Title: Social Manufacturing: Towards the popularization of personalized fabrication

Authors: Raúl Tabarés Gutiérrez, Amaia Sopelana Gato, Jorge García Valbuena, María Teresa Moreno-Valdés.

Work Center: FUNDACIÓN TECNALIA RESEARCH & INNOVATION

Address: Parque Científico y Tecnológico, c/Geldo, Edif.700, C.P. 48160

E- Mail: raul.tabares@tecnalia.com

Acknowledgments: Publication subsidized with funds from the program to support Technology Centers and their Corporations and Technological Alliances, Emaitek Program, Basque Government

Abstract: Due to the development of new open technologies, many social technology-based movements such as "Do It Yourself," "Hackers" and "Makers" have stand up in recent decades. Our goal in this paper is to perform a comprehensive analysis of all these trends and propose "Social Manufacturing" as a term which comprises a new paradigm of personalized manufacturing based on new open technologies. We describe the main features of this movement after reviewing the existing literature, ending with the results of qualitative research completed with the collaboration of different makerspaces based in Spain.

Furthermore, we also describe the opportunities and challenges that are starting to be unveiled for this movement. Paying special attention to policy makers and other stakeholders that might benefit from the innovative and regenerative impact of this new movement on the urban environment.

Keywords: makers, DIY, hackers, P2P, P2P production, prosumers, open innovation, social innovation, makerspaces, hackspaces, Fab Lab.

1. Introduction

In recent years, because of the potential created by new technologies in the field of digital design and the realm of personal fabrication (Birtchnell & Urry, 2013), the people's level of empowerment through personalized fabrication has constantly increased (Ratto & Ree, 2012). In addition to this, the advent of collaborative spaces in both the physical and virtual worlds has led to a boom in knowledge and innovation expressed through very wide-ranging initiatives such as MakerBot (Ratto & Ree, 2012), RepRap-Based (Kostakis & Papachristou, 2014), Maker Faire (Stangler & Maxwell, 2012), Thingiverse (Townsend, Jeffery, Fidler, & Crawford, 2011) and Rally Fighter (Chris Anderson, 2010) among others. All of these projects use the new potential allowed by personalized fabrication along with a peer-based production basis which has proved to be an interesting collaborative approach for developing different kind of works (Benkler, 2011) and providing new outlooks for today's economic system (M Bauwens, 2005).

With the objective of broadening our knowledge about the aforementioned initiatives and identifying common features of these spaces and movements, as well as ascertaining how much capacity for innovation they possess, we decided to discuss their role in the development of the long-desired transition towards the society of innovation (Innerarity, 2009). To do so, we focused our research on the characterization, analysis and definition of the main characteristics and conditioning factors of these new movements and at the same time, placing an emphasis on the spaces which provide their inputs. This article explores the role of HackSpaces, MakerSpaces, Fab Labs and other collaborative spaces which make available to their users the open, democratizing technologies that empower them.

After this introduction it follows a summary of the main conclusions of our review of the existing literature on the aforementioned movements. The following section provides a description of the results of our exploratory and descriptive study of a qualitative nature which was carried out in the year of 2014[1]. This exploratory field study was based on four real case studies of co-creation spaces. The research methodology used to obtain the results was based on semi-structured interviews from which we determined the main characteristics defining this movement. Then, we completed an analysis of all the information gathered as well as the conclusions of the literary review. The general idea of

[1] This study was completed with the help of the Basque Government, with funds provided through the program to support Technological Centers and their Corporations and Technological Alliances, also known as the "Emaitek Program."

this contribution is to expose the main opportunities and challenges which, in our opinion, are faced by the "Social Manufacturing paradigm".

2. Where the new DIY Wave is carried out: a brief review of the literature

Although "Do It Yourself" (hereinafter referred to as DIY) phenomenon has become a mature movement considering it began in the roaring 1920's with pirate radio broadcasting (Haring, 2008). It has remained more or less present since the 1970's (Kuznetsov & Paulos, 2010) and was popularized in the 1980's and 1990's (Atkinson, 2006) with many authors even identifying a "third wave" (Fox, 2014). We must not set aside another type of technical and social movements which have arisen in recent eras establishing a new and wide-ranging paradigm of innovation based on open innovation (Chesbrough, 2003), crowdsourcing or collective innovation (Howe, 2009; Surowiecki, 2005) and production amongst peers (Benkler, 2006). These paradigms are distant from the classical linear model of innovation (Lundvall, 1992) and are clearly shaped by "bottom-up" approach. These sorts of self-empowering philosophies have also gained momentum in recent years due to the new possibilities spawned by personal fabrication (Mota, 2011) and other types of open technologies conceptualized as "open hardware."

It can be complicated to define a movement like DIY (Atkinson, 2006) and certainly one definition may not encompass all three areas into which that movement is normally divided (art, design & crafts). After having reviewed the bibliography in this issue we have decided upon the following definition: *"We define DIY as any creation, modification or repair of objects without the aid of paid professionals"* (Kuznetsov & Paulos, 2010)

From this assumption, it can be inferred some of the most useful elements when it comes to understanding other trends that have arisen throughout the years. These elements share in common the altruistic and amateur facet of producing artifacts and diverse technologies. Following the appearance of DIY, other new movements have come about known in the digital realm as "Hackers" (Himanen, 2002) and later as "Makers" (C Anderson, 2012) when they transcended to the physical realm. In our opinion, both terms share the non-professional and open character of creating, modifying and repairing digital or physical objects. However, these movements differ mainly from the original DIY in terms of the collaborative nature of their production amongst peers, the use of open-source technologies and their access to knowledge through the Internet. We would like to offer both definitions of the terms which we have mentioned in order to illustrate these similarities and differences.

