

CONNECTION MAKING ANALOGUE-DIGITAL SYNOPSIS BETWEEN FABRICATION HUBS

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ABSTRACT

The paper intends to apply the emerging theories on network science to the production chain of contemporary society, hyper-globalized and hyperconnected, to provide an alternative point of view aimed at the multilevel development of a given territory/context. The subject of discussion will be the Fab Labs, specifically those belonging to the Fab Charter, framing them not only as places of digital fabrication, experimentation and research, but, above all, as nodes of a network that in recent years has expanded to connect realities geographically very far from each other. With the analysis of case-studies we will investigate the dimension and importance of planning and designing these systemic processes to lead to the onset of an organizational culture oriented to 'sensemaking' and with the aim of optimizing collaborative processes of the Fab Lab network, demonstrating the social value of 'glocal' production.

KEYWORDS

fablab, network, hub, amplification, glocalization

Fabfoundation.org describes the Fab Lab network as such: «The Fab Lab Network is an open, creative community of fabricators, artists, scientists, engineers, educators, students, amateurs, professionals, of all ages located in more than 78 countries in approximately 1,000 Fab Labs. From community-based labs to advanced research centers, Fab Labs share the goal of democratizing access to the tools for technical invention» (fabfoundation.org, 2019). These places of digital fabrication, experimentation and research are considered in this paper as nodes of a network that in recent years has expanded to connect realities that are geographically very distant from each other. By applying the emerging theories of network science to the production chain of contemporary, hyper-globalized and hyper-connected society, we want to provide an alternative point of view aimed at the multilevel development of a given territory/context (Fig. 1).

Network science – Starting from the first problem of graph theory formally discussed and solved by Euler in 1736, the so-called 'problem of Königsberg bridges', this discipline of mathematics is concerned with studying graphs, as schematizations of an immense variety of situations and processes. Demonstrating that there is no solution that allows the citizens of Königsberg to cross the city by crossing each of the seven bridges only once, Euler highlighted how each network possesses peculiar properties given by



Fig. 1 - Official logo of the Fab Lab program.

the geometric distribution of the connections between its nodes, which influences the way in which the same networks can be used. Considerable steps forward in the understanding of the behavior of complex graphs have been made thanks to the theories of Paul Erdős and Alfréd Rényi, who in 1959 defined the random graph model, later questioned as not explanatory of foundational processes of the birth of a real network (Barabási, 2003). Their contribution to the discipline was fundamental for understanding the dynamics that underlie the formation of a community: once the nodes of a graph are connected by a number 'n' of links such that each node has on average even a single connection to the rest of the network, a cluster emerges, an entity in which it is possible to move from any of the nodes that compose it to all the others. Erdős and Rényi (1959) hypothesized that the addition of links to each node followed the principle of randomness, but this approach cannot explain the complex dynamics underlying the immense variety of natural and social phenomena that are studied in graph theory.

However, the study of the clustering phenomenon has allowed us to understand a fascinating characteristic typical of real networks: these are 'small worlds' closely interconnected, in which each node is incredibly close to the others, in the sense that only a few steps are needed, in relation to the total size of the network, to reach any node that belongs to it. The birth of the 'small world theory' can be traced back to the famous experiment by Stanley Milgram (1967) made at Harvard, known as the '6 degrees of separation' experiment; examining the average length of the path between any two subjects belonging to the social network of American citizens, Milgram obtained an average of 5.5 passages between one individual and the other. His experimentation became famous in the public imagination thanks to the homonymous theatrical work presented on Broadway in 1991 and to numerous subsequent studies that have expanded and supported the theories behind it.

Recently, it has been shown that there is an average of 19 steps between any two URLs on the World Wide Web, a growing network of billions of nodes. Mathematically, this phenomenon was explained in the article *Collective Dynamics of Smallworld Networks* by Duncan Watts and Steven Strogatz (1998), who postulated that a social network falling under this paradigm must have a high global clustering coefficient, or measurement of the degree to which the nodes of a graph tend to be connected to each other. In most real-world networks, and in particular in social networks, nodes tend to create strongly united groups characterized by a relatively high density of connections;

the clustering coefficient of the real networks therefore tends to be greater than that of the graphs in which the links are randomly generated. The greatest breakthrough in understanding the topology of real networks came about with the definition of scale-free networks by Albert-László Barabási and Réka Albert (1999). Their analysis stems from the empirical observation of the World Wide Web network; observing the presence of hyperconnected nodes, or hubs, characterized by an extremely higher than average number of links, it was understood that this network, like most of the other real networks, cannot be based on the random model of Erdős. In a scale-free network, following a power law, a hub tends to become more and more connected with respect to any node, but above all it contributes to making the graph a 'small world' acting as a bridge between very distant nodes and creating short paths from one node to the other that in the absence of its presence would require many more steps.

