Can do-it-yourself laboratories open up the science, technology, and innovation research system to civil society?

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Can Do-It-Yourself Laboratories open up the Science, Technology, and Innovation Research System to Civil Society?

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Highlights

- DIY Labs are often inhabited by exclusive peer communities

- DIY Labs often embody the imaginative world of technological innovation

- The critical issue in DIY labs is openness to lay knowledge

- Intermediation is required to encourage the participation of non-experts in DIY labs

- Intermediary agents facilitate interrelationships and foster social innovation

Abstract

This paper deals with the potentialities for do-it-yourself (DIY) labs to open up the research and innovation system to citizen participation. DIY labs are spaces where academics and civil society stakeholders can gather to experiment with alternative research and innovation practices. I hypothesize that these collaborative practices are facilitated by intermediation. My results draw on the literature and on extensive field work in French DIY labs, also called fablabs, (bio)hackerspaces, makerspaces or third places. First, I discuss the relationship between DIY labs, epistemic communities and citizen participation. Second, I compare two situations of collaborative practices in maker communities. I show that managing the inclusion of

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non-experts in these technology-oriented communities requires a set of activities which need to be coordinated by an intermediary agent and are often distributed among community members. Third, I conclude that intermediation plays a key role in transforming technology-centered into socio-centered DIY labs. In socio-centered set-ups, technical experts and practitioners from the groups concerned (users, patients, residents, etc.), collaborate thanks to intermediary agents. Intermediation is a pre-requisite for DIY labs to open up the research and innovation system to civil society.

Keywords

Introduction

The term "DIY labs" refers to a range of spaces where people gather, socialize and share/produce knowledge-by-doing with a variety of tools. The expression "do-it-yourself", abbreviated to "DIY", emerged in North America after World War II. It was linked to leisure pursuits, creativity and independence from corporate activities. DIY practices were appropriated by the 1960s and 1970s counterculture as a way of expressing a critique of the dominant consumer society and participating in an alternative culture (Ferretti, 2019). It has flourished in the hacker and maker communities which value excellence, anti-establishmentism, openness, and a critical approach to technology (Maxigas, 2012). Most of their members are hobbyists and technology enthusiasts with a professional background in technology. In these peer communities, a tacit rule states that the premises of knowledge are to be gained prior to entering the community. DIY labs embody these various subcultures. They focus on innovation, collaboration, and experimentation with emerging technologies and traditional arts and crafts.

This paper deals with the potentialities for DIY labs to open up the research and innovation system to citizen participation. I hypothesize that DIY labs are boundary spaces where academics, firms and civil-society stakeholders can gather to experiment with alternative research and innovation practices. In doing so, they may contribute to the intertwining of different forms of knowledge and approaches to problem-solving and thereby modify established organizational structures. To elucidate the organizational dimensions of knowing in projects, I use the concept of project ecology (Grabher, 2004a). I analyze the projects that integrate newcomers into a maker community. How is knowledge produced and circulated in projects?

How are makers involved in such projects? What is the position of the coordinator of these projects? What set-ups does he use to promote the integration of novices? How are these practices transferred to individuals and organizations? To answer these questions, I draw on the literature on DIY labs and on an empirical study of French fablabs. French has a profusion of terms for "DIY lab", of which fablabs is the most widespread, due to its use in public policy-making (Lhoste and Barbier, 2018). Fablabs are often located in "tiers-lieux" (third places), an umbrella term used in public policy-making for boundary spaces dedicated to collaborative practices (Levy-Waitz, 2018). DIY labs host displacements of heterogeneous sets of techno-scientific practices under the nebulous rubrics of citizen science and participatory research (Houllier et al., 2017; Seyfried et al., 2014), social innovation (Edwards-Schachter et al., 2012) low tech and frugal innovation (Gibney, 2016), democratization of innovation (von Hippel, 2005), and civic technoscience (Dickel et al., 2019; Wylie et al., 2014). These forms of knowledge production are at the boundary between academic, corporate and citizen research.

