in the survey

and share and organise themselves, in the other ones there are between 2 and 15 employees, from these laboratories that answer, the average is five employees for each one.

It is possible to see from the answers that not all these spaces are Fab Labs, as intended and structured by the Fab Academy. There is difference in the equipment and technologies, the most diffuse, maybe because costless and easy to be used, is the 3d printer, just in one, there are not. Other diffused equipment are the Laser cutters, manual and electric tools and CNC machines. In less quantity, there are also in some of these labs thermoforming machines, paint booths and jewellery workshops; this is in function of the context specialization and locations.

Design and prototype is the most common service this maker space offers. As known and discussed in the previous paragraph there are not

defined and sustainable business model for this kind of spaces; this reflects the differences in the diffusion of services and targets. In fact, rather than Design & Prototype, they offer different kind of consultancy to companies, schools, start-ups and people reflecting the general and large interest of the makers' movement. IoT, electronics and robotics are also popular within this fabrication laboratories. Is quite strange that only four centres offer education services just because this centre has a typical social function and many of them work as social enabler. From the survey emerges that maker labs are not (mass) production sites but micro and self-production sites.

2.4 Fab Lab / makerspace system of relationship (Section 2)

The community that lives these spaces is defined and sectorial. The knowledge needed to be active in these spaces don't make them open. A technical and skilled community made by Designers, Engineers, Students, Makers is the most prominent in the maker spaces, followed by architects, artists, entrepreneur people, and craftsmen. Is interesting to be noted