Overview of community sociology – The term 'hub', very dear to the academic sphere, in literature finds different definitions even in disciplines of humanistic and social mold; in fact, among the first to focus his research work on social interactions we find Georg Simmel, who can be considered one of the fathers of modern sociology, together with Weber and Durkheim. The key concept of his thinking is interaction, the *Wechselwirkung*: society is characterized by the incessant interaction of its individual elements; social relations define it and form a 'new entity', not simply deriving from the sum of its parts. Sociology is thus a 'formal' science, devoted to describing the forms that reciprocal relationships (interactions) assume in different times and places, through the formation of groups or social circles. The ideal place in which these relational ramifications manifest themselves, or better, are naturally the place where by definition there are large concentrations of individuals, the big cities. The expansion of the group coincides, for Simmel, with the development of individuality, even if the differentiation of individuals is in turn necessary for the development of the group itself (Simmel and Jedlowski, 1995).

These concepts are the basis of the ideologies and methodologies of the famous Chicago School, founded, among others, by Robert Ezra Park (1864-1944), a student of Simmel, who identifies four fundamental interactive processes in urban space: competition, in the Darwinian sense the most elementary form of social interaction ('biotic order' of the city); conflict, a consequence of competition, concerns the actions of the individual and determines his position and his social status, dominant or subordinate; agreement, which involves the cessation of the conflict and the stable assignment of positions and statuses of power, defined and consolidated by laws and customs; assimilation, a process of interpenetration and fusion that can follow the agreement. The latter, according to Park et alii (1967, or. ed. 1925), is characteristic of the city that succeeds in integrating the various migrants and its various social components economically and culturally, even if all retain their identity and status. Park believes that the city is something more than a group of people, institutions, services, administrations, more or less

organized: the city is a state of mind, a set of attitudes and feelings organized in customs, traditions and ways of behavior. According to Park, in the diversified and cosmopolitan city the individual can choose ‘with whom to stay’, he is not obliged to follow the tradition but he can attend people more congenial to him and their ‘company’ will provide him with moral support and justification of behavior chosen by him. The city is thus divided into a multiplicity of moral regions (that of vice and bourgeois, bohemian, working class, that of singles, etc.), but not always the company is ‘chosen’; often we find ourselves living there and it fits us. This naturalistic approach presupposes the existence of an urban space left to *laissez-faire* and to the mechanisms of the market, as well as linked to a strong division of labor and social roles. And the almost total absence of urban planning. The perspective is no longer that of the theoretical view from above, but that of the vision from within (Manzini, 2015).

In this framework, transposed in a contemporary key, the theories of the pedagogy of catastrophes and degrowth, of which Latouche (2008) is the ‘putative father’, are inserted: a crisis can be an opportunity to regain awareness of one’s own resources and one’s limits, defining them as foundations and perimeter values and perimetrals rather than as constraints. It is extremely important in this historical period to focus on the concept of the Hegelian ethos, or the perception of being part of a community and a social morality where the realization of good takes place through institutional forms such as civil society, to face today’s urban problems. The human, economic, ethnic and environmental processes that manifest themselves in urban centers systematically escape plans and projects, maps and building logics, never as today, democracy is played in the public space, in the streets, on the sidewalks. Urban planning and design, on the other hand, are still trapped in an eighties vision, which mitigates passivity to the detriment of the needs and trends of reality. What is needed today, argues La Cecla (2015), is a new science of cities capable of guaranteeing a decent life for all – a basic concept of the ideology of the need for degrowth at local level – focusing on how to develop policies that promote this trend.

Fab Lab as hubs – The Fab Lab program was born in 2001 thanks to US professor Neil A. Gershenfeld, inside the Boston MIT Center for Bits and Atoms. From the beginning, the aim of the project was to teach future generations how to design and produce technological artefacts autonomously, favoring the dissemination of bottom-up experiences and products designed specifically for the community and the territory in which they will be used, according to logics that are far from those dictated by the globalized market but oriented to a democratization and widespread accessibility of the means of production offered by the individual laboratories, especially to communities with poor access to education or technology (Lena-Acebo and García-Ruiz, 2019). A Fab Lab is generally equipped with a series of tools (including mainly numerical control machines, printers for rapid prototyping and various tools) freely usable by those visiting the laboratory (Menichelli, 2016). After the birth of the project



Fig. 2 - Map of Fab Labs worldwide (credit: fablabs.io, 2019).

in MIT the program was widely spread all over the world, starting from Vignyan Ashram, India, the second Fab Lab ever, born in 2002 (Fig. 2).