The paper is organized in four parts. In the first section, I describe the methodological and theoretical approach. I draw on the conceptual framework of project ecology (Grabher, 2004a) to reveal the basic organizational architecture of project-based learning and the role of epistemic communities. This architecture is employed as a theoretical template for an exploration of knowledge hybridization in collaborative projects involving makers. I further characterize hybrid epistemic communities as combining scientific expertise and lay knowledge. In the second section, I explore the ambiguous relationship of DIY communities with the formal research and innovation system through the literature on civic technosciences and biohacking. These peer communities have imaginative worlds close to those of the epistemic communities

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from which they arise. In other words, they draw on normal science and their representations of civil society are close to diffusionist models where lay knowledge is ignored. The third section builds on my empirical work on French fablabs and illustrates my theoretical argument about project ecologies. I explore how different forms of knowledge may be linked together in hybrid epistemic communities through project ecologies. I show that a set of translation and facilitation activities are required to manage the inclusion of non-peer experts and legitimize lay knowledge in hybrid epistemic communities. In the last section, I consider the democratizing role of DIY labs through the key activities of intermediary agents. These agents coordinate the distribution of translation, enrolment, agency and diffusion activities between the community members. Their activities differentiate between technology-centered and socio-centered DIY labs. In the latter, scientific and technical experts collaborate with practitioners and the groups concerned (patients, residents, farmers, etc.) to address social and environmental problems. This collaboration is a pre-requisite for the opening up of DIY labs to civil society. I conclude that DIY labs are boundary spaces which embody DIY practices. They help to structure hybrid epistemic communities alongside or at the borders with academia and business. The intermediation activities are essential for fulfilling the promises of openness and democratization of innovation.

Methodological and conceptual frameworks

The results draw on the literature and on extensive field work conducted in French DIY labs (which are called fablabs, (bio)hackerspaces, makerspaces or third places), since the beginning of their institutionalization. The data come from a variety of sources and were collected between 2012 and 2017. I entered a maker community

without any IT skills but with long experience of being an individual DIY practitioner. Participating in the activities of a fablab community allowed me to collect materials and records made available by/for its members through various media. I interviewed over 40 makers, fabmanagers and organization managers collaborating with fablabs. I conducted participatory observation in several fablabs (for details see (Lhoste and Barbier, 2018, 2016), at La Paillasse, a DIY biohackerspace, and during various social events organized by the communities. This empirical material provided analytical data for the two articles cited above.

In addition to my research project, I contribute to several working groups reflecting on the cognitive, structural and political issues raised by the democratization of research and innovation. These working groups operate under the umbrella of a think-tank that brings together researchers, managers of academic organizations and representatives of civil society organizations. The think-tank lobbies for the inclusion of civil society organizations in research and innovation policies (Akrich et al., 2017). These embedded practices provided access to empirical material in a variety of DIY labs. This double positioning "in and out" has the advantage of providing an intimate knowledge of the field. Anthropologists run a risk of legitimacy regardless of the place they occupy in relation to their object of study (Ouattara, 2004). I seek the mainsprings of distanced analysis in methodological and epistemological rigor, reflexivity and peer discussion (Olivier de Sardan, 1995).

This study draws on actor network theory (Callon, 1986). According to this theory, the research and innovation process involves heterogeneous actors who play complementary roles and transform knowledge within a dynamic and situated process. This multidimensional social process incorporates different forms of knowledge from multiple sources. Therefore, innovation is distributed within networks

(Grabher, 2004b). These theories allow an understanding of how social networks produce, disseminate and circulate knowledge and how materiality is involved. The conceptual framework of project ecology (Grabher, 2004a) reveals the basic organizational architecture of project-based learning. It disentangles the core team, the organization, the epistemic community, and the personal networks. This architecture is employed as a theoretical template for an exploration of knowledge hybridization in collaborative projects involving makers.