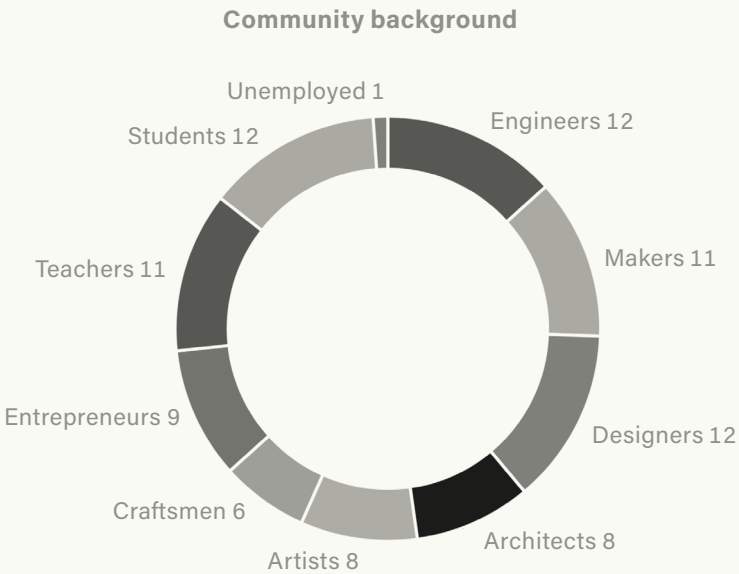


Figure 4a. Community background

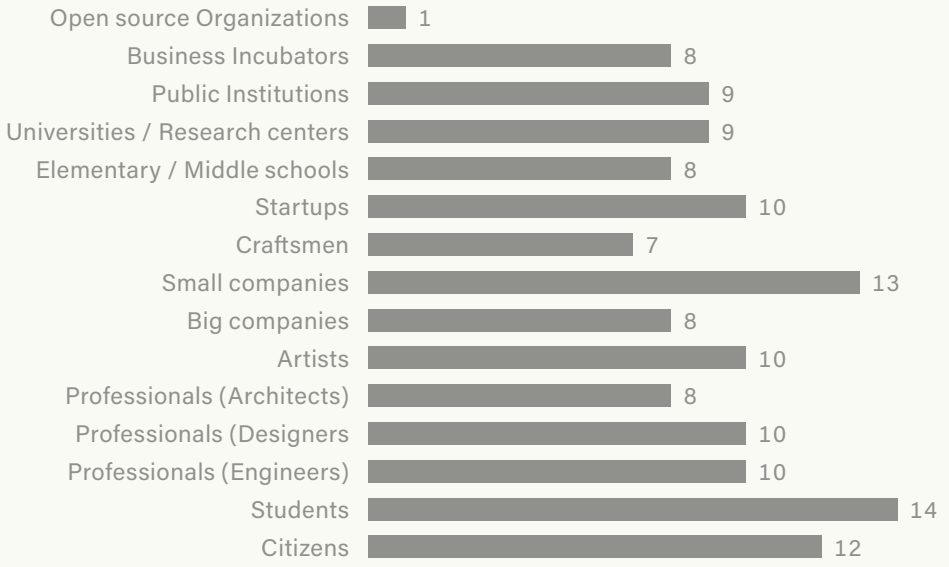


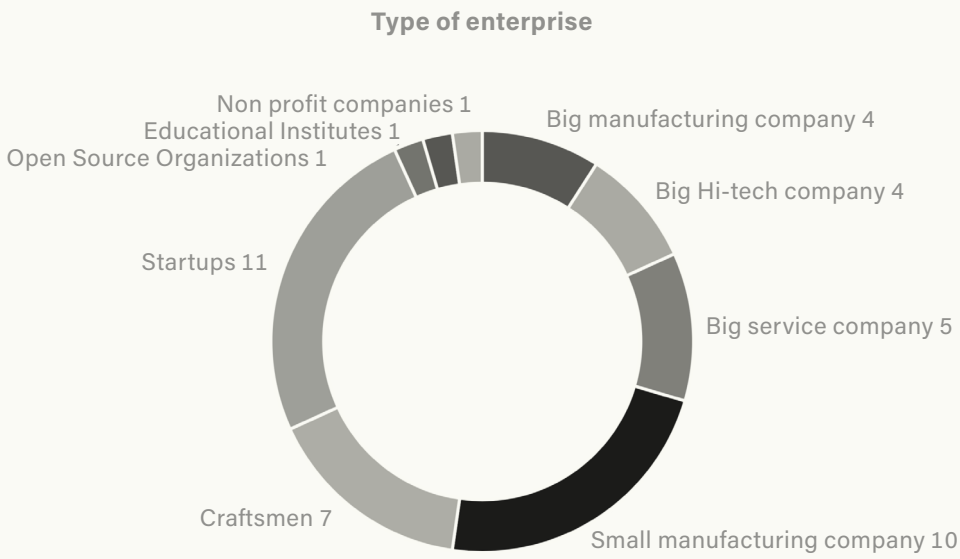
Figure 4b. Network of relationship of the Fab Labs involved in the survey

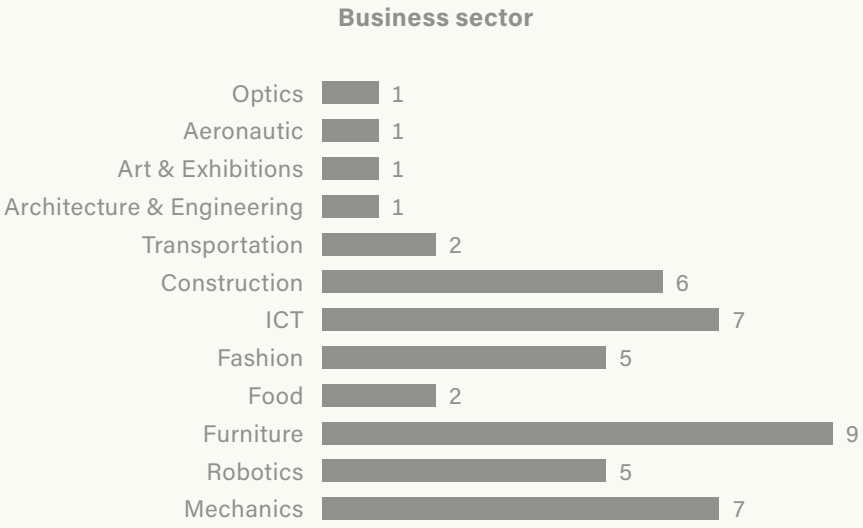
that in only one case unemployed people assist to these spaces, this highlight a potential of this spaces in employability, the capability of getting and keeping satisfactory work improving and renovating skills[17]. Students and small companies are the entities whom makerspaces collaborate the most. Regarding the professional areas, design, engineers and artist are important in the relationship with the Fab Labs; start-ups are also common in this type of centres. Sometimes, they conceived and develop a project that later is launched on the market.