Regarding the first definition, we base our upon that stated by Pekka Himanen in his work "The Hacker Ethic" (2002), in which he includes what he proposes to be the "jargon file." "*The hackers' 'jargon file,' compiled collectively on the Net, defines them as people who 'program enthusiastically' and who believe that 'information-sharing is a powerful positive good, and that it is an ethical duty of hackers to share their expertise by writing free software and facilitating access to information and to computing resources wherever possible"* (Himanen, 2002)

For the second definition, we use what the website *Urban Dictionary* proposes. Because the bibliography we have consulted sometimes refers to "maker cultures" and other times to the "maker movement" without clearly distinguishing who are the players in these two movements. Therefore, we have used this definition because it encompasses both of the aforementioned concepts; *"Makers are used to describe those who love to create things in their spare time (often electronic, often with their own hands). Also called Hobbyists. The term is popular in the open hardware and hardware hacking electronics communities"* (WordMaker, 2013)

Besides the classical DIY which we have mentioned above we must also point out another emerging phenomenon known as DIWO or DIT (Do It With Others / Do It Together). Despite the fact that several spaces have often used this term, the only written reference we have found is made on the portal Techopedia which states it as follows*: "Do It With Others (DIWO) is a joint project development model that enables like-minded people to collaboratively work on a task, project or any other service"* (Janssen, 2014)

All of these movements whose origins lie in classical DIY have been evolving into different labels like those mentioned above including "hackers" and "makers" as well as the more recent label "DIWO". They have transcended digital communities and specific events becoming more ubiquitous and adopting real-life stability in the form of spaces for co-creation. In the existing literature you can find a wide range of terms referring to the spaces which we wish to deal with. "Hackerspaces", "Fab Labs" or "Media Labs" are just some names that many authors have used to describe this type of spaces which offers different machinery for fabricating digital goods in a collaborative manner (Smith, Hielscher, Dickel, Söderberg, & Oost, 2013) and allow to "play with technology." These spaces provide their users with a good number of facilities and tools (always open-source) such as 3D printers, digital design tools, electronic kits, soldering equipment, laser cutters and a long list of other tools. This apparatus allow them to experiment and learn with other users through informal and practical learning (also known as "learning by doing") and developing self-managed projects.

The popularization and spreading of these spaces has increased notably in recent years. It is no surprising that the number of locations with spaces of this kind has been on a rising trend. We have verified that there are currently 2044 Hackerspaces distributed around the planet[2] and approximately 355 planned. With such figures, it seems clear that the phenomenon has shifted from being just an emerging trend to becoming a reality present in many urban environments as well as rural areas. In this sense Calafou and Farmbot (Calafou-Cooperativa-Integral, 2015; Cruz, Herrington, & Rodriguez, 2014) constitute significant experiences. The expansion of such spaces has also occurred due to the increasingly common holding of events dedicated to the hacker and maker phenomenon in a wide range of cities including Maker Faires, Hackathons, Open Hardware Summits and other similar events.

The varieties of tools and possibilities created by open hardware and personalized fabrication are overwhelming. Digital spaces where you can find free code design such as

[2] Data retrieved from: http://hackerspaces.org/wiki/List_of_Hacker_Spaces (consulted on 05/24/16)

Thingiverse[3] make it possible for users to modify, customize and produce technological objects and artifacts. This new culture of fabrication makes it possible to create everything from toys to vehicles (Chris Anderson, 2010) and at the same time empowering people through citizen participation (Hirikilabs 2014, ZAWP 2014). Therefore, given the plethora of projects and the ground-breaking nature of many of them it is not surprising that many media and authors have labeled the potential spawned by these types of movements and spaces as a "Third Industrial Revolution" (C Anderson, 2012; P2P-Foundation, 2012; The Economist, 2012), a "democratization of manufacturing" (Mota, 2011) or a way of promoting "grassroots innovation and entrepreneurship" (Gershenfeld, 2005).

Despite these disruptive ideas and probably techno-optimistic views (Sivek, 2011), the convergence of movements such as commons-based peer-production and digital fabrication is also seen as an opportunity to connect people with the activity of manufacturing goods and products once again. As part of a commitment to a more sustainable form of production and consumerism (Scholz, 2012) and one which is longer-lasting in terms of the durability of its products (C Anderson, 2012) and also contributing to the social good and corporate citizenship through making (Johar, Lipparini, & Addarii, 2015).

3. Grassroots innovation is located in the old town: case studies

We decided to approach these types of spaces in Spain to gather empirical evidence of the findings made in our bibliographic analysis. We therefore directly contacted with the representatives of Hirikilabs, Medialab-Prado, Wikitoki and ZAWP. Our selection criteria were based on the importance held by their user communities within the national territory. Three spaces are based in the Basque Country area and one in Madrid area (expert criteria). In order to collect information, we carried out semi-structured interviews with nine key informants that were recorded and transcribed. All of the participants received pertinent information on the interviews to be held in terms of the objectives and methodology used throughout an informed consent document. The interviewees accepted the terms and the scientific divulgation of any information contributed. The method used to design the interview was based on the earlier conclusions reached in the literature review described in the preceding chapter. The intention of this interview was to examine the following aspects:

- Analyzing the factors surrounding the ecosystem of "maker culture spaces" and their users.
- Exploring the innovation dynamics existing both inside and outside these spaces.
- Evaluating the relationship that these spaces and their users have with new open technologies.

[3] For further information, see: http://www.thingiverse.com/ (consulted on 05/24/16) This platform among other have a strong influence of The Whole Earth Catalog (http://www.wholeearth.com/index.php) which was a groundbreaking publication leaded by Stewart Brand.

We then provide a brief description of the organizations which were interviewed and present three broad categories containing the common features identified after the case studies were carried out.

