

THE INSTITUTIONALIZATION OF MAKING: THE ENTREPRENEURSHIP OF SOCIOMATERIALITIES THAT MATTERS

Evelyne Lhoste, Marc Barbier

In France, makerspaces have been institutionalized and popularized by the generalization of the label “Fab lab”, which is common to many discourses on innovation, is supported by public authorities and recognized by corporate business and high ranked universities. However, the initial structuration needs to be analyzed “from below” to understand how making at the local level is coupled to institutional entrepreneurship. The present paper focuses on the process of creation and development of makerspaces since the emergence of the French “Fablab fashion”. Our analysis is based on a sociological and ethnographic enquiry which started in 2012 (Lhoste and Barbier, 2016). A practice-based approach allows us to question how a field of situated maker practices is related to the organizational arrangements of a plurality of stakeholders, enrolled on premises of innovation and entrepreneurship. The description of practices is grounded in a structural model in which human actors, technological artifacts and organizations are closely intertwined. We address the following empirical research questions: How are sociomaterialities performed and organized in practice? How are a certain style of making practices and identity of practitioners progressively institutionalized and demonstrated at the local and global levels? Fablabs emerge as organized spaces where practices have agency and articulate knowing in practice with a proto-organization. Studying this process allows to understand how practices are related to the institutionalization of Fablabs at the local and global levels. We highlight the role played by Fabmanagers as intermediary agents, and how their various activities affect the achievement of the initial goal of the project proponents.

Keywords: makerspace, structuration theory, practice-based approach, institutional entrepreneurs, organizational learning

by Evelyne Lhoste & Marc Barbier

INTRODUCTION

The brand Fab Lab originated at the Massachusetts Institute of Technology (Gershenfeld, 2005; Kohtala and Bosqué, 2014), and has been popularized in the media, government and academia. The term is linked to the discourses on digital fabrication and innovation opportunities, and refers to digital fabrication workshops which promise democratization of innovation through the large availability of machines and shared knowledge. These hybrid and transitional collectives are part of a dynamic of the institutionalization of the maker

culture based on collaborative practices (Kohtala et al., 2014; Troxler, 2014, Fleischschmann et al 2016), sometimes viewed as the “next generation of the hackerspace evolution” (Maxigas, 2012) or the “third places of soft hacking” (Lhoste and Barbier, 2016). Meyer (Meyer, 2015) describes this dynamic as driven by the “positive virality of garage practices” which allows out-of-the-box innovation in an established techno-scientific framework. This movement shows continuity with several other movements such as the counter-culture (Turner, 2010), commons-based peer production collectives (Benkler and Nissenbaum, 2006; Kostakis, Niaros, and Giotitsas, 2014), free and open source technologists (Broca, 2013; Kelty, 2008), do-it-yourself and repair groups (Rumpala, 2014), and

arts and crafts (Krugh, 2014). In France, Fablabs have emerged as community-based or university-based places, some running experiments with the social and solidarity economy, and others more oriented toward traditional business models (Bosqué et al., 2014; Lhoste and Barbier, 2016; Mérindol et al., 2016). In broader terms, they constitute places “supported by diverse groups of actors, which aim to renew modalities of innovation and creation by employing open, collaborative and iterative processes to materialize physically or virtually” (Mérindol et al., 2016), *our translation*).

In this article, we posit that the celebration of these new modalities of innovation could blur the understanding of the transformative agency of Fablabs, and their contribution to the situated generalization of collaborative practices in the making. We ground our analysis in the structuration model proposed by Orlikowski and Scott (Orlikowski and Scott, 2008), to shed light on the creation and development of Fablabs. In this interpretative model, the concept of sociomateriality frames an examination of the constitutive entanglement of the social and material in everyday life and workplace organization (Orlikowski, 2007). This perspective which is strongly related to the “practice turn” in organization studies (Gherardi, 2000), allows identification of the shifting boundaries between human and material agencies during practice, rather than defining fixed relations prior to action. Considering Fablabs as organized spaces where practices have agency and articulate knowing in practice with a proto-organization, we hope to understand how the “formativeness” and the “agencement” (Gherardi, 2016) of situated practices are related to the process of institutionalization. To analyze the process leads to the study of the practices of those who are interested in both the development of human and material agencies and the institutionalization of Fablabs. It allows us to reveal the boundary work they perform at multiple organizational levels. Thus, we contribute to the framing of a grounded perspective of the organizational dimension on community-based innovation processes. These theoretical

underpinnings allow investigation of the following empirical research questions: How are sociomaterialities performed and organized in practice? How are a certain style of making practices and identity of practitioners progressively institutionalized and articulated at the local and global levels?

The paper is organized as follows. Sections 2 and 3 describe the analytical and methodological frameworks. Section 4 discusses the genealogy for adaptation of the MIT model to a French perspective. Section 5 describes the process of institutionalization, and compares types of institutional boundary work performed in diverse Fablabs. This provides insights into the distribution of institutional entrepreneurship among human actors, artifacts and organizations. Section 6 concludes with a discussion of the concept of distributed institutional entrepreneurship and how human and material agencies are interlocked during practice, to produce Fablabs as complex sociomaterialities and to transform both organizations and the Fablab concept. We highlight how the negotiations of a diversity of practitioners at the local level institutionalize a practice style and influence achievement of the initial goals of the project proponents.