2.5 Relationship and collaboration with companies (Section 3)

Among these laboratories there are some of them that have collaborated with more than 50 companies; some others even more than hundreds of them; some makerspaces don't keep a record of the number of projects

17 .Some spaces are working in this way, in the Ex-Filanda di Sulbiate (http://www.exfilanda.it/) the makerspace (http://www.makeinprogress.org/) works in relation to an employment office (Mestieri Lombardia) and offers training for the citizens and unemployed people, like the NEET (Not in Education, Employment or Training)





Figures 5a and 5b. Type of enterprise collaborates with the Fab Labs and related sectors

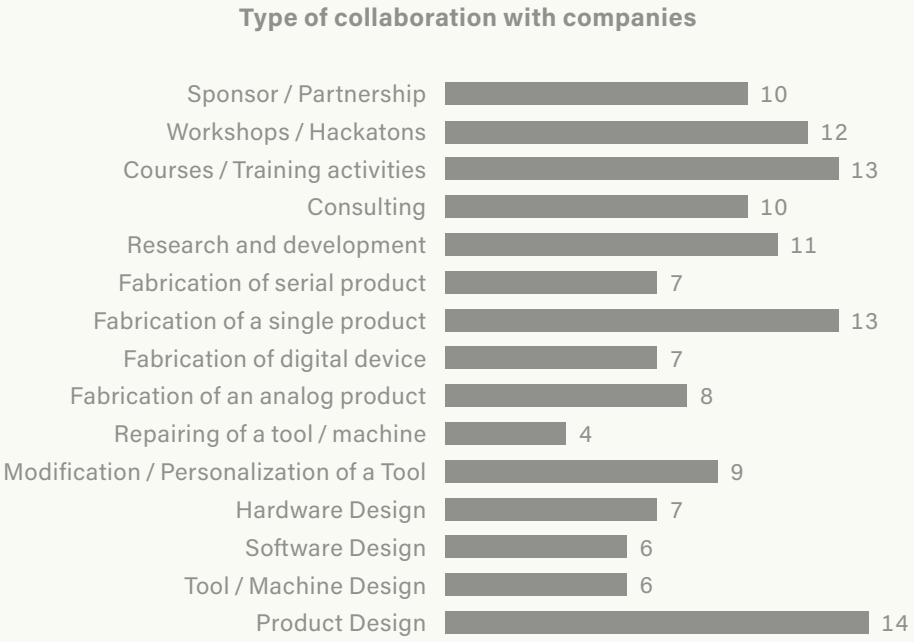


Figure 6. Types of collaboration with companies and services

or collaborations they do with companies. They just said that there were too many as well. On the other hand, some others have collaborated with a few companies, between 2 and 20. This means that there are not established relations between companies and Fab Labs. The numbers don't give us any structured indications because in some "experimental" projects were involved a large number of companies rather than structured activities were the relation usually is one to one. Also, there were no data on the continuity of the collaboration.

This aspect is confirmed also looking at the kind of companies they have been working with, most of them are start-ups, craftsmen and small manufacturing companies. The service offered is about consultancy on product design, since the generation of ideas to the design and prototyping until the phase of testing. This suggests the option for some of them to work as design and prototyping consultancies. In fewer cases, they worked with big companies (services, high tech and manufacturing) probably in experimental and contamination project (hackathons and workshops). Sims that businesses are attracted or fascinated by this kind of places and people, they try to collaborate if there is any free access or

experimental action (often paid by public or research funding) after that apparently each one goes in its' one way. The numbers emerged don't give us a better perception of the sustainability of this kind of services for the makerspaces, we are discussing in less the 40 companies for 14 makerspaces. All the maker labs analysed organize courses and training activities, workshops and hackathons. Most of them develop research activities in order to support small and medium companies in the development of new products. Going through the sectors, there is a strange mix of low-tech and high-tech sectors. The most important are the low complexity sectors such as Furniture, Mechanics, Construction, Fashion, Food that could be compared to the competences of the community discussed in Section 2. In the other hand, probably in the centre connected with universities or research centres, there is a sort of tech orientation with Robotics, ICT, Aeronautic and Optics.