Networks of experts who have jointly developed a common set of understandings on an issue are referred to as epistemic communities (Haas, 1992). The concept of epistemic community emphasizes the collective nature of knowledge production. It is based on the assumption that epistemic communities are made and materialized in action. It requires exploring the practices, objects, instruments and discourses that produce and maintain these collectives. Individuals are not only engaged in the production of knowledge, they also have shared political, social and economic ambitions. This notion is well summarized in the notion of epistemic culture (Knorr-Cetina, 1999). It articulates the role of expertise in the political identification of a problem. While Haas's early work focused on communities of scientists and professional experts, later scholars refer to hybrid epistemic communities that combine scientific expertise with the lay knowledge of patients (Akrich, 2010), residents (perhaps exposed to environmental pollution) (Kinchy, 2017) or amateur botanists (Millerand et al., 2011). Lay knowledge is based on individual experience of the problem and it can be discussed with peers. Lay people can also appropriate scientific expertise (lay expertise) related to the issue that concerns them. Akrich (2010) shows how patient groups engage in activist work where experiential and scientific knowledge plays a major role in the acknowledgement of their position vis-
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à-vis that of professional epistemic communities and its consideration in decision-making and public policies. Based on their research on neuromuscular diseases, Michel Callon and Vololona Rabeharisoa proposed to include what they call "concerned groups" in actor networks (Callon and Rabeharisoa, 2008). They showed that patients play an essential role in the definition of research problems and in the construction of a collective identity for the hybrid epistemic community. They conclude that the borders of epistemic communities are never stable, but dynamic and porous.

In the following section, I will use the concept of epistemic communities to explore the ambiguous relationship of DIY-lab communities with the formal research and innovation system through the literature on civic technosciences and biohacking.

DIY labs, peer communities, and citizen participation for innovation

The first DIY labs were founded by splinter scientists to counter the effects of bureaucracy and the rigidity of the research and innovation system (Ferretti, 2019; Landrain et al., 2013; Lhoste and Barbier, 2016). They claimed that DIY labs allow to produce scientific and technological knowledge outside the dominant research and innovation system. Open-source technologies offered them an alternative to conventional academic research practices[1] through peer production based on meritocracy (Kostakis et al., 2014) but they did not challenge the nature of the knowledge used.

According to the literature, most DIY labs are inhabited by communities focused on "civic technosciences" which question and transform how and who can make actionable knowledge (Dickel et al., 2019; Wylie et al., 2014). Most DIY communities

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[1]   https://www.theguardian.com/higher-education-network/blog/2014/jun/16/diy-labs-exciting-alternative-university-science-research accessed on November 15th 2019.

share rules and norms close to hackers (Dickel et al., 2019; Keulartz and van den Belt, 2016; Lhoste and Barbier, 2016). They have an ambivalent relationship with business and academia. The majority of hackers/makers are hobbyists and technology enthusiasts with a professional background in technology (Dickel et al., 2019; Lhoste and Barbier, 2016). Similarly, the biohackers movement is rooted in an open challenge to synthetic biology (Keulartz and van den Belt, 2016, Landrain et al., 2013). Everything occurs as if DIY labs and open source technologies allowed epistemic communities to spill over the boundaries of the laboratory. As Dickel (2019) puts it, "civic technoscience expands the regime of technoscience into society".

DIY labbers appear to view research and its interactions with society through the lens of the epistemic culture in which they were nurtured, whether computer/digital sciences or biotechnologies. Their positivist imagination is defined by a series of attributes derived from the linear model of innovation, and above all by the belief that innovation is technology-driven, always good, and a factor of progress (Joly, 2019). As a result, their representation of civil society is grounded implicitly in an adaptation of the so called "deficit model" (Ziman, 1991). The knowledge deficit model attributes public skepticism regarding new technologies to a lack of understanding of science. It is associated with the divide between scientific knowledge and lay people's lack of knowledge and rationality. The model implies that communication should focus on improving the transfer of information from the former to the latter. Alongside this passive description of lay people, DIY "techies" believe that if technologies were cheaper and open-source, enthusiastic citizens could contribute to civic technosciences (Dickel et al., 2019; Wylie et al., 2014). This assumption is based on two misconceptions: first, that democracy depends on do-ocracy (Patterson, 2010), and second, that DIY bio-tinkering only differs from the epistemology of conventional

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synthetic biology in that the same actors have crossed the boundaries of the academic lab (Keulartz and van den Belt, 2016). Moreover, it hinders a comprehensive approach to socio-technical networks (Callon and Rabeharisoa, 2008) and the role of non-scientific knowledge in hybrid epistemic communities (Akrich, 2010).