MIT has supported the birth of these laboratories through the official registration at the Fab Foundation. Since 2014, the list of all official Fab Labs has been maintained and updated through the fablabs.io site, a reference point for the open source community. To date, the site has registered 1458 Fab Labs spread across all continents, with the exception of Antarctica. Analyzing data extracted from fablabs.io immediately emerges the evidence that this closely connected community is not evenly distributed on the planet: of the more than 1000 Fab Labs registered at the Fab Foundation, 720 are located in Europe, 406 in the Americas, 262 in Asia and only 70 in Africa and Oceania. We are talking about a strongly western community. Specifically, 202 Fab Labs are based in the US alone, that have a population of 327 million inhabitants; France and Italy follow closely, with a widespread distribution in the territory, respectively 191 and 138; here, however, the Fab Lab per capita ratio rises dramatically: in fact in Italy there are 434,000 inhabitants for each Fab Lab, while in France the ratio is 350,000 inhabitants for Fab Lab. India and China, despite being countries heavily devoted to industry, are not yet included in the dynamics of sharing of the maker movement: in the Chinese state there are only 22 Fab Labs compared to a population of over a billion people, in India instead there are 53 laboratories. In Europe, Germany and Spain travel in the order of 60 laboratories, in the Iberian state, however, Fab Lab Barcelona stands out in the field of research; it is managed by IAAC (Institute for Advanced Architecture of Catalonia). In the rest of the

world, especially in African countries, less than 10 Fab Labs per state are active.

Network visualization has been exploited to capture the image of how effectively the Fab Labs belonging to the system are interconnected. Taking advantage of the Netvizz application, it was possible to download the ‘friendship between pages’ network of the Fab Foundation Facebook page. This is the network that connects this page to all those that followed it, plus the relationships between them. The Gephi open source software was used to perform a basic statistical analysis of the network in question, allowing to obtain a graph in which the nodes are organized in groups of ‘greater mutual relationship’. The 281 nodes (the Facebook pages analyzed) are connected to each other by 2431 links; the diameter of the graph, defined as the shortest path between the two most distant nodes that build the network, is only 5 steps: we are observing a ‘small world’ in which the pages of the Fab Labs of the entire planet have a strong reciprocal relationship, a world in which projects and ideas travel rapidly across the globe, in compliance with the values expressed by the open source community (Fig. 3). A first look at the topography of the graph shows that most of the nodes form a rather united community, while in the upper left there are smaller, more isolated clusters, held together by the hub represented by the Fab Foundation page (node indicated in yellow; size of the nodes is proportional to the number of followers of the given page: Fig. 4). Adding the labels with the names of the pages shows that, in principle, the less connected nodes are external to the Fab Lab community: these are mainly Colleges and technical institutes. On the contrary, in the right and thickest part of the graph connections there are laboratories from all over the world, from Genoa to Tokyo to Latin America.

Territorial cluster – We have so far described the Fab Labs in relation to each other within the global community of participatory planning and the open source community. In this sense they operate as bridges, minimizing the geographical distances between individuals and societies with a similar mentality. Going down to a lower level, we need to analyze the relationships that the Fab Labs are able to create and feed within the specific territory in which they operate. Two radically different and contrasting case studies were analyzed to highlight criticalities and opportunities offered by the Fab Lab model. Firstly, the small reality of the Genoa laboratory, included in the Lsoa Buridda Social Center, was studied. The analysis of the ‘friendship between pages’ graph gives an extremely poor result, indicative of the scarce activity of the Facebook page: it is connected only with the nearby Fab Lab Alessandria and with the page, much more active and followed by users of the social network (it counts more than 10,000 followers), of the aforementioned Social Center in which Fab Lab Genoa is based (Fig. 5).