ANALYTICAL FRAMEWORK

In the organization studies literature, institutionalization is the process that enables patterned relations and actions to “gradually acquire the moral and ontological status of taken-for-granted facts which, in turn, shape future interactions and negotiations” (Barley and Tolbert, 1997). Based on this definition, we analyze institutionalization of the maker culture as the co-creation of sociomaterialities that enables simultaneously makers’ practices and the stabilization of standards and norms related to the design and use of the places where these practices are performed. Understanding this structuration process is rooted in a sociology of organizations that has prevailed since Anthony Giddens’s work on

social structuring in practice in which human actions are enabled and constrained by structures that are the result of previous actions. In this framework, activities are negotiated collectively at the interface of structure and agency. Human agency is “the ability to form and realize one’s goals” (Giddens, 1984) using rules and resources which constitute the social structure. As a consequence, the social structure may be either reaffirmed or changed. When analyzing practices in organizations, we need to ask how individual and collective human agencies negotiate compromises in action, and how the human and non-human elements are interwoven and stabilized. By introducing materiality into human agency, the structurational model of technology (Orlikowski, 1992) overcomes the dualism between the objective, structural features of technologies on the one hand, and the subjective, knowledgeable action of human agents on the other. The concept sociomateriality intertwines practice with the technology in which it is embedded (Orlikowski, 2007). This term reminds us that materiality is present in every social activity. In referring either to technologies or organizations, any social practice is possible because of some materiality, and it shapes the materiality of a technology and its effects (Leonardi, 2012). Over time, the technology and the artifacts produced during the enacting of structures may reinforce (perform) or transform (re configure) the existing configurations (Orlikowski and Iacono, 2000). Examination of these (re)configurations allows us to identify the shifting boundaries that occur between human and material agencies during practice, rather than defining fixed relations prior to action.

This framework helps to explain how the ongoing activities of human agents drawing on digital fabrication are objectified and institutionalized without being rationalized. Exploring the process of institutionalization of Fablabs equates with examining how the structuration process is enabled and sustained, and how it receives organizational impetus over time. As Lawrence et al. (Lawrence et al., 2001) suggest, the temporal dynamics of institutionalization in knowledge organizations leads

to the study of institutional entrepreneurship. Here, institutional entrepreneurship refers to the “activities of actors who have an interest in particular institutional arrangements and who leverage resources to create new institutions or to transform existing ones” (Maguire et al., 2004). Paying attention to the design and establishment of Fablabs by entrepreneurial intermediaries – Fabmanager or founders – sheds light on how sociomaterialities are organized through the practices of institutional entrepreneurship that establish and legitimize Fablabs as places for making. Tracey et al. (Tracey et al., 2011) insist on the “multilevel nature of bridging institutional entrepreneurship, showing that it entails institutional work at the micro, meso, and macrolevels”. Maguire et al. (Maguire et al., 2004) following Fligstein (Fligstein, 1997), underline that institutional entrepreneurship depends on the existence or the stability of an organizational field.

In line with this literature, Fablabs could be explored as organizations supported by various structuration activities which indicate the establishment of an organizational field: networking of community-based initiatives and practices, design and support of a standard and associated definitional struggles, private and public support at various levels. Therefore, the institutional boundary work of Fabmanagers should not be considered as driven purely by the micro-logics of the sociomaterialities of the makerspace. It is also grounded in the emerging attention of policy makers and incumbent actors for Fablab initiatives. The notion of sociomateriality unfolds in institutional entrepreneurship over time and space through a series of technologies and artifacts produced by the actors in their practice, and progressively equip the Fablab within and outside its material walls. It is articulated at two organizational levels: 1. By giving substance to the local networks of users, it sets the place and space of sociomateriality, 2. By attracting public and private resources and support, it establishes the long run settings. These entrepreneurship activities shed light on the boundary work of those agents described by

Cecchini and Scott (Cecchini and Scott, 2003) as “grassroots intermediaries” who assemble all the entities involved in the process at various organizational levels. Ultimately, it reveals how the performativity of the MIT Fablab format is gradually performed through the activities of humans mobilized in the design and production of a Fablab embedded in the existing institutional environment.

METHODOLOGY

To conduct our investigation on sociomaterialities, we studied Fablabs that were materialized by the MIT Fablab logotype, referred to the Fab Charter, and claimed to be fully open. This quite strict empirical delimitation allows comparability since commitment to a charter establishes a common attitude of institutional entrepreneurs towards what needs to be institutionalized. The first empirical data were collected from a set of 37 interviews conducted between November 2012 and June 2013

in 7 Fablabs (Lhoste, 2013; Lhoste and Barbier, 2016). The interviewees were users and, depending on the hosting organization, founders, fabmanagers and science explainers. In 2016-2017, we conducted a second set of 30 interviews in and around 4 of the Fablabs involved in the first interview round, focusing on Fabmanagers, project managers and stakeholders. Evelyne is also engaged in regular participative observations in Fablabs and social events. We collected material settings in the Fablabs, along with digital traces on websites and blogs, and documents such as guides, charts, official reports and press clippings. Coding and analysis of the empirical materials were performed using NVIVO CAQDAS software which is known to be effective for this type of approach. We aimed at comparability, and systematically characterized the situation of each Fablab based on qualitative variables used to organize our interviews and observations to target the main objects of our enquiry: the discourses and practices of the actors involved in the lives of the Fablabs and their foundation (Table I).