- Hirikilabs[4] was created in 2013 as a project by the laboratories of Tabakalera (a center for the creation of contemporary culture), with the collaboration of the Donostia-San Sebastián 2016 European Cultural Capital Year (DSS2016). It is located in the city of San Sebastián (Gipuzkoa) and receives funding from local, regional and European public institutions. The interview was held with the Tabakalera's Director of Laboratories, the Workshop Technician and the Learning Manager.
- WikiToki: Founded as an association in 2013, it is an initiative of a private nature with a public vocation and is not directly linked to any specific institution or role-player but instead is a combination of different people and organizations. It is located in the neighborhood of San Francisco and receives support from the Municipal Government of Bilbao. In the interview five people from four different groups were represented.
- ZAWP: This is an acronym of "Zorrotzaurre Art Work in Progress" a movement which came about in 2008 to deal with the urbanism plan approved in the districts of Ribera de Deusto and Zorrotzaurre (Bilbao). Both areas combine a post-industrial past as a portuary zone. The president of this association and the project coordinator took part in this interview.
- Medialab-Prado: This is a program of the Department of Arts, Sports and Tourism of the Municipal Government of Madrid. It was conceived as a people's laboratory for production, research and dissemination of cultural projects which explores the forms of experimentation and collaborative learning that have arisen as a result of digital networks. The person interviewed was its technical coordinator. Medialab-Prado is considered as one of the most important urban labs in Spain and also as a significant and successful pioneering initiative.

The spaces in which we carried out our field work shared several similarities; they all act as open and distributed spaces which arose at the crossroads produced by the merging of technology and society, they are linked with the promotion of free culture and art, they systematically provide support for several projects (though they are not considered incubators but rather connectors of the community, neighborhood or city), they also promote commons (Estalella, Rocha, & Lafuente, 2013) and they receive support in some way from the public administration. At the same time, they all want to regenerate and to revitalize the urban space that they occupy. Curiously, the locations where they can be found tend to have an industrial or manufacturing-related past which inspires all of these initiatives with great symbolism. These actions tend to be promoted by city councils or development agencies which support these types of movements in order to breathe new life into certain economically depressed or deteriorated areas.

[4] HIRIKI is taken from the word HIRIA, which means "city" in Basque language.

We understand these sorts of phenomena as a social construction of technology (SCOT Model) (Bijker, Hughes, & Pinch, 1987; Bijker & Pinch, 1984) or a network of relationships (Latour, 1992) where users matters (Oudshoorn & Pinch, n.d.) more than as a technological paradigm (TTP) (Dosi, 1982). Technology is at all times the backbone of meaning for this community and it is not the driver of engagement for the different groups of users. But rather the technological developments which arise in these communities are the result of interactions amongst the different social groups that meet up in these spaces (Bijker et al., 1987; Bijker & Pinch, 1984; Bijker, 1995).

The following is a more detailed description of the three characteristics shared by this type of spaces which we have identified as revealing of their idiosyncratic nature.

3.1. Commons-based peer production

One of the findings of our research remarks the cooperative and collaborative work basis that is fostered in these kinds of spaces. The physical materialization of a large number of digital technologies present on the Internet and the Web (Gershenfeld, 2005) has opened up new possibilities for social production processes. That is why this transition from the virtual realm to the real world has also enabled to transfer the modes of digital production to the physical environment too (Ratto & Ree, 2012). Commons-based peer production (Benkler, 2006) is the work dynamics that has arisen due to the boom of "Web 2.0" and its collaborative applications (P. Anderson, 2007). This characteristic way of pursuing initiatives has made it possible to develop outstanding collaborative projects such as Linux, Wikipedia and many others. This collaborative basis has played a critical role in many initiatives undertaken in the digital world opening up unique and exceptional possibilities for co-creation (Ratto & Ree, 2012). Therefore, it is not surprising that these spaces promote collaboration and empowerment for their members across its different activities. The aim is about connecting people in the local community. In other words, they apply the basis of "the platform" as a system for innovation like collaboration happens in the digital space.

"The idea is that anyone who comes in through the door can take part in any of our activities. They are not made to feel left out and are allowed to participate. The way in which we promote this form of participation, when we hold workshops for producing prototypes, is to make another call out to collaborators after selecting the projects. That is when the collaborative work begins and it is the part which we definitively highlight. Our center promotes the establishment and strengthening of relationships between people so that they can meet, cooperate and share knowledge. Media Lab Prado invites and allows users to design, alter and modify research and production processes, which is how it sustains an active community of users. It is represented in digital forums and actively collaborates with similar Labs and universities. Collaboration is being sought with other Labs in the region. All relations are very positive. There is no competition in the maker culture world" (Medialab-Prado)

This modus operandi also allows cultivating social capital throughout the different linkages that are created by the members of the community. That makes possible that these spaces became a meeting point for many types of people with different and disparate interests and origins. As a result, the mindset reigning in these environments lays on thinking globally but acting locally. They do not frown upon collaboration with others spaces of the same

characteristics and they seek out opportunities for collaboration with other organizations that may be aligned. They consider themselves spaces for innovation but with a focus on the earliest stages of the process. Specially, when there is an exploration of technologies often coined as "prototyping". In our opinion, this is the reason why they are not considered as incubators. The distance to the market at this stage is still huge but these spaces clearly act a hub where innovation and unusual connections happens regularly.

"It is quite clear that, though we remain local, we must also work at a global level, because after all, we are working for people and it is through such work that you provide these people with more opportunities. In terms of networking, we are co-founders of the Basque Country's Network of Creative Experiences; we are also co-founders of the Trans-Iberian Network of Independent Spaces and we are working very actively on both. In addition to, we are working on the Living Lab (TRANS EUROPE HALLS) and the Network of Spaces for Innovation of Latin America and the Caribbean. We work with many stakeholders at the local, national and international levels" (ZAWP)

Last of all, we would like to point out that though these sorts of spaces are rapidly growing at urban areas they are also starting to appear in rural places. In our field work we were able to discover the case of Calafou (Calafou-Cooperativa-Integral, 2015) which has become a reference for this type of urban spaces. That makes us think that this phenomenon could also be very relevant for revitalizing rural ecosystems and nurturing its social capital.

