SHAPING SUSTAINABILITY IN FAB LABS

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ABSTRACT

This paper presents a narrative case study describing interactions in one Fab Lab in Helsinki, Finland. The intent is to reveal how (or if) sustainability concerns are socially shaped within an organization in the same way participatory innovation can be shaped. The contribution of the paper is two-fold. First, it augments understanding of environmental impacts and attitudes in Fab Labs; secondly it describes how peer learning is encouraged in Labs, thereby setting the stage for participatory innovation in what is – in essence – a novel infrastructure for product development. The preliminary findings suggest pathways that can lead towards participatory invention or innovation as well as environmentally responsible practice.

INTRODUCTION

Fab Labs ('fabrication laboratories') offer access to digital manufacturing equipment in spaces where individuals can design and fabricate their own inventions and products. Since establishment of the first three Fab Labs in 2002 (an outreach project of MIT's Center for Bits and Atoms), the network has extended to number in the hundreds. Each Lab is unique and retains its own profile with regards to associated institution (university, research institute, private organization, etc.), funding and revenue model, target users, and so on, and therefore the network (which was not begun with the intent of establishing a network) is akin more to a bazaar than a franchise. Nevertheless the attempt is made to retain common equipment and operating procedures across all Labs so that projects and learnings can be shared throughout the network. Unlike professional product prototyping services, the equipment in Fab Labs tends towards the smaller 'desktop' variety. Users therefore operate the equipment directly and without mediation of a technician except in initial training when needed. As will be elaborated below, this is one key aspect of the culture of peer-to-peer learning deemed desirable. Another distinguishing characteristic, laid out in the Fab Lab Charter (http://fab.cba.mit.edu/about/charter/), is that Labs must be open (at least in part) to the public and not restricted to specific users by paid membership or other criteria. The Charter entreats users of the Open Access days to document and openly share their projects. This thereby forms another key element in the collaborative, open climate of any Fab Lab.

Bringing digital manufacturing capacity to the level of the individual is regarded by some as potentially disruptive (e.g. Lipson and Kurman 2010). Disruptive technologies combined with practices and values aligned with empowerment and peer learning means the Fab Lab model could well be a stepping stone to more widespread implementations of distributed production – as an alternative to, or alternate form of, mass production. This has clear implications for participatory innovation research and knowledge building, as revealing how collaborative actions and cooperative values are shaped in Fab Labs is transferable to other contexts. Moreover, if sustainability-oriented values and pro-environmental behaviours can be shaped and encouraged in a similar way, long-term implications include the ability to promote more sustainable operational models for Fab Labs and maker spaces in future.

In the author's doctoral research, environmental, social and economic sustainability are inevitably intertwined; nevertheless, the focus level is on environmental sustainability. More importantly, the focus remains on how the actors themselves define or address sustainability, how they prioritize their decisions, and how they take up or ignore constraints imposed by environmental impact – especially in a context rife with

paradox and complexity concerning appropriate use of materials and energy.

LITERATURE AND METHODS

The literature on Fab Labs remains scant as it is a relatively new focus for study and researchers often rely on reports and studies published online for easy access, in accordance with principles of openness, rather than in academic journals. One of the first accounts by the founder of the Fab Lab network Neil Gershenfeld (2005) explores the nature and implications of personal fabrication. English-language overviews and surveys of Labs are also beginning to appear (e.g. Eychenne 2012). Much of the emerging conceptual work (such as van Abel et al. 2011; Bauwens et al. 2012) is indebted to Benkler's notion of "commons-based peer production" (Benkler 2006) and investigates the realm where digital-based, distributed peer production enters the material world.

Environmental issues in maker spaces are also rarely addressed in academic journals. Studies tend to focus on the technologies and processes, thereby usually implying digital manufacturing more generally and environmental engineering-led impact assessments (e.g. Franco, Lanzetta and Romoli 2010; ATKINS Project 2007).

Regarding the phrasing adopted in this paper, i.e. the "social shaping of sustainability", this has conventionally been addressed in different (normative) terms, such as how consumption patterns are affected or behaviour changed in consumer, marketing as well as policy research (e.g. Stø et al. 2008; DEFRA 2008) and change management in organizational literature (e.g. Daily and Huang 2001). Alternatives to these approaches, which may be more appropriate to the rather odd 'prosumption' middle ground where Fab Labs sit, focus on practices and social groups rather than individual behaviour or purchase patterns (e.g. Hargreaves 2011) and end-user (and/or lead user) involvement as opposed to employee/employer relationships (e.g. Rohracher 2003).