Nevertherless, DIY labs are situated at the boundary between the professional and non-professional academic worlds, and they provide an opportunity to open up to lay knowledge. However, openness is more than opening doors to citizen, particularly in labs inhabited by rather exclusive epistemic communities. It is therefore crucial to examine whether and how these communities become "civic", through a better characterization of the alternative forms of knowledge production they lay claim to and of their openness to lay expertise.

The participation of non-experts relies on intermediation

To obtain a better understanding of how DIY labs can accommodate new forms of expertise, I will describe the conditions of emergence of two collaborative projects in fablabs. In France, fablabs were co-designed by users to suit their personal interests (Lhoste and Barbier, 2016). As a result of this co-design, they differ, among other things, in the different knowledge and levels of commitment of their members. The term "members" refers to individuals who belong to the active core of the community, whether professionals or volunteers, or support it through membership and personal activities (Lhoste and Barbier, 2018). Contrary to other members who are more interested in the technological challenge of prototyping a machine, fabmanagers are also motivated by the success of the fablab they have co-created. Therefore, they endorse the role of project leader.

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In a first case study, I examine how the entry of a lead user (and his prosthesis) transformed a community of makers into a hybrid epistemic community. Lead users are individuals or organizations who develop a product adapted to their own needs (von Hippel, 2005). In Von Hippel's examples, lead users carry both professional/technical knowledge and user knowledge, whether as sport addicts or as informal caregivers. In fablabs, makers are hobbyists and technology enthusiasts who are devoted to their project of interest. They gain expertise (and reputation within the community) through their engagement with open-source projects – mainly prototyping their own 3D printer (Dickel et al., 2019; Lhoste and Barbier, 2018). They share technical knowledge with peers around each other's projects. They contribute to the common project: the development of the fablab itself. They seldom spontaneously engage in another. Beside the case study I describe below, I was able to interview one maker who succeeded in involving other individuals in the prototyping of an open-source water purifier suitable for smallholdings. As described by Callon and Rabeharisoa (Callon and Rabeharisoa, 2008), the conditions of success and failure of a project are partly distinct from its conditions of emergence and depend on the entry of new stakeholders. After this first step of emergence, the maker needed practitioners to test the prototype in farms which he failed to find in the core team. In the first case study, the user of the prosthesis was in the project team from the beginning. He was a condition of its emergence and further contributed to its success. As observed by von Hippel (Von Hippel, 2007), users who innovate are scarce. Considering that the motivations, skills and social (and sometimes physical) resources of such users are the prerogative of a small number of lead users, I have analyzed how fabmanagers lead and organize collaborative projects in the second case study.

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In the second case study, I describe how the fabmanager structures a network through project ecologies. As in most public fablabs, he develops strategies to include the less gifted and less enthusiastic users and incentives for makers to participate on a long-term basis. He also coordinates projects in order to distribute translation and facilitation activities within and outside the community. All these activities contribute to structure a network through project ecologies.

A lead user

This project started with the meeting between an individual with a disability (whom we will identify here as the user) and a fabmanager. Ten years after the accident which cost him his right hand, this young man declared that he "had the blues" when he learned that a robotic hand "costs a fortune" and is not funded by Social Security. During an event organized by the Rennes metropolis in October 2012, the user went to the local fablab stand and inquired about the possibility of making a bionic hand using open-source technologies. According to the fabmanager, "something special happened between N, the prosthesis and the makers who were there. Instead of being afraid of the prosthesis, people looked at it with curiosity". This quote reveals the roles of both the prosthetics and the human in the interaction with makers. It also emphasizes the importance of technical knowledge. The makers agreed to embark on the user's project "as long as he contributed". When he returned in March 2013, a core team had formed around the fabmanager. The user joined the core team to design a prototype. As well as bringing his experiential knowledge to the makers, he also discussed the orientations of the project and contributed to sketches. Three months later, a prosthesis prototype was exhibited during a maker convention. This object aroused great interest among visitors and the user was invited to participate in

several international events for makers. At the Boston Maker Fair, he met research laboratories and companies. He also lent his image to the Brittany Region for a communication campaign on "digital technology and disability" and gave several "Ted conferences". In doing so, he acquired technical and social skills and integrated into networks.