"If you try to think of a maker site at the country-wide level such as Calafou…a town located in Catalonia that is what could be called a maker community. It is a self-run village that is thinking about how to produce the whole value chain, the whole system of life from the free and open (…) I believe that, at the country-wide level, there is more maker culture in small towns than in cities because in towns there is much more of a culture for making things and it is where communities have not broken down entirely. On the other hand, in cities we are pure consumers and the community ceased to exist long ago. Of course, there are always some technical "geeks" who have gotten down to doing the work of the maker culture" (WikiToki)

3.2. Open technologies

Another of the issues related with these collectivities that we would like to highlight is the use of non-proprietary technologies. This is something at the backbone of movements like hackers or makers. Both groups have used and promoted "open-source software" and "open hardware" in order to use technology as an instrument for meeting the community's needs. Technology is envisioned as an element of empower and not as an objective itself (Bookchin, 1965). Some of the open technologies which have allowed new possibilities to DIY movements include CNC (Computerized Numerical Control) drills, 3D scanners, laser cutters, Arduino circuits, Raspberry Pi controllers and, of course, 3D printers, as well as many others.

"Nearly all technologies that are being used are open-source such as the Arduino microcontroller, MakerBot and Prusa 3D printer. Open technologies are desirable due to budget limitations. Technology is not the core but rather a way for involving those interested in collaborative processes" (Medialab-Prado)

These technologies have gone into the public domain because the patents have expired and it has been possible to transfer manufacturing "from factory to desk" (Gershenfeld, 2005).

The popularization of this type of technologies has also led to a democratization of innovation as has been pointed out by some authors on similar phenomena (Hippel & Katz, 2002; Von Hippel, 2005) despite there are still many barriers located in the diffusion and access to knowledge (Morozov, 2014). In our opinion, this has led to the crystallization of a new paradigm of collective innovation with fewer entry barriers and in a much more amateur basis. In our field work, the different spaces are advocators of open technologies because they believe that technology must be considered as an instrument and not as an end. They prioritize collaboration, openness, sustainability and co-creation as the main drivers of any kind of project.

"There are two challenges; the distributed concept of creation and collective design on the one hand while at the other is the idea of sustainability linked to technology and making technology more accessible or more citizen-based. Our view of technology is quite broad including not only ICTs or advanced technology. We have an instrumental view of it that makes possible to build projects and make things. It means putting a series of technologies with an open philosophy into context and generates a community-based dimension. That creates a social context which allows for a relationship between people who use it as an instrumental goal to produce an impact on society" (Hirikilabs, 2014)

3.3. Informal learning

In the last part of this section we would like to describe the kind of learning dynamics that are found in this type of spaces. Although they offer internal and external training in diverse formats it is also delivered in an informal way. The idea of a community of practice (Wenger, 1999) seems to be present at every time and taking place both in the physical spaces and in the different digital platforms that are used by this type of spaces.

"The idea of collaboration and of community-based creation and then work by that community in meeting spaces such as a Hack Meeting, Fab10, is the DNA of our work" (Hirikilabs)

Many and different activities exemplifies this learning dynamics that are delivered in these spaces. Much of them are associated with the use of new open technologies, such as training to start using 3D printers, laser cutting, creative electronics and chiptune music, to name a few examples.

"Education, training and sharing knowledge are some of the Lab's top priorities. The trainers are both external and internal depending on the subject matter. Media Lab Prado has a large pool of experts with whom it collaborates regularly. The trainers come from very specific fields such as scanning and 3D printing to make reality-based 3D models and produce prototypes. It is a "very small world" in which people are delighted to share and enrich their knowledge" (Medialab-Prado)

The objective of all these learning dynamics seems to be rooted in the promotion and strengthening of a community of practice that can serve as a nexus linking the different individuals who take part in this space at some time whether temporarily or not. The dynamics of empowerment and informal learning that persistently succeed constitutes an exciting target for research which we would like to highlight for future studies. We also agree with other authors in the change that is experimenting education thanks to

technology towards a more productive model where students are active participants and not only passive actors (Deriu, Uras, Simbula, Ardu, & Paddeu, 2013).

4. Social Manufacturing: The new personalized peer-to-peer manufacturing

As mentioned above, there are many trends and movements around concepts such as DIY, DIT, P2P Production, Makers, Hackers, etc. and different social spaces where these movements are taking shape and becoming visible to society such as HackSpaces, MakerSpaces, Fab Labs, etc. Our goal in this article is to propose a term that groups together the different trends and nomenclatures into one single concept which we refer to as "Social Manufacturing."
In the existing literature, we have found this term mentioned many times, but it has not been used with the meaning of "collaborative social fabrication" which is something that we would like to stress in this article. This term has been used in reference to cloud-based services platforms (Shang et al., 2013; Yin, Huang, Liu, & Wen, 2011) and in relation with the value chain of various fabrication processes (Takahashi 2011; Wu, Schaefer and Rosen 2013) whereas other references involve the coupling of social innovation with the advanced fabrication (Espiau, 2014) or "rapid prototyping" allowed by these new open technologies (Brown, 2013).

The meaning which we would like to propose in this article is related with new forms of customized fabrication which have become possible because of open technologies involving at the same time a collaborative system of production and informal learning. New open-source technologies make possible to recreate nearly any product that already exists in society (Townsend et al., 2011). Joint with the potential of virtual communities of innovators that are managed through the Internet (The Economist, 2012) makes possible products that tend towards a marginal cost of zero (Rifkin, 2014). This fact inclines us to think that we are witnessing a new paradigm in terms of manufacturing and the relationship that has with society, design and the production of goods (Michel Bauwens & Kostakis, 2015).

That is why we would like to propose "Social Manufacturing" as a term that implies expressions of digital production that is characterized by:

- A p2p production basis.
- Using of open source & non-proprietary technologies.
- Promotion of informal learning (offline and online).

We believe that these three factors are the quintessence of the new innovation ecosystems that are based in p2p and open manufacturing. The transformation lies not only in the use of new technologies but also in the organizational systems and the way the knowledge flows. In our opinion, these spaces are also learning ecosystems that can pave the way for future social innovations and business opportunities. The real challenge is how to scale up these ecosystems to other scenarios like traditional manufacturing factories (S. Lindtner, 2014) and how society can evolve to a basis where knowledge can be easily shared, replicated and transferred. This is one of the most recent CAPS projects (Collective

Awareness Platform for Social Innovation and Sustainability) projects[5] approved by the European Commission throughout its Horizon 2020 research framework program. The name of this project is OPENMAKER and tries to gather traditional manufacturers, makers, hackers and other stakeholders into a single environment in order to foster a much more social and sustainable manufacturing culture throughout different prototypes and collaborative platforms and spaces.