2.6 Relationship and collaboration with designers (Section 4)

Also, deepening the relationship between makerspace and designers emerge the situation verified with the companies. Broad numbers of designer and a reduced number of projects/collaborations, most of them experimental or episodic. The numbers don't give the exact picture of this relationship if not connected with the typology of projects/actions and the continuity of this offers. Many of the makerspace involved don't keep

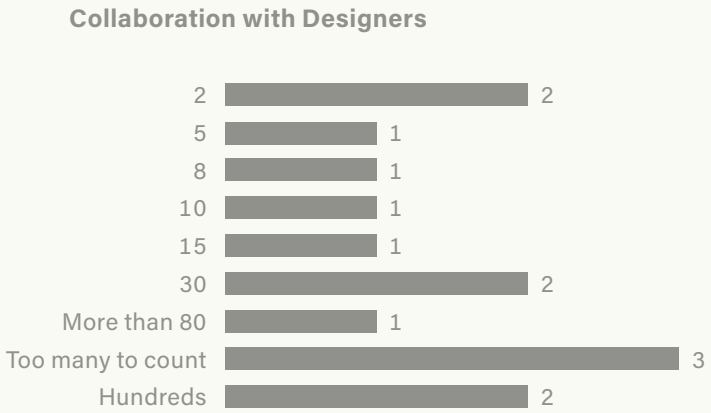


Figure 7a. Collaboration between designers and FabLabs.

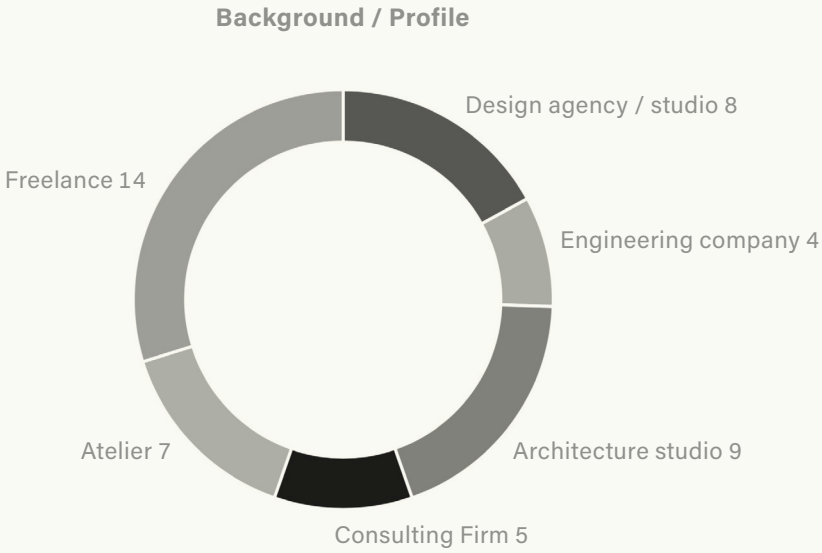


Figure 7b. Background/profile of the designers

record of the designers' collaborations this means that typically designer goes to the maker space to experiment, test, meet people, solve technical problems and making prototypes. This usually happens also with no cost.