Organization of Space and time	Surroundings of the site, surface area, opening hours, conditions of privatization
Material devices and artefacts	Digital and conventional equipment, furnishing, appliances, adornments, arts and crafts.
Accessibility and social grid	Opening hours, rates of access, participation of users in collective tasks, presence of employees
Relationship to surrounding institutions	Financing, origin of founders and fabmanager, attitude towards conventions and norms
Users’ practices	Type of activities, form of sociabilities in making
Knowledge production and circulation	Organization of training sessions, spontaneous exchange of tacit knowledge, education, project participation, documentation

Table I. Descriptive framework

Building on this empirical approach, we structured the field of our enquiry to account more precisely for Fabmanagers’ boundary work and activities. The number of discourses, research studies and scientific discussions on Fablabs grew during the progressive structuring of our findings resulting in our organizing them according to the grounded

theory presented in the previous section (Figure 1).

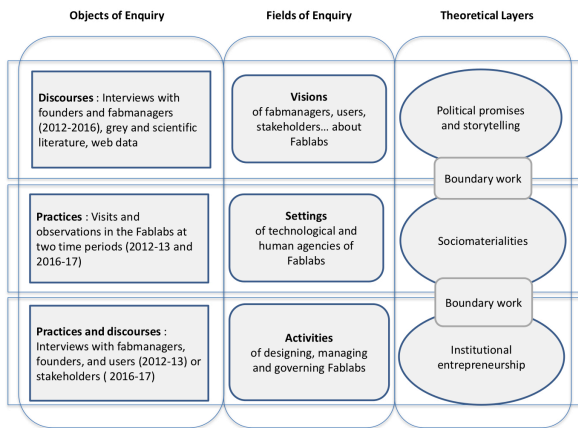


Figure 1: Linking collected material to theoretical framework: correspondence between discourses and practices, fields of enquiry and theoretical layers.

RESULTS 1: THE DYNAMICS OF THE EMERGENCE OF THE FABLAB MOVEMENT

Over the past 10 years, the term Fablab has become more common in discourses on innovation and public policies, and the maker culture triggered several initiatives, whether registered directly as Fablabs or not. We authored a previous socio-historical account of the opening of Fablabs (Lhoste and Barbier, 2016). Here, we contextualize the emergence of Fablabs in France taking account of the worldwide movement. The Fablab network spurred around the world following the award to the MIT's Center for Bits and Atoms (MIT-CBA) of a grant from the National Science Foundation for an outreach program in 2003 (Kohtala and Bosqué, 2014). These authors describe how the Fablab network was shaped by MIT-CBA and the situated interactions of charismatic storytellers with local

stakeholders, similar to what Troxler ((Troxler, 2014)) describes in the case of the Dutch movement. In 2008, an article on digital tinkering published in a top French political newspaper did not even mention Fablab. This very same year, a computer sciences engineer created a non-profit association aimed at establishing a Fablab in Toulouse (see citation in Table 2A). With a colleague, he organized shoptalks in community rooms, and participated in a shared knowledge festival organized in the area. This sets the information and communication goals required to form a community. Thanks to these individuals' academic links, by the end of 2009, the first digital equipment received public funding, and they were able to hold their meetings in a small room at Toulouse University before moving to a larger space in the basement of a community member's house. They were active in contacting town councilors and fostering ties to the international Fablab movement. In 2010, Artilect was given Fablab status by the Fab Foundation, and obtained financial support from the European Social Fund. Its founders attended the first international Fabconference to be held in Europe where they were introduced to a French think-tank created in 2000 to prepare for digital transitions (Bottollier-Depois, François et al., 2014). In 2012, the urban community "Toulouse Metropole" rented an ancient *chaudronnerie* to open a third place, "Le multiple", which was occupied mostly by Artilect. According to its website, the Artilect community includes 1,000 members. The cost of membership is cheap, and the lab is open six days a week. It experiments with business models to hybridize non-profit and for-profit activities. With the help of the community, the fabmanagers organize training sessions, and regular events including the annual Fabfestivals (9,000 visitors and over 200 volunteers in 2017).

Name	Origin of the Project	Citations of founders telling their motivations to start a Fablab	Net-iki
Artilect	Grassroots = a computer engineer	"I did my post doc at Cornell University, in the lab led by Lipson who is at the origin of Fab@home, it is a concept very close to the Fablabs. I also met Neil Gershenfeld. We created an association with the goal of decompartmentalization, of interdisciplines. It is important to see a problem from different angles. It's pretty weird to say we're in the lab with 400 people who have the same profile. Diversity is a bit like what they had in Cornell..."	Grassroots = members of a socio-cultural association acting for High rate internet access in their rural area " Why a fablab? Already this is the first thing we saw happening and that resembled our problems. I was thinking about co-working too. But I saw the fablabs go by and I thought that the material was important. 3D materializes things ..."