5. Current crossroads and challenges

After performing the characterization of these new movements and spaces in terms of urban and social spaces we would also like to place an emphasis on the various challenges and potential threats which they must face. Whether due to current gaps in the law or the disruptive nature of these new open technologies we cannot leave out several pieces of evidence which allow us to envisage emerging challenges to be faced in the upcoming years. We believe that it is of special importance that these challenges have to be assumed by policy makers, academia and industry. All of these players must collaborate when it comes time to tackle the different challenges arising. The popularization and adoption of these types of technologies continue at a fast pace but it is mostly doing so in an informal manner and often through the "word-of-mouth". Mostly throughout the new platforms created as a result of the paradigm of Web 2.0 and Social Media that make it easier to share multimedia and promote the exposure and dissemination of user-generated content (Stefanone, Lackaff, & Rosen, 2008). This high rate of dissemination and adoption is not free from potential barriers for its social appropriation (Toboso-Martín 2014). Most notable amongst them are a lack of criteria for the standardization of their final products or the safety of materials (Lipson & Kurman, 2010). It also involves intellectual property and business models issues that have to be decided upon as must the return on the investment made by public powers and their socioeconomic impact on the city or territory in which they act. It is well known how hackerspaces can foster collaboration between a wide range of social actors (Maxigas, 2012) but this potential needs also a backup by an accurate framework provided by the civil society.

For instance, in the literature reviewed we have observed a real risk of excessive legal protection by policy makers (Weinberg, 2010). This protection could stop the development of innovation and business opportunities associated with these new disruptive open-source technologies. The customization and modification processes that foster making phenomenon to different objects are a possibility for open innovation and collaboration between different "non-usual suspects". In our judgment, proper dissemination and divulgation of these new technologies must be performed vis-à-vis with policy makers, legal experts and society as a whole. The current situation does not entail any intellectual property right violations (in most cases due to different gaps in current legislation) but it is clear that legal battles may arise in which the different lobbies affected by these new technologies will be taking part (Bradshaw, Bowyer, & Haufe, 2010). While it is true that potential negative impacts can be inferred from certain open technologies like 3D printing,

[5] CAPS is an initiative by the European Commission to promote Social Innovation through digital platforms. More information about it at https://ec.europa.eu/digital-single-market/en/news/building-community-action-some-reflections-collective-awareness-platforms-sustainability-and

such as the loss of jobs in mature sectors and other impacts not yet identified. The truth is that not ensuring the benefits of free access to this type of open technologies could hamper many of the potential benefits of the social appropriation of these technologies in society (Weinberg, 2010). And at the same time, it will be a way to deny the increasingly and remarkable prosumer character of the citizens (Ritzer & Jurgenson, 2010) in the twenty-first century innovation society (Innerarity, 2009).

In the interviews held at the spaces which took part in the research, an unconditional commitment to free culture licenses and a predominance of the open-source philosophy were made apparent. An emphasis is placed on searching for alternative intellectual property and commercial exploitation management models.

"There are no guidelines in terms of Intellectual Property. There is a predominance of open-source licenses and a philosophy of the free and open. (DIY, DIT)" Alternative post-capitalist models are required" (Hirikilabs)

Therefore, it is not surprising that new types of commercial licenses such as copyleft and "creative commons" are the ones chosen by these types of spaces and organizations to determine the authorship of these creations and the prototypes developed. Perhaps this may also be a legacy of the values of what is digital. Following that assumption we believe that they may not have problems of a legal nature in their everyday work (in accordance with the testimony gathered) because their users do not take part on the different projects with a mindset based upon a monetary return on investment.

"There are no guidelines for establishing the service's intellectual property, though they do enter into agreements as a very standardized form of collaboration. We have different standardized agreements which we later adapt to whatever the specific relationship in question requires. Moreover, it in some way acts as a filter for those who do not truly believe in the project, because those who are really committed and involved do not mind signing a document" (ZAWP)

On the other hand, we would like to point out the questions brought up by this type of space in terms of return on investment. While it is true that they are often self-organized movements that attempt to obtain the resources necessary for their existence, in our research we also detected that many municipalities or regional authorities help financing this type of spaces. The idea behind this funding is an attempt to recover urban areas that have deteriorated due to de-industrialization processes. In this sense, the Basque Country boasts of a significant industrialist past tightly related with manufacturing. Its transformation to a knowledge society has also been studied as a paradigmatic case (Galarraga, 2011) but at the same time the culture of manufacturing still remains due to the numerous SME´s that work in activities related with fabrication. Some authors have shown how "making" has its own politics (S. Lindtner, 2014; Silvia Lindtner & Li, 2012; Sun, Lindtner, Ding, Lu, & Gu, 2015) as other authors has shown how technology and artifacts has politics too (Winner, 1980). In this way, these new phenomena are fostered by some administrations but at the same time they differ from values and attitudes upon which area, collectivity or purpose represents. That is why more research must be carried out in this respect. It is still needed to justify the role of this kind of spaces as dynamic-players that can regenerate the social capital in urban areas and how some of them are really intertwined

in social communities or just a bunch of machinery and people that get funded by a regional administration to promote any kind of activities.

It becomes necessary to go further of the classical economic indicators, because these types of spaces often have a great influence on the regeneration of social capital in many depressed urban areas. And at the same time, it is compulsory to analyze the diverse economic impacts. In most cases, these types of spaces do not have a defined business model, because they are a hub of entrepreneurs and projects which are arising at the dawn of these new technical and social movements (Mota, 2011). They do not perform classical activities of incubation and accompaniment but undoubtedly they work as hubs and supporters of innovation ecosystems that are appealing to entrepreneurs. We must therefore rethink the innovation indicators that are applied to this type of environments.