2.7 Special projects with companies and designers (Section 5)

After reviewing the projects in which the makerspaces had collaborated with companies or with designers, the following question was if they had done any collaboration in which they integrate these two entities together to work with them. According to the answers, nine makerspaces (65%) said that they had collaborated, meanwhile, 5 of them (35%) said no. They were asked about any incentive or financial support from an institution to develop a project with companies and designers; among the options, they could choose more than one, they replied that 7 of them had requested support to the government, to public organisations and also have received money from companies. Two of them have obtained support from Schools/Universities, one of them from local syndicates. Two makerspaces have not requested or received any incentive. This

highlight a situation where makerspace are demonstrative spaces, all the most relevant collaboration and activities are connected to specific research or experimental action founded by public or private institutions or companies. This kind of projects/collaborations is a valid source of funding for the spaces but is unfortunately episodic; this affects the Business Model and the growth possibilities of the Space. They remain small and also the technology doesn't evolve after the setup. In fact, all the Fab Labs and makerspaces interviewed are interested and willing to participate in projects that involve Companies and Designers together especially the ones with the right funding to pay people, space and infrastructures.

3. Conclusions

According to what we investigate about the several initiatives and global proposals, what is coming and follows all this movement, is take advantage of the machines and technologies and participate in critical development processes impacting the maker community at a state or local level. This can also take shape as key stakeholders across different sectors like universities and industry, to identify and collectively develop ways to address key needs, making several changes to the neighbourhoods and cities and generate new digital manufacturing alternatives based on real needs through a sustainable, innovative vision that help and support national production and development, using innovation centres like Fab Labs and makerspaces as innovation and cultural hubs at the local scale.

In synthesis, both critical and positive aspects emerge from the survey. First of all, the current situation of Maker Labs. After 15 years characterised by an initially low level of diffusion and exponential growth of Fab Labs and makerspace, probably the highest phase of their Hype Cycle is done. This aspect is neither good nor bad: it is both real and reasonable. Many of these labs have been launched thanks to first public funds, and now are facing the challenge to be economically sustainable, but also environmentally and socially. At the same time, the whole Makers movement is now in the crucial challenge of growing economically, increasing and "making official" their level of professionalism, including the ability to evolve making (and makers) as possible on traditional markets: a "new third way" to the production of goods strictly connected to the circular economy. To date, there is still no an official market for the

maker economy and maker labs are not yet credible players for the circular economy, especially in urban contexts[18].

Despite, as shown by the survey, the makers lab are probably platforms able to build large networks that make users-citizens, professionals and businesses interact. Moreover, the growing emphasis on the Fourth Industrial Revolution, which in some productive contexts such as Italy has already excluded Fab Labs to the access for technological innovation to companies. They cannot access to the funds to evolve themselves in "lab 4.0", and at the same time, they cannot be involved by the other manufacturing companies (mainly SMEs) to develop experimental projects on IoT production or technological revamping. The crucial question, as also emerges from the survey, is that Fab Labs are structures that think and work "for projects". In most of the cases, maker labs work and are innovative if there are public or private commissions for research, innovation and consulting projects. Or, if the labs even if they are autonomous, are highly connected to a productive, territorial and/or social contexts which have a broader economic, social vision/project and officially recognises them as relevant actors. Without this support – which in reality should be considered a path of co-evolution with companies and institutions – maker labs are "forced" or "condemned" to fight for survival or, in the most virtuous cases, to be only activators or pre-incubators of innovation that find an economic and productive development in other contexts. This is because the maker labs with their "technological standard" available to them today cannot reach the quality that allows projects/products to break into the market. And the problem is that this standard can be competitive still for a few years. The risk for these spaces is to gradually exhaust their ability to be attractive not only for businesses but primarily for professionals and user innovators, in other words, the maker communities. By eliminating these possibilities, the use of these spaces for training purposes and technological literacy would remain the main (or the only) option. But without the relationship with businesses and professionals, it would undoubtedly be less effective.

The data demonstrates that the pioneer era is almost done. We are in a maturity step where more structured business models and growing processes are needed. The emergence of different research projects, many of them backed by the EU funding, might also be interpreted as a sign of

18 http://market.fablabs.io/ it constitutes only an embryo of a real market of the products developed by makers with maker labs.

maturity of the movement. Shifting from the evangelistic phase to a more "conscientious" one, still in its early steps, characterised by a more rigorous practice and research that at the same time interacts with established stakeholders like public institutions and companies. Making seems to be no more the scope of the activities but the means or the philosophy. Making better policies, better society, better competences to find creative, alternative and effective ways to the Industry 4.0 with a social and circular approach.