In order to better observe the community that revolves around the Genoese laboratory, the network of the Lsoa Buridda page was therefore analysed, consisting of 113 nodes and 222 links. In this case, we immediately notice how the graph is much less cohesive than the one generated around the Fab Foundation; not surprisingly, even though it is a much smaller network, the diameter is 6. It means that the Lsoa Buridda

page follows and is followed by a very heterogeneous group of pages, which have few relationships among them. Specifically, the network is composed of numerous pages of collectives, social centers, occupied spaces, music labels and independent artists; connections with cultural institutions, museums and schools in the city are totally missing. Likewise, there are no connections with open source communities related to rapid prototyping and technological projects and innovation (Fig. 6). Buridda calls itself a self-managed occupied social laboratory, born on 11th May 2003 with the occupation of the headquarters building of the former Faculty of Economics of the University of Genoa, abandoned for several years. The Fab Lab, one of the very first born in Italy, immediately took up residence in the building. Following the eviction in 2014, all the activities have so far been moved to the former Magisterium owned by the University in Corso Monte Grappa (Fig. 7). The evidence of the network analysis accompanied by the reading of the vicissitudes of this center paints a picture in which the political convictions of the founders unfortunately acted as a deterrent to the creation of an active community really involved in the cultural panorama of the city of Genoa.

The opposite and much more positive experience is that of the Fab Lab Barcelona, already mentioned in this paper as one of the most active in the world in terms of research. Part of the Institute for Advanced Architecture of Catalonia, the Fab Lab supports

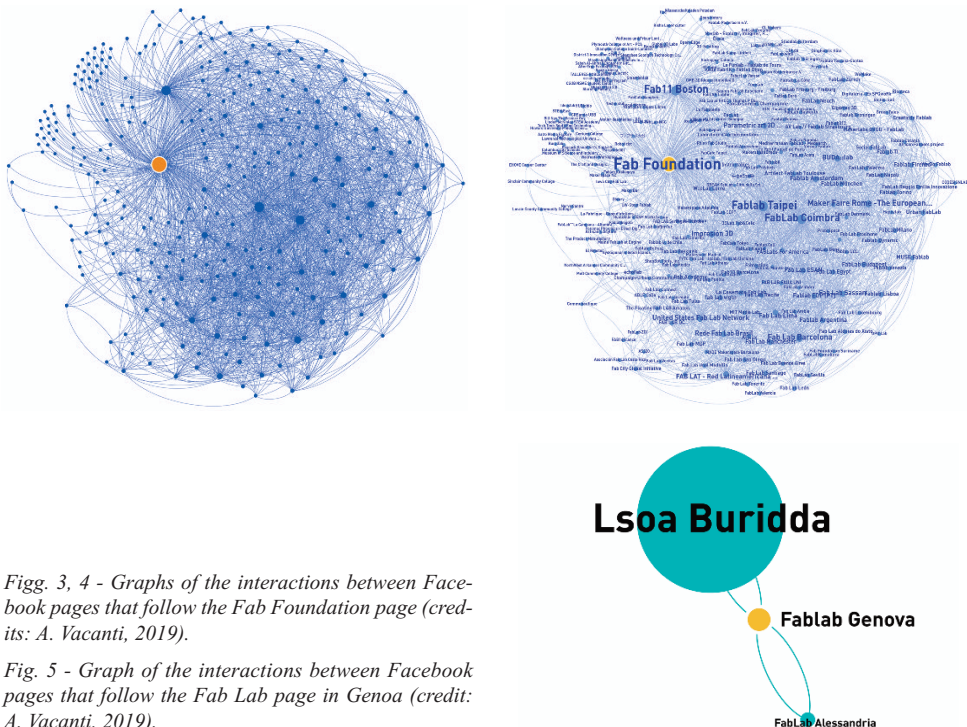
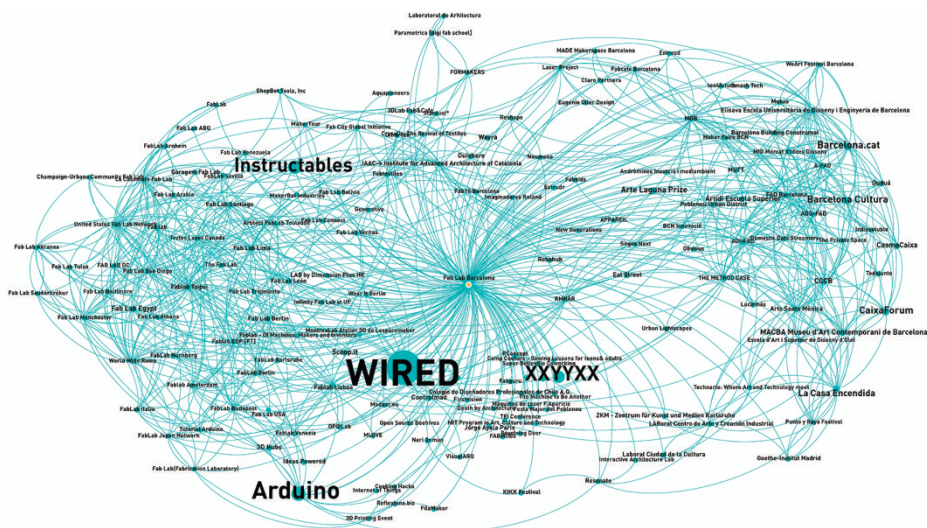
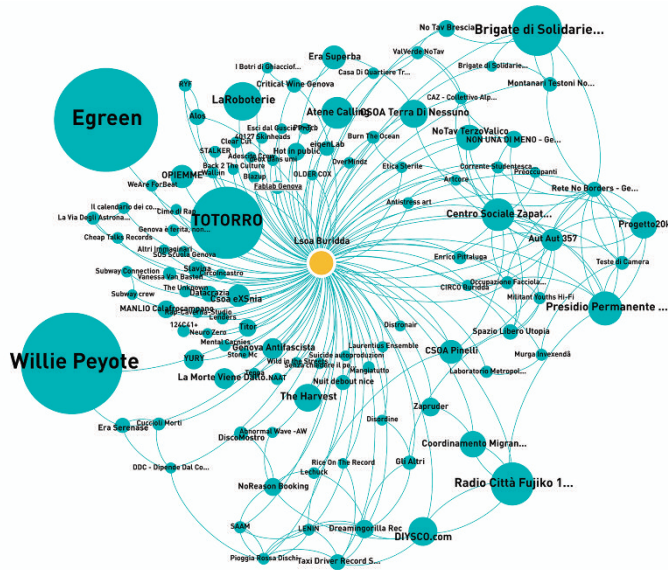