NYBI.CC	Grassroots = a group of makers/hackers	"For a living, I work in 2 startups from computer research ... I am a doctor and engineer. I introduce myself as co-founder. How did it start? I do a lot of watching on the Internet and I followed the evolution of fablab. What I started to do is create a website. I ordered a Reprap kit, found some friends to mount it, I talked about it. I published it in the hackerspace list when we did not have the local or anything. The other big meeting was with (another maker) at FING in Paris."	La Casemate	6 science center managers submitted a proposal to a national Call launched by the French Ministry of Research and Education.	"Digital is anchored in our practices. In 99, we opened the first internet place open to the public. ... We will not help innovation by doing workshops on dinosaurs."
Faclab	Two University professors (entrepreneurs and makers)	"To sum up initially it's a personal craving, basic sharing needs, to see that the wave of personal fabrication is coming up. We start with the Forge (another Fablab they created) ... And there we make a mistake, we speak about it to the director of the University ... He introduces us to the vice-president. We show the first of the 4 slides of our PowerPoint when he interrupts us. He says OK I understood I want one ..."	Carrefour numérique2	"There was no line for scientific culture in the Grand Emprunt (a national Project call on Research and Education). So we mobilized. ... to open it, the people who knew each other discussed and decided to get together to write a proposal ... It's a bottom-up approach."	"I suggested to submit the idea of fablabs in the Inmediat project... In the other fablabs, they do not think in terms of public attendance and they are looking for a business model. For us, how we will articulate both the general public and the rest ... Politically, it would be extremely difficult to take 6 million euros to accommodate 200 people!"
Faclab			Le Dôme		

Table 2A. Origins of the Fablabs projects and motivation of founders in 7 fablabs. Adapted from Lhoste 2013, our translation.

This narrative exemplifies the boundary work of founders who gradually and diachronically built the Fablab and the community, and enrolled public stakeholders to support it. In the early 2010s, there were some 20 Fablabs established in various cities and towns, as the result of the initiatives of early adopters and other grassroots intermediaries (Table 2A). Members of this emerging community began meeting in 2011 during various events including a machine construction bootcamp organized in Nantes and the first French Fablab conference held in Toulouse. In 2013, our early cross cutting analysis (Table 2B) showed that they were places with varying degrees of membership formalization, flexible access, and openness to public participation. The user's activities were very diverse. While making involves programming, electronics and digital fabrication, it spans many other hands-on activities as situated practices. Most claimed an attachment to the values of other social and environmental movements such as upcycling, community gardens and repair cafés (Rumpala, 2014). This laid the foundations for a French network of Fablabs which was formalized in 2016 through an association. In 2017, France had the highest number of Fablabs after the US, registered on the Fab Foundation website (fablab.io). Fablabs

have been established in both urban and rural environments, in community centers, science centers, universities and other organizations more or less oriented towards education, innovation and contribution to the maker movement. They are aimed not just at market-oriented innovation; their governance often emphasizes social values over business, and most are subsidized by local and national public authorities (Mérindol et al., 2016).

Concomitantly, many public authorities at the local, regional and national levels welcomed this flourishing initiative. In 2012, the French Ministry of Higher Education and Research awarded funding to six science centers to update *Culture scientifique et technique* (a concept close to science, technology, engineering, the arts and mathematics (STEAM) and public understand of science in a diffusionist approach) with digital technologies. In 2013, the French Ministry of Industry supported 14 so-called Fablabs through the National Innovation Program oriented towards entrepreneurship. One hundred of the 800 public computing drop-in centers that emerged across the country during the early 2000s have been transformed into Fablabs. In 2016, more and more territorial communities (from cities to regions) were contributing to the structuration of territorial networks of Fablabs. In addition to the provision of public funding, several private foundations are supporting Fablabs engaged in education projects.

Name	Artilect	Casemate	Net-iki	NYBI.CC	Faclab	Carrefour numérique 2	Le Dôme
City	Toulouse	Grenoble	Biarne	Nancy	Genevilliers	Paris	Caen

Self-Rating MIT	AAAB	AAAA	AAB+B	AACA	AABB (aiming AAAA)		
Open Since	2009	2011	2011	2011	2012	2014 (on beta test in november 2012)	2015 (on beta test in june 2013)
Hosting Organisation	NGO	NGO (Science center)	NGO (community center)	NGO	Cergy-Pontoise University	National Museum	NGO (science center)
Funding	public	public	public and private	none	public and private	public funding	public funding
Membership (indicated prices are for individuals)	30 euros/year	No (pay access to digital equipment)	15 euros/year	120 euros/year	No	No (pay access to equipment)	10 euros per month (+ symbolic fee to digital equipment and training sessions)
Number of members	100	391 access cards	70	26 in 2012	15 regular users	individuals and out of school groups	a dozen betatesters
Number of visitors	Founder, fabmanager and volunteers	Fabmanager + science explainers	volunteers	volunteers	fabmanager (facilitator)	fabmanager and science explainers	fabmanager
Staff		8766 (3300/year)	235	10-20/week	5563 (3500/year)		70/month
Location	1600 m2 in open space	120 m2	70 m2	60 m2	160m2	400m2 in a 1000 m2 open lab	
Digital equipment	2 laser cutters, vinyl cutter, 4 3D printers, milling machine	laser cutter, vinyl cutter, 3D printers, 2 milling machines	3D printer	3D printer	laser cutter, vinyl cutter, 2 3D printers, milling machine	3D printer	3D printer

Table 2B. Analytical description of 7 Fablabs included in the case study. Adapted from Lhoste, 2013.