Given this background, the latter perspective that acknowledges how actors shape the meaning of artefacts and technologies (as in Williams and Edge 1996; Bijker 1995) serves to position the research. In the present article, nonetheless, the objective at this stage is to describe and reveal rather than, as yet, deeply analyse or make clear links to the theoretical framework.

Ethnographic fieldwork was conducted by the author in the founding phases of a new Fab Lab in 2012 and the descriptions in this case study are based on a large part of this data (i.e. about 160 audio and video recordings, six semi-structured interviews, photographs and fieldnotes). The intent was to capture what actors actually do to both establish and use the Lab to fulfil their objectives. One key aim was to identify the barriers and drivers to recognizing and prioritizing sustainability issues (or, more widely, how 'sustainability' was represented).

In this paper, the circumstances are described especially from the Organizers' point of view. Their dilemmas, motivations, successes and distractions are depicted as such on the basis of appearing numerous times in the data. Attention is also paid to discrepancies between what actors express as convictions and preferences and what they actually do. This is especially relevant in the data set on the Lab's digital fabrication courses. It is here that Organizers have a key role in shaping users' (i.e. Aalto students') attitudes and behaviours regarding both collaborative invention and sustainability-oriented practices – especially in the context of an educational institute.

AALTO FAB LAB

Finland's first Fab Lab opened in Aalto University's Media Factory in June 2012, while planning for its opening and operation began in 2010. The Fab Lab enables physical computing and product prototyping for students and staff as well as novel ways to engage with the public in projects and/or during the Open Days. The first public access Open Days began in October 2012 (one day per week).

Aalto Fab Lab is a small organization, consisting of one full-time studio master and two half-time employees in 2012. Decision-makers include Media Factory's manager and director. The Lab's space (about 100 m^2) is divided into space for teaching/lecturing and working/designing, an enclosed space for noisy and dusty equipment (i.e. laser cutter, milling machines), and space for other equipment (electronics stations, 3D printers, vinyl cutter, computers) and books. An adjoining room offers office facilities and storage.

ORGANIZER 1

The Fab Lab's Studio Master began work in November 2011. She has a background in computing and work experience in another Fab Lab. She was the main (often only) person responsible for physically setting up the Lab equipment and procedures: deciding on and ordering the equipment and materials; coordinating with the Lab's space designer, builders, and authorities (e.g. fire inspectors); troubleshooting the software and hardware; building the website; and deciding on documentation procedures, use instructions and workflow. In parallel she was completing her own Fab Academy exercises, giving tours to numerous visitors including journalists, and planning and teaching the first Digital Workshop Basics courses. These courses gave Aalto students the first introduction to the equipment and procedures through hands-on exercises as well as the culture of sharing through having to execute documentation or 'instructables'.

The purpose of the above lengthy description of tasks is to emphasize the many hats a typical Fab Lab manager must wear and the challenge to prioritize. The Studio

Master's attention is often directed to the documentation problem (i.e. the mechanics of how users can best document and share their work) and the workflow and user protocol issues (so users can be as independent as possible), in accordance with values supporting openness, sharing and peer learning.

In interactions, the Studio Master clearly and regularly encourages a help-yourself-and-help-others attitude through her words and behaviour. She continually emphasizes in Lab introductions that users do the work themselves and she and the other employees are there only to help and guide. She routinely states that users should help the next one in the queue and teach them how to use the machines. She reinforces this through her behaviour: if two students are working together at a machine or computer screen, for instance, she approaches them to gauge the extent of the problem and then physically draws away to let them continue helping each other.

What was rarely observed was advice on environmental choices, given the substantial attention needed to facilitate learning the equipment and social norms. The selection of materials and equipment, for example, is clearly guided by bureaucracy and the need to streamline. Complex procurement procedures in the university including payment processes; ease of ordering in bulk through MIT, Aalto ARTS' wood workshop or another Aalto unit; price increases through customs charges and import taxes: all these factors lead to choices that are usually not environmentally optimal. Moreover, not all materials are equal with regards to 'fabbability': a British source of plywood was found that gave better results in the laser cutter than the local Finnish supply. In addition, standardized, virgin materials are more predictable than waste (reused) materials in terms of equipment settings and output, and this was usually pointed out when a student brought in a material of his/her own: not as a preference per se but as a practical issue regarding the need to test settings (e.g. in the laser cutter).