Fig. 3, 4 - Graphs of the interactions between Facebook pages that follow the Fab Foundation page (credits: A. Vacanti, 2019).

Fig. 5 - Graph of the interactions between Facebook pages that follow the Fab Lab page in Genoa (credit: A. Vacanti, 2019).



various educational and research programs related to the multiple scales of human habitat. It is also the headquarters of the global coordination of the Fab Academy program in collaboration with the Fab Foundation and the MIT Center for Bits and Atoms; the Fab Academy is a distributed education and research platform in which each Fab Lab operates as a classroom and the planet as the campus of the largest University under construction in the world, where students learn the principles, applications and implications of digital production technologies. Here, projects such as Hyper Habitat IAAC (official selection for the Venice Biennale XXI) or Fab Lab House (Audience Award in the first Solar Decathlon Europe in Madrid; Fig. 8) have been developed. The friendship graph of the Fab Lab Barcelona Facebook page (about 12,000 followers) consists of 174 nodes and 902 links, with a network diameter of 5. It is also far from the cohesion level of the Fab Foundation graph, however the qualitative analysis of the nodes that compose it depicts a much brighter panorama of the Genoese experience: in the network there are numerous global Fab Labs, from Bolivia to Berlin to Venice, some pages of important realities such as the innovation magazine Wired and Arduino. Above all, there are many pages related to affirmed realities in the cultural panorama of the city of Barcelona, such as Museums, Cultural Centers, Schools and Universities (Fig. 9).

Glocalized heterotopia – In 2014, Barcelona became the protagonist of a concrete experiment: in the historic industrial district Poble Nou of the Catalan city: for a week, an area of about one square kilometer was transformed into a Fab City. Here a circular model for the city was born, capable to reuse waste and to create new objects and re-enter them in the production cycle. Craft shops, technology experts together with scholars and designers have shown that it is possible to create a circular system within a large urban center by creating connections and synergies. For example, making fabrics produced from plastic collected on Spanish beaches, or producing eco-leather from pineapple leaves. This initiative carried out by MIT, IAAC and the Fab Foundation aims to transform cities into places of local production and global connection in which citizens are a fundamental part of change (Diez, 2018). What Bauman and Bordononi (2014) defined as ‘glocal’: a neologism that indicates a reality that combines globality and locality together, as well as a communication addressed to the global context while taking into account the specificities of the individual local cultural realities. In the world, every community has its own social and cultural values that express the identity of that territory: by globally sharing these values with other communities, the local culture is enriched and becomes a ‘glocal’ culture. For this reason Fab City is

Fig. 6 - Graph of interactions between Facebook pages that follow the page of Lsoa Buridda (credit: A. Vacanti, 2019).