This dynamics has been sufficiently important for the actors to count themselves and demonstrate to the rest of the world how numerous they are. Since

2011, Fabmanagers have registered on the official website Fablab.io. The registration and self-rating based on Fab Charter criteria allowed them to use the logotype. This flexible procedure has facilitated the further spreading of Fablabs. Indeed, the term Fablab was used strategically to avoid explicit reference to the hacker culture:

"To communicate with the word hackerspace is not obvious. And then there is the fact that there is a charter in the Fablabs. That way we're pretty sure of the color of the sheep." (Core member, Net-iki, 2013)

"We are more open (than a hackerspace), a bit like a makerspace. On the institutional side, the term Fablab is better. We are opportunists ... Fablab, hackerspace, makerspace, we do the same things. But it is the values put forward that are different." (Core member 2, Nybi.CC, 2013)

In 2017, the website of the French Fablab network (www.fablab.fr/) refers both to the fablab.io website and the mastery.info cartography, itself being based on diybio.org, hackerspace.org and fablab.io, translates the blurring boundaries between the fabber/maker/hacker communities in France. According to these websites, the French spelling of Fablab has not been formalized; the use of capital letters have a tendency to disappear as if the Proper noun "Fab Lab" is being transformed into a generic term, fablab. The term Fablab is used well over the Fablab network in media and institutions (corporate business, top class universities and French engineering schools, public organizations such as the Ministry of National Education and institutions such as *Culture scientifique et technique...*). We are therefore witnessing a process in which the actors are putting a label on what they are designing. As a matter of fact, the relations of French Fablabs with the Fab Foundation and the rest of the global network are as diverse as the spelling is unstable. Artilect and a few other Fablabs have developed individual relationships with the Fab Foundation through participation in FabAcademy training programs. Many of these relationships are based on personal links between the Fabmanagers and MIT-CBA. Others interact with foreign Fablabs based on EU funded networks or on *Francophonie*. As an acknowledgement of this complex networking, the

French Fablab network is co-organizing the 14th international FabConference in 2018. It will be held in two registered FabCities, Paris and Toulouse and distributed events will take place in territories.

In line with Orlikowski and Iacono's (2000) observations on technologies and organizations, "gurus", grassroots initiatives and public policy instruments are not the only key actors shaping Fablabs for particular organizational or socio-economic ends. Once an innovation is deployed, its developers and managers have little control over how specific workgroups and teams will use it and shape it to their own needs. For this reason, it is important to take account of the practices in a given environment and to observe the structuring of the daily life of Fablabs inhabited by people and objects. The concept of sociomateriality is a resource to allow differentiation between "espoused technologies" and "technologies in use" (Orlikowski and Iacono, 2000). Therefore, we will now focus on situated practices and interviews with practitioners.

RESULT 2: SOCIOMATERIALITIES AS IDENTIFIERS OF INSTITUTIONAL ENTREPRENEURSHIP

To further investigate how the Fablab model has been enacted by its users, we focus next on the results of our observations of situated practices and interviews with practitioners. The general descriptive framework presented in Table 1 covers the heterogeneous structuration: the architecture of its space and time, its business model and openness, the socio-professional trajectory of its team leaders, users' productions and participation in the process, and their discourses and activities. In order to describe institutional entrepreneurship, we report the sociomaterialities of seven Fablabs studied in 2013 (Table 2B) and in four of them, compare the subsequent activities performed in 2017 (Tables 3A and B).

Name
City

Faclab
Genevilliers

Designing and organizing the place	Surroundings of the place	Genevilliers is a popular and multicolored city in the North of Paris. The building is located on a large road lined with office buildings
	Facilities	The Faclab is situated on the ground level of a university building with access from the main hall. Several classrooms have been changed into a 240 m2 FabLab : 3 workshops, a lounge area with yellow angle couch and coffee table + full kitchen equipment and dining table, give away area (gratuiterie)
Accompanying and valuing users' practices	Type of collective tasks	Fablab improvement sessions (tidy up, make shelves, mount a milling machine..). Organization of events and training sessions. Participation to outside events to promote the Faclab and the maker culture.
	Type of users contributing to collective tasks	All users (including trainees) contribute to all types of collective tasks in exchange of free access to the Faclab.
	Role of Fabmanagers	Facilitators and prompters. Organize contribution of makers. Contribute to academic curricula.
	form of sociabilities in making	The fact that a maker federates a group of makers around his own project is very seldom. Knowledge and food sharing. Monthly community gatherings.

2017.

Table 3A. Analytical description of sociomaterialities and activities in Faclab in