"Web analytics gives us an idea, but it cannot be counted. Here projects have been developed up to the prototype level, but it is very easy to see cases like that of a kid who spent three months here toiling away at the 3D printer and then founded a company that was sold for 400 million dollars. Up to now, tools have not been used to study the business model. The restructuring of the current model and migration to one which allows for better profitability on assets is being considered, above all through paid, affordable training courses with discounts for the unemployed and students …The social impact generated is not known" (Medialab-Prado)

From the perspective of the spaces studied, at least two of them declare that they have no interest in evaluating economic aspects, whether because their sources of financing are public, or because they do not see it as linked to their philosophy as an organization. Although the impact of specific projects is known, it is not the objective of this exploratory study to identify the relevant socioeconomic impacts of these movements. Despite this, they have been considered in the literature (Deloitte, 2013), and this constitutes one of the emerging challenges for research.

"ZAWP is not going to be a business, nor is it going to form part of anything that has to do with business. However, yes to participation in the products which come about through its resources. No specific analyses have been performed, but information is kept on the impact produced: companies which have come out of here, projects which have been created, the people who have passed through, ages… People have come to live here. We have recovered many thousands of square meters... Yes, we are having an influence on urban planning, because, in the end, ZAWP is helping to get them take into account the Creative Economy and its ability to create an impact in terms of regenerating an urban area"(ZAWP)

Last of all, we would also like to point out another of the challenges which we have identified in the years to come. New innovation ecosystems will have to organize their repositories of knowledge. It is obvious that these types of locations share knowledge and transfer it, whether through dynamics which promote informal or formal learning. However, it is also obvious that the challenge emerging in light of this situation requires the effective systematization of those knowledge repositories. In this sense, the main threat of Web 2.0 platforms is the fragmentation (P. Anderson, 2007; O´Reilly, 2005) of the information which they keep and therefore, the knowledge they may produce.

"The WikiToki page itself is a Wiki; the fact that it does not operate as a cumulative repository does not mean it is not a sort of distributor or hub. And then, for instance, all of the activities are recorded in a document and an open file is generated; even the project which we submitted to Creation Factories is about how to create order in all of this. If the question is whether all of that has been built already, then the answer is no, but there is a desire to get it done. Everything on WikiToki, all of its internal activity, is documented, and the external activity is also documented on the website" (WikiToki)

We have observed that the studied spaces share knowledge in wide-ranging ways and using different tools, but they all suffer from a lack of systematization and/or advanced management. Although we have found this lack of an advanced system for knowledge management, we have at the same time seen an increase in awareness about the problem and a will to deal with the challenge.

6. Conclusions

We have explored the current state of the art of terms such as Makers and Hackers, as well as collaborative innovation spaces such as Hackerspaces and Fab Labs. We have also reviewed the particular features owned by these co-creation spaces and the most important challenges they face highlighting their various implications in different sectors and fields. We propose "Social Manufacturing" as an ideological umbrella covering all of these new forms of personal fabrication of objects which entail a new form of relationship between society and consumer goods. In our opinion, this is a concept which combines the existing literature, as well as other issues like learning and collaborative production which differ from the prior literature.

As we have stated previously we tend to think that it is critical to safeguard the society´s future interests and resist forthcoming expected pressures that some lobbies will impose to policy-makers. These are a few of the key factors which might arise when it comes to facilitating a change in society's relationship with the production of consumer goods (Michel Bauwens & Kostakis, 2015). Some potential benefits have yet to be fully envisaged but we already see some signals in sectors such as education and the creative and cultural industries. We strongly think that an emphasis must be placed on social dissemination (Rogers, 1962) of these open and non-proprietary technologies in order to facilitate the evolution of the society to a much more prosumerism basis. The public perception of this phenomenon tends to adopt techno-optimistic views (Sivek, 2011) but we clearly envisage room for fruitful experimentation between different stakeholders like other authors have described (S. Lindtner, 2014). The need for an education based in "learning by doing" approach where digital (Ferrari, 2013) and other soft skills have recently gained significant importance incline us to think that the use of technology in education has a paramount role nowadays. The public perception created about this phenomenon is of vital importance because a possible negative view of it could create undefeatable barriers (López Cerezo & González, 2013) for the social appropriation (Toboso-Martín 2014) and popularization of this phenomenon. Unless adoption of the phenomenon is widespread it will be difficult to achieve success (Echeverría, 2013) but at the same time, we have to avoid optimistic and narrow views of this new wave of DIY phenomenon.

Last, we emphasize the need to push forward research in order to determine the socioeconomic impact of these distributed creation spaces on their ecosystem. We have found there is a lack of data for measuring this performance. And what´s more important we have observed that there are many reasons that lead us to think that they have various positive effects (in light of the empirical data gathered) but the truth is that there is no available information that can be used. Therefore, we envisage research opportunities that can contribute to the development of theoretical frameworks that help us to understand the role of "Social Manufacturing" and its impact in society.

BIBLIOGRAPHY

Anderson, C. (2010). In the Next Industrial Revolution, Atoms Are the New Bits. Retrieved May 12, 2014, from http://www.wired.com/2010/01/ff_newrevolution/

Anderson, C. (2012). *Makers: the new industrial revolution*. Random House.

Anderson, P. (2007). *What is Web 2 . 0 ? Ideas , technologies and implications for education by*. Retrieved from http://www.jisc.ac.uk/media/documents/techwatch/tsw0701b.pdf

Atkinson, P. (2006). Do It Yourself: Democracy and Design. *Journal of Design History*, *19*(1), 1–10. http://doi.org/10.1093/jdh/epk001

Bauwens, M. (2005). The political economy of peer production. *CTheory*. Retrieved from http://www.informatik.uni-leipzig.de/~graebe/Texte/Bauwens-06.pdf

Bauwens, M., & Kostakis, V. (2015). Towards a new reconfiguration among the state, civil society and the market. *The Journal of Peer Production*, (7). http://doi.org/10.1017/CBO9781107415324.004

Benkler, Y. (2006). *The Wealth of Networks: How Social Production Transforms Markets and Freedom*. New Haven and London: Yale University Press.