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Annex 1. Survey Structure

Section 1 General info about the Fab Lab / makerspace	contact person and role year of opening number of employees lab capabilities lab activities and services
Section 2 Fab Lab / maker-space system of relationship	professions skills and background of the lab community projects and collaborations developed with designers, institutions and companies
Section 3 Relationship and collaboration with companies	number of companies have been collaborated with the lab type of enterprises business sector kind of collaboration between the lab and companies most important projects developed by the lab with companies limitations before or during the projects
Section 4 Relationship and collaboration with designers	number of designers have been collaborated with the lab designers' background field of activity in the design sector most important projects developed by the lab with designers limitations before or during the project
Section 5 Collaborations with companies and designers	economic support/incentive to develop research and/or projects with companies and/or designers participation in projects that bring companies and designers together most important projects developed with companies and designers the project has been distributed on the market limitations before or during the project other kind of projects developed with companies and designers interest to participate in projects that stimulate the collaboration companies and designers together).

Table A1. Sections and questions of the survey

DingFabrik Köln (Germany)	http://www.dingfabrik.de/ www.facebook.com/dingfabrik/ Opening year: 2011 Number of employees: n.a.
Openlab Hamburg (Germany)	http://openlab-hamburg.de/ www.facebook.com/openlabhamburg/?rf=1206387326106054w Opening year: 2016 Number of employees: 8
FabLab Amsterdam (The Netherlands)	http://fablab.waag.org/ https://www.facebook.com/fablab.amsterdam Opening year: 2006 Number of employees: 12
Bristol Maker Lab (UK)	http://kwmc.org.uk/projects/bristolmakerlab/ Opening year: 2015 Number of employees: 3
The FabLab – Milan (Italy)	http://www.thefablab.it/ www.facebook.com/thefablab/ Opening year: 2015 Number of employees: 5
Fab Lab Torino (Italy)	http://fablabtorino.org/ www.facebook.com/fablabtorino/ Opening year: 2012 Number of employees: 0
Mio Cugino – Milan (Italy)	http://www.miocugino.com/ www.facebook.com/miocugino/ Opening year: 2013 Number of employees: 4
FabLab IED – Madrid (Spain)	http://fablab.iedmadrid.com/ Opening year: 2015 Number of employees: 7
Deusto FabLab – Bilbao (Spain)	http://ingenieria.deusto.es/cs/Satellite/ingenieria/es/deustofablab https://twitter.com/deustoFabLab Opening year: 2015 Number of employees: 3
Createc3d – Granada (Spain)	https://createc3d.com/ www.facebook.com/createc3d/ info@createc3d.com Contact: Juan Robles, Technical and Design Service Opening year: 2013 Number of employees: 3

Table A2. List of maker labs answered the survey
(continues on next page)

FabLab UE – Madrid (Spain)	http://fablab.uem.es/ https://www.facebook.com/fablabue jose.real@universidadeuropea.es Contact: Jose Real, Fablab coordinator Opening year: 2015 Number of employees: 5
FabLab Lux – Esch sur-Alzette (Louxembourg)	http://www.innofab.fr/ www.facebook.com/innofabcastres Opening year: 2015 Number of employees: 2
Innofab – Castres (France)	http://www.innofab.fr/ www.facebook.com/innofabcastres Opening year: 2015 Number of employees: 2
MakerWorks – Ann Arbor, Michigan (US)	http://maker-works.com/ www.facebook.com/MakerWorx/ Opening year: 2012 Number of employees: 11–15