Name	Casemate	Carrefour numérique2	Le Dôme
City	Grenoble	Paris	Caen

Designing and organising the place	Surroundings	Grenoble is wellknown for its international-grade scientific cluster. La Casemate is located in the fortifications of the City. It is the oldest science center in France.	The Cité des Sciences (worldclass science museum) is located in a cultural complex open to tourists and the working-class neighborhood. The Carrefour numérique has a strong legitimacy in the field of STEAM and digital literacies	Caen is in Normandy. Le Dôme is a new building located in a developing cultural peninsula with a Arts & Media School, a modern music concert hall and a library. It is named after the dome structure on the roof. This unique piece of architecture is considered as the totem of Normandy French Tech.
	Facilities	The Fablab is situated on the second floor with separate access from outside : two red lounge couches and coffee table in the fablab, picnic area with microwave and fridge. On the first floor : staff offices and exhibition area + a biology laboratory. Roof top garden.	A 1000 m2 open lab housed in the basement level of a world-class science museum: a 400 m2 Fablab, several meeting rooms, no kitchen facilities, a couch in the entrance hall	A 3 storey transparent building of 2500 m2 dedicated to open innovation : a Fablab, an open space including lounge and kitchen corners, a showroom, and several meeting rooms. The Fablab is a 300 m2 glass-walled room, on the 2nd floor of the building
Taking care of material devices and artefacts	Technical equipment	laser cutter (2), vinyl cutter, digital milling machine (2), 3D printer (5), 3D scanner, binocular microscope, sewing machine, 36 inch printer	Lase cutter (2), Digital milling machines (3), 3 D Printer ((4), sewing and embroidery machines (3), 3D-scanner, Precision lathe Proxxon PD 400 CNC, Vinyle cutter and printer, Thermal press	Laser cutter (2), Sewing and embroidery machines, 3D printers (2), digital milling machines (2), badge machine, vinyle cutter, equipement for electronics
	participation of users	Golden rules of the Fab Charter	Golden rules of the Fab Charter	Golden rules of the Fab Charter

Accompanying and valuing users' practices	Type of collective tasks	Training sessions (to use the machines) and classes (make a skate board or wooden skis), Documentation. Educational programs.	Visits, training sessions, classes and events (hackathons, drones...)	Collective projects aimed at producing artefacts such as an open source kit for electrically assisted bike. Visits, classes and events.
	Type of users contributing to collective tasks	Residents (the most skilled users called "makers ++" by the fabmanagers) contribute to classes in exchange of reduced membership fees. A former user has been hired to set up a biofablab.	NGOs and Intermediary organizations organise out-of-school programs on digital fabrication and making. Teachers use the Fablab as an education facility.	Residents (organisations) are committed to participating in programming and collective governance. Individuals contributed to the Fablab project and to educational project.
	Role of Fabmanagers	Coordinate educational programs. Participate to logistic tasks when the Fablab hosts events mixing scientists and experts. Hosted one session of the Fabacademy (the former fabmanager is now director ad Fabfoundation). Documentation.	advisory services and technical training for individuals and groups, whether scholar, out-of-school or vocational. Pilot one of the five territorial Resource Centers for digital education.	Coordinate projects aimed at training out-of-school youth. Co-coordinate the local network of Fablabs. Documentation. Pioneer in open badge approach.
	form of sociabilities in making	Designed and run two digital platforms : Echosciences and Fabmanager (including documentation).Open night.	When groups are working, the Fablab remains open to the public. Makers answer questions and are helpful on demand.	Events such as hackathons and Turfu festival. Training sessions. Peer to peer training.

Table 3B. Analytical description of sociomaterialities and activities in La Casemate, Carrefour numérique and Le Dôme in 2017. The participation of users is mentioned in reference to the golden rules in

the Fab Charter i.e. *safety*: not injuring people or damaging machines; *operations*: assisting with cleaning, maintaining, and improving the lab' *knowledge*: contributing to documentation and instruction.

Customizing a Fablab

Our empirical study of Fablabs shows that users constitute a heterogeneous population in terms of age, gender and professional background. The Fablab, as a space, delimits a world for both makers (architects, artists, craftsmen, modelers, designers, graphic designers, etc.), digital hobbyists (hackers, computer scientists and electronics specialist), students (either on their own or with their teachers), journalists, and researchers. It is inhabited by labile material traces of their activities: oil paintings (Net-iki, 2013), three-dimensional materialization of an excerpt from President Barack Obama's address on 3D-printing (Artilect 2013), homemade 3D-printers (Artilect, Nybi.CC 2013), a stabile made of laser cutter leftovers with a picture of each user with his project (Faclab 2013), the prototype of a biking jacket (Faclab 2017), laser cut lamps and dinosaurs (La Casemate 2013), skate boards (La Casemate 2016), etc. When displayed on a shelf at the entrance to the Fablab, they allow visitors to situate the Fablab they are entering as a place of materiality and concrete "things".

The seven Fablabs we studied in 2012-2013 were the initiative of individuals who designed and operated a makerspace to satisfy their individual needs which differed across objectives and situations (Tables 2A and 2B). While Artilect, Net-iki and Nybi.CC can be considered as grassroots initiatives (Smith et al., 2013), Faclab and the three science centers were backed by organizations, and therefore, may appear as top-down initiatives. However, we consider their founders as lead users (von Hippel, 2005) since they were also early adopters of a new socio-technical device in their organizations. Many of the early adopters originate from academia. The founders of Artilect, Net-iki, Nybi.CC and Faclab acknowledged a willingness to concretize their entrepreneurial projects and develop a critical stance towards the national research and innovation system. Some claimed also that they shared the hacker community norms and values. In contrast, the fabmanagers of science centers received grants from the French Ministry of

Research and Education to develop various digital instruments, including two Fablabs and digital equipment for a third one (which was Artilect). They originally mobilized Fablabs in a more instrumental way but the dynamics of the structuration process show that the sociomaterialities of the Fablab progressively reconfigured the organization in each case. The activities of all these early adaptors (Fablab founders, fabmanagers, science explainers, academic staff, science center staff, etc.) include the practice of digital fabrication and making, raising funds, enrolling users, and regulating and managing makers' practices at both the local and global levels. They allowed the construction of the sociomateriality.