Fig. 7 - Facade of the new occupied headquarters of Lsoa Buridda in Genoa (credit: L. Buridda).

Fig. 8 - Students at work at Fab Lab Barcelona (credit: Fab Lab Barcelona).

Fig. 9 - Graph of the interactions between Facebook pages that follow the Fab Lab page (credit: A. Vacanti, 2019).

collegial, multidisciplinary and co-designed, it moves in a fluid context, in which different actors collaborate depending on the projects: engineers, designers, architects, urban planners, public offices, artisans, shops, associations, informal groups, small and large companies (Nike and Ikea are partners).

Ma(r)ker as minimum unit – We can affirm that for a balanced and self-sustainable urban development, declined in the economic-productive and socio-environmental sectors, different stakeholders of the same urban network can play a vital role. The creation of a circuit is essential to widely disseminate this systemic approach; in this cross-linked structure, the hubs, the connection nodes, can be the Fab Labs that work increasingly alongside the Administrations and in partnership with large and small companies, but remain focused on people, in a place where citizens are perceived not only as consumers but as producers capable of performing this function by accessing digital tools for manufacturing and creating culture. In this scenario, the activators/catalysts of these practices that operate in these places, the makers, create what MacCannell (and Lippard, 1999) defines as a ‘marker’ – an artefact capable of giving identity and recognizability to the construction process of the image of the territorial reality to convey and to represent the complexity of its material and symbolic characteristics. They therefore undergo a sort of further semantic upgrade, qualifying as the Ma(r)ker: co-producers and co-designers, who hybridize new technologies to traditional production systems, fabricating artefacts that carry symbolic values of belonging to a given territory.

Conclusions – According to Buckminster Fuller (1972), in order to teach a community a new way of thinking, we must neither impose it nor teach it, but rather set the conditions for the community to have the tools to be able to build its own. This way the conclusion of the paper can be summarized: in the current delicate socio-political world situation, to overcome the shortcomings caused by increasingly complex global dynamics, it is necessary to bring to light a collective conscience that transcends geographic boundaries and points out the real ones and specific needs of each territory; to obtain this, it is essential to create the conditions that make these objectives possible, increasing participation in bottom-up mechanisms guided by figures with skills and attitudes that allow the right structuring of connective systems.

Fab Labs can be seen as organizations born for ‘sustainability’, in the different meanings that this word brings with itself: a social sustainability, an environmental sustainability and an economic sustainability. However, these laboratories are still a rather new and little studied research context. For example, there is no knowledge on how the organization and management of their activities are carried out and what challenges the Fab Lab managers have to face in translating these types of sustainability into action in specific social contexts (Galuppo et alii, 2019). Very often the main problem of laboratories is finding and managing economic flows, so the relationship with companies and large industry is essential to ensure the survival of these places.

The research and development processes that characterize companies often refer to consolidated technology partners and suppliers that belong to a rather closed system. Those who work in spaces of innovation such as Fab Lab and makerspace often do not fall within the relational sphere of companies and therefore remain outside the frequencies intercepted by the antennas of small and medium-sized enterprises. This highlights a limit on both sides. If on the one hand companies often fail to enter into open innovation logics and abandon their traditional supply networks, on the other hand makers tend to form closed universes that do not relate easily to the surrounding economic environment. Despite various virtuous exceptions, we need to work towards greater integration between the two worlds (Schiavo, 2017).

The case studies analyzed have in fact highlighted how two Fab Labs, although belonging to the same program and guided by the same values, have an extremely different impact on the global system and above all on the region in which they operate; among the many factors that distinguish the two experiences, we believe it was fundamental for the positive development of Fab Lab Barcelona the relationship with a reality linked to a project such as the IAAC, which was able to guide the development of the laboratory and tie it to achievements, experiences and innovative research in the world of design, technology and architecture. Fab Lab Genoa, on the other hand, did not know how to network on its own territory, which in any case presents greater challenges than a big city like Barcelona, and let other realities and stakeholders hybridise their experience, thus remaining a phenomenon that is mainly isolated and not tied to the world of innovation and project. The tool of Network Visualization allowed, in this paper, to immediately highlight the differences and the specificities of the two case studies examined. In the future we propose to continue this type of analysis by finding larger datasets that are able to shed more light on the phenomenon of participatory design in general and makerspaces in particular.

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