Over time, the initial project became more complex. In 2013, the core team founded a non-profit organization, *MyHumanKit*, with the aim of "using digital manufacturing to solve problems related to disability". In 2015, the association organized a first hackathon in partnership with a functional re-education center. In 2016, a professionalization process began: the core team members became employees of the organization. They also managed to interest more and more strategic actors. This dynamic of interest was reflected in the launch of the Fabrikarium project, a multi-day hackathon organized in partnership with the company Airbus and Floss Manuals francophone, an epistemic community dedicated to editing documents for free software. In 2017, the organization opened a fablab dedicated to the disabled - the Humanlab - within a campus oriented towards training and research in solidarity professions. Simultaneously, different digital tools were developed: a multilingual digital platform, chatrooms and forums, a repository for created objects, wikis. A manifesto was added to the fablab charter, a symbol of the individualization of the hybrid epistemic community. It outsources the cause of disability in professional networks linked to makers at local and global levels. It also contributes to the visibility of users with disabilities (and their driving role) through interactions with caregiving organizations and networks. It thus participates in the broader movement of transformation of institutions and representations of disability (Fillion and Roussel, 2019).

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This genealogical account helps to understand how the project ecology gradually unfolds. At the beginning, the core team constitutes an epistemic collective, a concept which allows us to emphasize the fact that at this stage, the links between the members are weak and based on a shared objective (Lindkvist, 2005). The prosthetics hosts various mediation operations which contribute to both the construction of this collective and the visibility of the cause which it defends. The technologies at play in the prosthetics and the challenge they represent, allow individuals (user and makers) to legitimize their place within the community of makers in local and global networks. The epistemic collective gradually reaches the degree of social cohesion and culture characteristic of a community supported by materialities, practices and values. Its narrative is circulated by the founders and transcribed on the association's platform. Structured by a small project team, it has a similar form to open software communities (Cohendet et al., 2003). Thus, the documentation of the prototypes on the association's website becomes part of the promotion and validation system. This local and global boundary work helped to make the epistemic community autonomous from the maker community.

A project grounded in a socio-technical network

The second case study draws on a project in a collaborative innovation space, the Dôme in Caen. The glass building is a unique piece of architecture and the icon of Normandy French Tech. It contains meeting spaces of various capacities, a fablab and an open space. The fablab was installed in a 300 m^2 glass room, right in the middle of the second floor. It is a place for scheduled visits, for example in the context of professional meetings, initiation and training courses, as well as public or private events whose formats come from the world of makers (hackathons, weekly

meetings, etc.). The open space welcomes organizations as long as they participate in the programming and collective governance of the Dôme. Through these activities and the materialities they leave in the open space, resident organizations contribute to the boundary work which links the Dôme to professional networks.

The project I studied, called Hope and Bike, aims to design an open-source electronic card for E-bikes. This project was born out of personal interactions between the fabmanager and the manager of a local bicycle repair and rental co-op. After considering several ideas for collaboration, these two individuals actualized their common values in the design of a low-cost electronic card to link an electric motor and a battery. This card was originally designed by a maker. The fabmanager assembled a core team with volunteer makers, residents and local partners of the social sector. The epistemic collective experimented and structured a learning curriculum for young drop-outs while designing the card. They developed organizational learning and built the project ecology and the prototype synchronously and gradually. When the makers lost interest in the prototype, residents were more regularly involved and a new partner was recruited. Furthermore, the prototype has received several awards, which enabled the Dôme to acquire legitimacy in different networks. In education networks, the project continued with a new three-year public-private partnership to structure a training pathway using projects with skills validation by open digital badges (Ravet, 2017). In research networks, the Dôme embarked on a participatory research project in partnership with local research laboratories on energy transition, thus confirming its membership of this epistemic community. In disabilities networks, they organized a 3-day hackathon during the European Disability Employment Week 2017 to build a motorized tricycle for a person with a disability in partnership with a local association and the MyHumanKit community.