Accomplishing boundary work through sociomaterialities

While designing and organizing their Fablabs, early adopters translated and performed institutional actions in managing material devices and artefacts, and accompanying and valuing users' practices. Users also participated in these collective tasks under their supervision. In doing so, they formulated the reasons for the boundary work of institutionalization (Tables 3A and 3B). Reporting on the four Fablabs (which we visited several times over the 3-year period) constitutes a narrative of this boundary work and the institutionalization of making. The Faclab (Table 3A) offers various academic courses related to digital fabrication; the other three are focused on STEAM activities and digital literacy in science centers (Table 3B). All are involved in promoting and organizing changes to practice in the particular Fablab space and its proximity. This boundary work makes visible the sociomateriality through couches, digital machines and electronic supplies, and also articles, websites, conventions, and grant applications, and the artifacts produced and exhibited in the Fablab and/or on its website. Thus, the sociomateriality is both within and outside the physical limits of the Fablab organization.

“The fablab was labeled in summer 2010, by the MIT. Label they relaxed afterwards. There is a list on which people register in a fablab of an Icelandic site and after it is repatriated to the MIT website with the publication of an official list. It is in discussion with the fablab international association which is supposed to govern a little all this.” (Founder, Artilect)

The Faclab can be considered a reference model to study the process of innovation in a sociomateriality since the boundary work is performed by the core team (director and fabmanagers) and the community of users. At the structural level of the organization, the Faclab is a technical platform dedicated to pedagogic innovation, with openness to the public being a pre requisite for the training of students. Access is based on the exchange of knowledge and services to the community (Table 3A). Unlike other Fablabs that have breached the sharing economy rules by introducing a tariff for using the digital machines, there is no reservation system which means that users may have to wait for the machine to be free. Thus, users participate in all kinds of institutional entrepreneurship (Table 3A). The fabmanagers facilitate knowledge exchange between knowers and knowledge seekers, and stimulate participation in collective tasks through regular incentivizing emails to the mailing list. They use this medium also to reprimand members who have abused the shared equipment. Local boundary work is contingent on users’ personal and professional networking. It depends mainly on word of mouth and participation in local public events (Social and solidarity economy week, Sustainable development week). This dynamics is characterized by its slow pace. Although continuity may be impeded, it is firmly anchored in users’ needs. The practice agencies progressively transform the space into an inhabited setting dedicated to making as a shared and distributed purpose. In turn, the community of users is performed and gradually re(configured):

« My mission was fabmanager. It was not clear since I was the first in France. I do not think we ever did a job description. I have to write it. What would I put in? It’s facilitating the word. Roughly speaking, explain the philosophy of the place and put them in touch with those who can help them. We talk to people, we try to know them, to know what they are working with and we are there all the time; And as I have a little memory of faces, it helps. Machines? They turn. Eventually, I taught people to use them, or they learned from other people. » (fabmanager of the Faclab)

The core team of the Faclab has also set boundaries to the institution-to-be, and contributed to establishing a common identity at the national level. On March 3rd, 2013, the Prime Minister officially announced the government roadmap to “foster a national policy on digital development” during his visit to the Faclab. The space had been arranged to make it clear that Fablabs referred not only to technology but also to social practices, and that the network extended across the national territory. Since then, the Faclab has been contributing to the structuring and professionalization of the field mainly through advanced learning programs on Fablab management and digital fabrication. In addition, its former fabmanager has been made President of the French Fablab Network.

The three other Fablabs -La Casemate, Le Carrefour numérique and Le Dôme - share the goals, values and organizational rules and norms of the institution, *Culture scientifique et technique* (Public understanding of sciences), which conveys a diffusionist vision of the relationship between sciences and society. However, they differ in their history and environment (Table 2B). These time and space discrepancies allowed us to analyze the process within the community of makers and at the boundaries of the organizational environment in which it operates. As an example, let us consider the changes we observed during our two visits at La Casemate. In 2013, the staff was learning how to

“do Fablab” as one of them put it. They had assembled a temporary exhibition staging the maker movement and featuring a fully-equipped Fablab with a fabmanager trained in one of the largest and oldest European Fablabs (WAAG, Amsterdam, NL). The exhibition highlighted artefacts produced by local non-governmental organizations and science explainers. Meanwhile, the science explainers were experimenting, seeking a balance between making scientific knowledge more accessible through artefacts produced using the digital machines, and adding this new turnkey instrument to their shared repertoire of interactive resources for visitors. In 2017, the science center had been entirely converted into an open lab (Fablab, living lab and media lab). This spatial transformation had been accompanied by the building of a community of makers and the departure of some of the science explainers who could not adapt to this organizational transition. One of them is now employed full time in the Fablab along with art facilitators but is still under the remit of another department. While the organization has been transformed, the practices of making have also been reconfigured to maintain the boundaries between experts and lay persons through residencies; when they are with scientists, Fabmanagers are confined to logistic tasks (Table 3B). Through the production of OS software and digital platforms for the *Culture scientifique et technique* community, *La Casemate* has also contributed to the global institutionalization of making and transformation of the institution, *Culture scientifique et technique*. The dynamics of sociomaterialities illustrate how the fablab transformed the organization and the institution *Culture scientifique et technique*; the change velocity of the organization, the individuals and the technologies is imprinted in them.