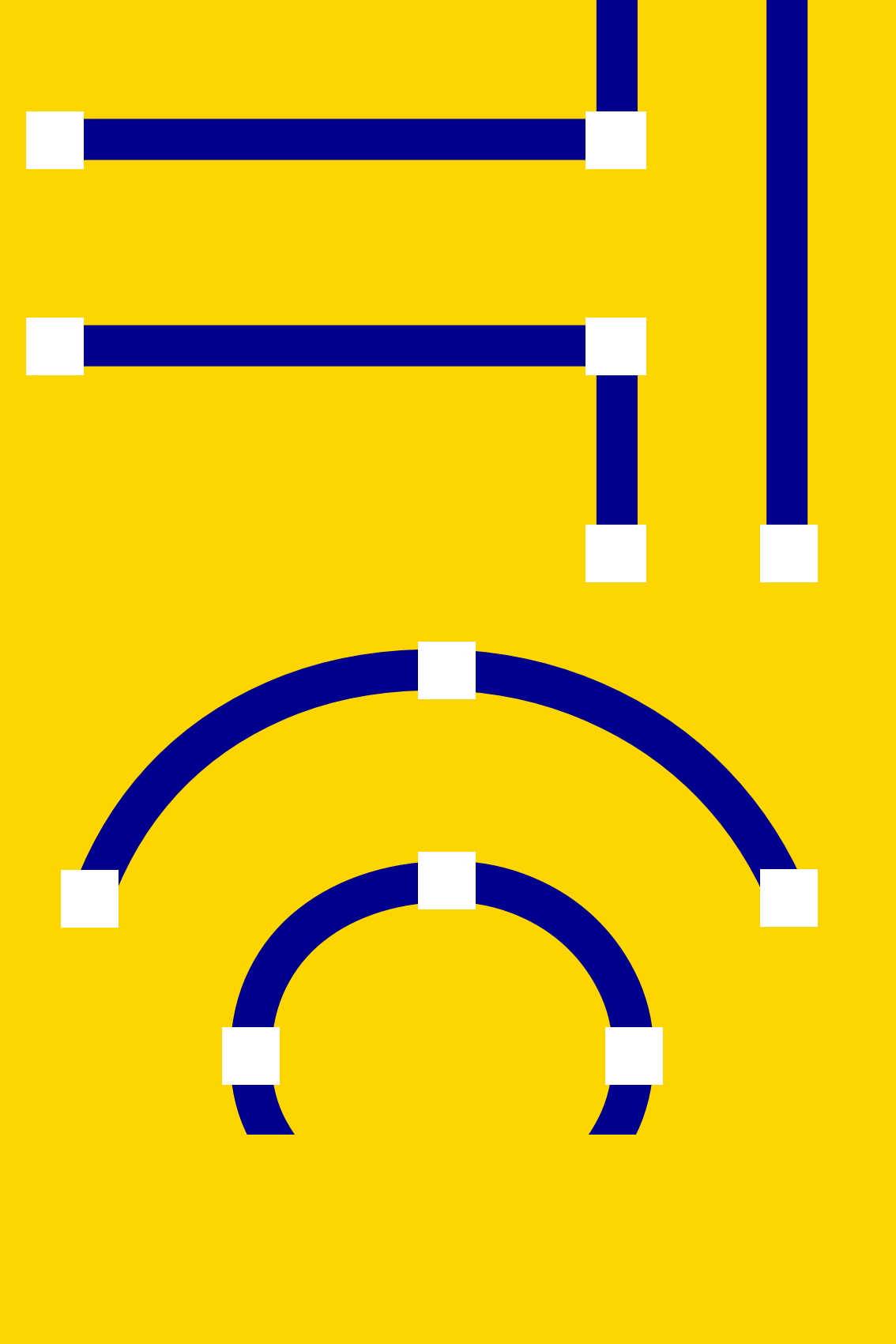
Table A2. List of maker labs answered the survey
(continues from previous page)