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This project ecology formalizes the mechanisms for the progressive integration of individuals and organizations into networks. It helped to establish the Dôme at the boundary of the maker community, epistemic communities and other professional communities. As a socio-technical setting, the Dôme is the epicenter of a project ecology where individuals exchange knowledge and know-how. These exchanges are materialized by physical objects - prototypes, documentation tools, events, a curriculum and open badges, etc. - which circulate in networks. These translation, facilitation and enrollment activities have contributed to the construction of a hybrid epistemic community with a plurality of knowledge.

These examples of collaborative practices experienced in maker communities demonstrate that a range of activities are required to manage the inclusion of lay experts in these technology-oriented communities. These activities need to be coordinated by an intermediary who facilitates the innovation process by acting as a boundary spanner between the different worlds (Howells, 2006). The idea of intermediary agent or boundary spanner was first applied to explain forms of interaction in industry innovation activity (Doganova, 2013) and the establishment of new relations to scientific knowledge through the activities of knowledge brokers (Schlierf and Meyer, 2013). In fablabs, intermediation activities are often distributed among members of the community and material resources such as machines, guidelines, and so on. They are coordinated by the fabmanager. The intermediary agents who coordinate these activities occupy the position of "obligatory passage point" (Callon and Law, 1989; Doganova, 2013). They perform both enrolment and dissemination activities as institutional entrepreneurs, together with a combination of agency and translation activities. However, intermediary agents are not passive actors. By facilitating interrelationships, they contribute to the production of technical

and social knowledge. Moreover, their reflexivity and interest are important for innovation, the objectives of which often emerge and are concretized during the process (Steyaert et al., 2015). They facilitate the engagement of citizens in research and innovation, a process that has been described as community-based research where the knowledge is produced in line with common community objectives (Strand et al., 2003).

In conclusion, DIY labs make it possible to take research and innovation activities out of the academic laboratory. These spaces allow members of the community to debate the questions that arise in their everyday lives, share different forms of knowledge and design common solutions that are not necessarily high tech. It is the facilitation and translation activities that occur around machinery and in meeting spaces that allow non-technological experts to contribute. The notion of intermediation suggests activities related to exploration, creation and synchronization of a hybrid epistemic community structure and a DIY lab.

Techno-centered vs. socio-centered DIY labs

In the community-based research process occurring in DIY Labs, intermediary agents perform translation, mediation and enrolment activities. Based on the literature and case studies, DIY labs seem to be inhabited by two categories of communities. The first type are epistemic communities of "techies" permeated by the myth of technological progress. These techno-centered labs embody the tensions between openness and exclusiveness through their location and through the presence of sophisticated equipment and technical experts (Lhoste and Barbier, 2018). The second type are hybrid epistemic communities open to experiential knowledge. In these socio-centered labs, machines are as important as meeting rooms, couches

and kitchen equipment. Fabmanagers enable the spanning of boundaries, translate technical knowledge and facilitate participation by stakeholders. These stakeholders bring new perspectives, information and knowledge to the research and innovation processes. Humans and non-humans transform the DIY lab into a third place where people from different worlds can collaborate to solve social and environmental challenges.

Framing DIY labs as third places for community-based research allows us to highlight the organizational, epistemological and political questions raised by socio-technological choices. Hybrid epistemic communities experiment collaboratively through participatory research and social innovation processes. These practices are characterized by distributed intermediation practices involving experts from different domains (scientists, engineers, users, patients, residents, etc.) who provide their own particular expertise, whether scientific, technical or experiential. This knowledge diversity is essential for social transformation and ecological transition. Acknowledgement of socio-oriented DIY labs, and their reinforcement through public policy would allow the emergence of organizational structures necessary to technical democracy.

Acknowledgements

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