Transforming the surrounding organizations

While contributing to institutional entrepreneurship at the local and global levels, the boundary work in each Fablab contributes to transforming their

backing and surrounding organizations. As a resource for individuals and intermediary organizations, a Fablab may be involved in many different projects. By bringing together different audiences, it allows boundary spanning and redefines the boundaries of the making community. The boundary work differs with the fablabs and their environments. In the Faclab, users’ personal and professional networking slowly blurs the boundaries between the university and community organizations. The comparison of the science centers allows us to characterize further the transformation paces of sociomaterialities. The more the museum is anchored in its territory, the easier it is to institutionalize a new technology as a trusted partner. On the contrary the harder it is to enter a new field. As an example, *La Casemate* brings digital manufacturing in the nearby high schools, and forces the teachers to making instead of using the turnkey education kits they used to provide them by coordinating projects with these partners. But it failed at entering the institutional field of innovation in contrast to *Le Dôme* which missed historical roots as a museum (Malinovskyy et al., 2016). Through residencies, *Le Dôme*’s fabmanagers have achieved cross-pollination and stabilized alliances with the surrounding organizations. The presence of intermediary agents within these partner organizations facilitates the boundary work. As for the *Carrefour numérique* whose users force the backing organization *Cité des Sciences* to move on and invite them to drone conquests, although the fablabs situation (in the basement of the museum) reveals how the museum views it. All these examples illustrate different aspects of how the sociomaterialities of the Fablabs interact with and transform the surrounding organizations.

INSTITUTIONAL ENTREPRENEURSHIP AS A DISTRIBUTED INNOVATION PROCESS

The narrative of Fablab politics in relation to the detailed report “from below” provides an understanding of the different institutionalization layers and organizational textures. We applied the

concept of sociomaterialities to Fablabs to try to understand how the community's search for funding alongside its organizing and sustaining activities led to a distributed institutional entrepreneurship. This is comprised on individuals, technologies/techniques and artifacts, and organizations. In other words, the structuration of the Fablab and its institution in creating a close or more distant environment, are two sides of the same coin. In every Fablab, there is a core team whose mission is to disseminate the maker subculture and hybridize its narratives with those of the surrounding institutions, while preserving the cognitive distance separating the maker and the professional ethos. As a way of structuring the distributed institutional entrepreneurship, the core team progressively tightens (transforms) alliances into formal agreements (projects and residencies). The artifacts produced along the way embody the negotiations between makers' ways of knowing and those defended in institutions, and may either reinforce or impede human and organizational agencies. Thus, institutional entrepreneurship is embedded not only in technologies, but also in the organizational texture of places and the anchoring of projects in an emerging field of related organizations.

Institutionalization of the MIT-CBA model into an institution-to-be, the "French Fablab," has been the result of democratizing innovation (von Hippel, 2005). A substantial part of the literature on distributed innovation focuses on self-organized hacker communities (Elliot, 2006; Heylighen, 2016), innovation by collectives of users with involvement strategies (Hyysalo et al., 2016), and grassroots innovation processes (Smith et al., 2013). Thanks to a better understanding of the role of communities, this renewal of innovation studies stresses the activities of engaged users, expressing a collective and strategic motivation for the politics of their own practice. In the present study, the core team members are the embodiment of these engaged users. Based on their ability to take on the role of leader, they are able to stabilize the institutional framework which is co-constructed in practice. As knowledgeable agents, they have to make

compromises and set priorities when leveraging resources to "create new institutions or to transform existing ones" (Maguire et al., 2004). When adapting their projects to the social and political constraints of a nascent environment, they enable the structuration process and sustain the organizational impetus over time. To benefit from the knowledge of users and creative communities while also protecting the institution-to-be, they develop forms of organization, and management settings which produce a tension with the self-organizing mechanisms that characterize those community. In addition, they develop organizational knowledge i.e. a reflexive consciousness of this agency and the capacity to refer to this agency as a system of practices that they can also manage. Their organizational knowing comes from their regular contribution to the life of the place. In this context, we can refer to Cook and Brown (Cook and Brown, 1999) and Gherardi (Gherardi, 2009) who provide evidence of and investigate these differences in knowledge and knowing in organization theory. Therefore, it is important to understand and recognize the role of these intermediaries among the different institutionalization (local and global) levels, and their ability to adapt the initial model and integrate it into local networks through the process of innovation.

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ABOUT THE AUTHORS

Dr. Evelyne Lhoste is a researcher at INRA. She develops social studies on innovation, science and technology and is a member of the board of Alliss, a collective supporting new forms of interaction between sciences and society. She contributes to the renewal of innovation studies by focusing on the practices of engaged users that express collective and strategic motives towards the politics of their own practices. Her recent work was dedicated to distributed innovation in open labs/third places. As a former communication officer for a research center, she experienced the diffusionist practices of science popularization. (<http://umr-lisis.fr/membre/evelyne-lhoste/>)

Dr. Marc Barbier is researcher at INRA and director of the IFRIS institute in Paris. He is co-editor of the

Revue d'Anthropologie des Connaissances. He develops social studies on innovation, science and technology and manage the CorTexT online Platform to empower scholars with textual analysis. He has worked on agri-environmental policy device, on public problems related to food safety risk and related trouble between scientific expertise and decision-making. He is presently working on agro-

ecological transition and the emergence of innovation regime based on experiential knowledge and intermediation. (<http://umr-lisis.fr/membre/marc-barbier/>)