Because of the practical concerns, the Studio Master has been less able to spend time developing what she called "organic connections" and interests she had before her position in Aalto. This refers to e.g. a Media Factory-funded project where people learned about waste and e-waste issues and experimented with reuse and recycling, as well as previous projects she has conducted on creative reuse of laser cutter off-cuts. One may conjecture that once the Lab begins to assume routine operations she may pursue these more 'benign' interests, thereby potentially influencing users' perceptions of what can be done in a Fab Lab.

ORGANIZER 2

The Producer is responsible for coordinating events (such as the Open Knowledge Festival) and community building. His background is in industrial and strategic design and he has an extensive history researching and experimenting in the area of Open Design, digital fabrication and peer-to-peer networks. It is important to note that he is an influential voice in this (global) community. He began his work contract with Media Factory in December 2011.

He also teaches the Digital Fabrication Studio course subsequent to the Studio Master's introductory course. His values and goals come through in how he conveys the culture of fabbing through his lectures, including stories told about other Labs and sharing of numerous projects documented on the internet, and how he guides the students to final results. His success criteria for his course are therefore more rigorous: fabbability is paramount, i.e. what it means to *design* for digital fabrication. In his lectures and in guiding projects he espouses the "bits to atoms" 'mythology' rampant in Fab Labs. Simply put, this concerns the relationship between the digital input and the material output as well as the meta-level where products can embed various layers of information. "It's never only digital and never only physical material but both together." One common method of playing with this meta-level as well as adhering to the community rules on sharing designs is to print (e.g. etch) the blueprint (or source code) on the product's surface in the form of e.g. a QR code.

The Producer's favourite fabbed product by far is a glass bowl: a team effort where a pattern was milled into a piece of wood in the Fab Lab, the wood was constructed into a glass mould, and one of the students (with glassblowing experience) formed the glass bowl by blowing, cutting and polishing in the school's glass studio. The praise for this work comes also unprompted and after other interesting and praiseworthy student work has come out subsequently. This observation has implications for how influential actors and groups may shape what is 'success' in future fabbing based on, for example, traditional artisanal skills.

This Organizer's time constraints also dictate what he needs to prioritize, his stance tempered by the practical consideration of a short course's learning objectives. Despite his own emphasis on empowerment and peer learning (stated explicitly in interviews), he acknowledges that the courses do not allow time to learn how to e.g. set up collaborative projects. In the course the Organizer focuses on developing a design literacy for fabbability (in the author's terms, not the Organizer's) while 'assuming' the Lab environment itself (including other Organizers) takes care of the openness and sharing: "There *is* peer-to-peer learning. It's not that I tell them: 'Do p2p learning!' It happens because they want to have it." By extension the students have accepted this culture merely by registering for the course. When prompted about sustainability considerations, he concedes that time does not permit: "it's better that they have another course about sustainability and materials".

The scope of this paper limits what can be discussed regarding the students themselves, and further narratives will expound on their motivations, actions, preferences

and responses to Lab norms, as well as how they themselves shape the Lab's culture. Some students for instance do explicitly take on environmental concerns (through material reuse, for instance) but these were in the minority and their effect indeterminate. Other priorities and/or an actor's self-interest were also seen to deliver unintended environmental benefits (such as 3D printing time and energy consumption).

With regard to the Organizers' intent to promote peer learning through sharing and openness, the Organizers themselves report observing this culture taking shape and the data confirms this to a large extent. Further examination of this young Lab as well as other, more mature Labs will unpack how (or if) this culture can plant seeds for participatory, collaborative invention processes.

DISCUSSION

In this case study we examined how issues pertaining to sustainability were shaped in the process of socially shaping the culture of a new Fab Lab. While sustainability is espoused, it does not render Fab Labs as any clear platform as yet for 'participatory sustainable innovation' amidst the other issues that are shaped.

Some signals do emerge, nevertheless. In wealthy contexts where financial resources are relatively plentiful, it is *time* that becomes the scarce resource to leverage in creative ways if one aims to be a change agent. Moreover, while these students express a myriad reasons for choosing to make a certain object, collaborative projects taken on by Fab Labs themselves (cooperation among several Labs) tackle specific local problems. This localized need-based approach (intimating value-sensitive design) carries potential for more sustainable practices overall.

The discourse in the 'maker movement' claims that this kind of distributed, open knowledge building through hands-on learning and designing embeds responsibility. It remains to be seen, in further observation and empirical analysis, how this sense of responsibility emerges, is expressed, and is sustained.

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