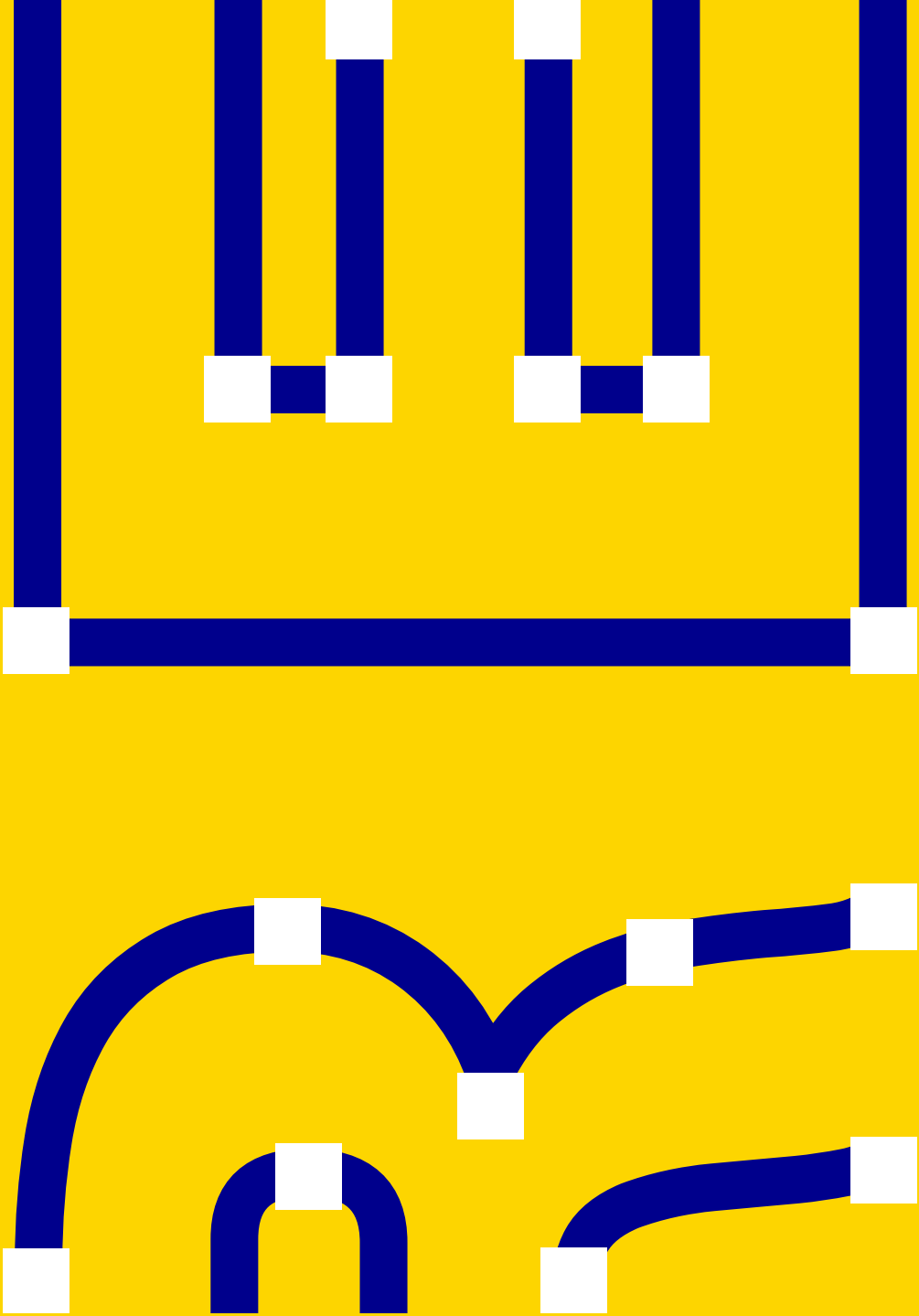
SURVEY APPLICATION

INTERNATIONAL CONTEXT

COMPANIES	PROJECTS 35	ENTERPRISES 1° Startups 2° Small Manufacturing Companies	SECTOR 1° FURNITURE 2° ICT/ Mechanics/ Robotics	COLLABORATION 1° PRODUCT DESIGN 2° COURSES/ TRAINING ACTIVITIES /WORKSHOPS
DESIGNERS	PROJECTS 28	PROFILE 1° FREELANCE 2° DESIGN STUDIOS / AGENCIES	SECTOR 1° PRODUCT DESIGN (General) 2° FURNITURE (Specific)	

Table A3. General data about developed by Fab Lab / Makerspaces with designers and/or companies





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