Benkler, Y. (2011). *The Penguin and the Leviathan: How Cooperation Triumphs over Self-Interest*. Crown Business.

Bijker, W. E. (1995). Sociohistorical Technology Studies. In S. Jasanoff, G. Markle, J. Petersen, & T. Pinch (Eds.), *Handbook of science and technology studies, revised edition*. (pp. pp. 229–257). Thousand Oaks, CA: SAGE Publications.

Bijker, W. E., Hughes, T. P., & Pinch, T. J. (1987). *The social construction of technological systems: New directions in the sociology and history of technology*. (W. E. Bijker, T. P. Hughes, & T. J. Pinch, Eds.). Cambridge, MA: MIT Press.

Bijker, W. E., & Pinch, T. J. (1984). The Social Construction of Facts and Artefacts : or How the Sociology of Science and the Sociology of Technology might Benefit Each Other. *Social Studies of Science*, *14*(3), 399–441.

Birtchnell, T., & Urry, J. (2013). Fabricating Futures and the Movement of Objects. *Mobilities*, *8*(3), 388–405. http://doi.org/10.1080/17450101.2012.745697

Bookchin, M. (1965). Hacia una tecnología liberadora.

Bradshaw, S., Bowyer, A., & Haufe, P. (2010). The Intellectual Property implications of low-cost 3D printing. *ScriptEd*, *7*, 5–31. http://doi.org/10.2966/scrip.

Brown, R. (2013). Social Manufacturing. Retrieved February 24, 2015, from http://es.slideshare.net/richardbrown94849/social-manufacturing

Calafou-Cooperativa-Integral. (2015). Calafou | postcapitalist ecoindustrial colony. Retrieved January 31, 2015, from https://calafou.org/en

Chesbrough, H. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Boston: Harvard Business Press.

Cruz, J., Herrington, S., & Rodriguez, B. (2014). Farmbot. *Digital Commons*. Retrieved from http://digitalcommons.calpoly.edu/mesp/241/

Deloitte. (2013). *Impact of the Maker Movement*. Retrieved from http://oaklandmakers.org/wp-content/uploads/2014/06/Impact-of-the-Maker-Movement.pdf

Deriu, M., Uras, S., Simbula, G., Ardu, D., & Paddeu, G. (2013). Playing by the rules: co-designing interactive installations with pupils. *Interaction Design and Architecture(s)*, *18*, 40–53.

Dosi, G. (1982). Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. *Research Policy*.

Echeverría, J. (2013). Evaluar las innovaciones y su difusión social. *Isegoría*, (48), 173–184. http://doi.org/10.3989/isegoria.2013.048.09

Espiau, G. (2014). Social Manufacturing. Retrieved February 24, 2015, from https://gorkaespiau.wordpress.com/2014/09/15/social-manufacturing/

Estalella, A., Rocha, J., & Lafuente, A. (2013). Laboratorios de procomún: experimentación, recursividad y activismo. *Teknokultura*, *10*, 21–48. Retrieved from http://teknokultura.net/index.php/tk/article/view/121/pdf

Ferrari, A. (2013). *DIGCOMP: a Framework for Developing and Understanding Digital Competence in Europe. eLearning Papers*. Seville. http://doi.org/10.2788/52966

Fox, S. (2014). Third Wave Do-It-Yourself (DIY): Potential for prosumption, innovation, and entrepreneurship by local populations in regions without industrial manufacturing infrastructure. *Technology in Society*, *39*, 18–30. http://doi.org/10.1016/j.techsoc.2014.07.001

Galarraga, A. (2011). *Procesos inconclusos: La industria y el conocimiento en la C.A. del País Vasco*. Universidad del País Vasco.

Gershenfeld, N. (2005). *Fab: The coming revolution on your desktop - From personal computers to personal fabrication*. Basic Books.

Haring, K. H. (2008). *Radio´s Technical Culture*. Cloth.

Himanen, P. (2002). *La ética del hacker y el espíritu de la era de la información*. Destino. Retrieved from http://eprints.rclis.org/handle/10760/12851

Hippel, E. von, & Katz, R. (2002). *Shifting Innovation to users via toolkits* (April 2002 No. Working Paper 4232-02). Retrieved from http://ssrn.com/abstract_id=309740

Howe, J. (2009). *Crowdsourcing: Why the Power of the Crowd Is Driving the Future of Business*. Crown Business.

Innerarity, D. (2009). La sociedad de la innovación. In *¿Cómo es una sociedad innovadora?*

Janssen, C. (2014). What is Do It With Others (DIWO)? - Definition from Techopedia. Retrieved January 21, 2015, from http://www.techopedia.com/definition/28410/do-it-with-others-diwo

Johar, I., Lipparini, F., & Addarii, F. (2015). *Making Good our Future - Exploring the New*

boundaries of Open & Social Innovation in Manufacturing. Retrieved from https://webgate.ec.europa.eu/socialinnovationeurope/sites/default/files/sites/default/files/SIE - Making Good our Future - May 2015.pdf

Kostakis, V., & Papachristou, M. (2014). Commons-based peer production and digital fabrication: The case of a RepRap-based, Lego-built 3D printing-milling machine. *Telematics and Informatics*, *31*(3), 434–443. http://doi.org/10.1016/j.tele.2013.09.006

Kuznetsov, S., & Paulos, E. (2010). Rise of the Expert Amateur : DIY Projects , Communities , and Cultures. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries* (pp. 295–304). ACM.

Latour, B. (1992). *Ciencia en acción*. Barcelona: Labor.

Lindtner, S. (2014). Hackerspaces and the Internet of Things in China: How makers are reinventing industrial production, innovation, and the self. *China Information*, *28*, 145–167. http://doi.org/10.1177/0920203X14529881

Lindtner, S., & Li, D. (2012). Created in China: The Makings of China's Hackerspace Community. *Interactions*, *19*, 18–22. http://doi.org/10.1145/2377783.2377789

Lipson, H., & Kurman, M. (2010). *Factory @ Home : The Emerging Economy of Personal Fabrication*.

López Cerezo, J. a., & González, M. I. (2013). Encrucijadas sociales de la innovación. *Isegoría*, (48), 11–24. http://doi.org/10.3989/isegoria.2013.048.01

Lundvall, B.-A. (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter Publ.

Maxigas. (2012). Hacklabs and hackerspaces - Tracing two genealogies. *The Journal of Peer Production*, (2). http://doi.org/10.1017/CBO9781107415324.004

Morozov, E. (2014). Making It. Retrieved April 12, 2016, from http://www.newyorker.com/magazine/2014/01/13/making-it-2

Mota, C. (2011). The Rise of Personal Fabrication. In *Proceedings of the 8th ACM conference on Creativity and cognition* (pp. 279–288). ACM.

O´Reilly, T. (2005). What Is Web 2.0? Design Patterns and Business Models for the Next Generation of Software. Retrieved March 22, 2014, from http://oreilly.com/web2/archive/what-is-web-20.html

Oudshoorn, N., & Pinch, T. (n.d.). *How users matter: The co-construction of users and technology*. (N. Oudshoorn & T. J. Pinch, Eds.). Cambridge, MA: The MIT Press.

P2P-Foundation. (2012). *A synthetic overview of the collaborative economy*. *Aliso*. Amsterdam. http://doi.org/10.5642/aliso.20123001.01

Ratto, M., & Ree, R. (2012). Materializing information: 3D printing and social change. *First Monday*, *17*(7), 1–25.

Rifkin, J. (2014). *The Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of Capitalism*. Palgrave Macmillan.

Ritzer, G., & Jurgenson, N. (2010). Production, Consumption, Prosumption: The nature of

capitalism in the age of the digital "prosumer." *Journal of Consumer Culture*, *10*(1), 13–36. http://doi.org/10.1177/1469540509354673

Rogers, E. M. (1962). *Diffusion of Innovations*. Free Press.

Scholz, T. (2012). *Digital labor: The internet as playground and factory*. New York: Routledge.

Shang, X., Liu, X., Xiong, G., Cheng, C., Ma, Y., & Nyberg, T. R. (2013). Social manufacturing cloud service platform for the mass customization in apparel industry. In *Proceedings of 2013 IEEE International Conference on Service Operations and Logistics, and Informatics* (pp. 220–224). IEEE. http://doi.org/10.1109/SOLI.2013.6611413

Sivek, S. C. (2011). "We Need a Showing of All Hands": Technological Utopianism in MAKE Magazine. *Journal of Communication Inquiry*, *35*, 187–209. http://doi.org/10.1177/0196859911410317

Smith, A., Hielscher, S., Dickel, S., Söderberg, J., & Oost, E. van. (2013). *Grassroots digital fabrication and makerspaces: reconfiguring, relocating and recalibrating innovation?* (SPRU-Science and Technology Policy Research No. 2013-02). Retrieved from http://www.researchgate.net/publication/258835556_Grassroots_Digital_Fabrication_and_Makerspaces_Reconfiguring_Relocating_and_Recalbirating_Innovation/file/60b7d529188536e47c.pdf

Stangler, D., & Maxwell, K. (2012). DIY Producer Society. *Innovations: Technology, Governance, Globalization*, *7*(3), 3–10. http://doi.org/10.1162/INOV_a_00134

Stefanone, M., Lackaff, D., & Rosen, D. (2008). We're all stars now: Reality television, Web 2.0, and mediated identities. *Proceedings of the Nineteenth ACM …*.

Sun, Y., Lindtner, S., Ding, X., Lu, T., & Gu, N. (2015). Reliving the Past & Making a Harmonious Society Today: A Study of Elderly Electronic Hackers in China. In *Cscw 2015* (pp. 3933–3942). Vancouver. http://doi.org/10.1145/2675133.2675195

Surowiecki, J. (2005). *The Wisdom of Crowds*. Anchor.

Takahashi, D. (2011). Kenandy raises $10.5M for cloud "social manufacturing." Retrieved January 15, 2015, from http://venturebeat.com/2011/08/29/kenandy-raises-10-5m-for-cloud-based-social-manufacturing/

The Economist. (2012). A third industrial revolution. Retrieved May 12, 2014, from http://www.economist.com/node/21552901

Toboso-Martín, M. (2014). Perspectiva axiológica en la apropiación social de tecnologías. *Revista Iberoamericana de Ciencia, Tecnología Y Sociedad*, *9*(25), 1–18.

Townsend, A., Jeffery, L., Fidler, D., & Crawford, M. (2011). *The Future of Open Fabrication*. Palo Alto, Ca. Retrieved from http://www.iftf.org/our-work/people-technology/technology-horizons/the-future-of-open-fabrication/

Von Hippel, E. (2005). *Democratizing Innovation*. Cambridge, MA: The MIT Press. Retrieved from http://web.mit.edu/evhippel/www/democ1.htm

Weinberg, M. (2010). *It will be awesome if they don´t screw it up: 3D Printing, Intellectual Property, and the Fight Over the Next Great Disruptive Technology*. Retrieved from http://www.publicknowledge.org/news-blog/blogs/it-will-be-awesome-if-they-dont-

screw-it-up-3d-printing

Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity*. Cambridge University Press.

Winner, L. (1980). Do Artifacts Have Politics ? *Daedalus*, *109*(1), 121–136. Retrieved from https://blog.itu.dk/I-II-E2013/files/2013/11/winner-l-do-artifacts-have-politics.pdf

WordMaker. (2013). Maker. Retrieved January 31, 2015, from http://www.urbandictionary.com/define.php?term=Maker

Yin, C., Huang, B., Liu, F., & Wen, L. (2011). Common key technology system of cloud manufacturing service platform for small and medium enterprises. *Computer Integrated Manufacturing Systems*, *17*(3), 495–503.