Experimenting with Novel Socio-Technical Configurations

The Domestication of Digital Fabrication Technologies in FabLabs

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Abstract

Grassroots digital fabrication workshops (such as FabLabs), and associated technologies (such as 3D printers), are attracting increasing attention as a potential source for addressing a variety of social and environmental challenges. Through an analysis of an in-depth case study on FabLabs, this paper aims to provide insights into the practices emerging in these workshops and realities of the relationship between its members and technologies that are currently under-researched. It does this by drawing upon the domestication literature that concerns itself with how people use, adapt and reject technologies and integrate them into their life. The paper examines the significance of the interactions between people and technologies in FabLabs and offers concluding reflections on the role of these relationships within broader social and environmental changes.

Keywords: Digital fabrication technologies, Workshops, FabLabs, Domestication

Introduction

Around the world, diverse groups of people are repairing, hacking and assembling things in digital fabrication workshops. Equipped with versatile digital design and manufacturing technologies, global networks of workshops, like FabLabs, create spaces for experimenting with technologies and collaborative projects – from making toys and jewellery to solar panels, open-source smart meters and eco-houses. Observers and "fabbers" (i.e. visitors and members of FabLabs) have argued that these workshops have the potential to change practices of innovation, design, production and consumption (Smith et al. 2013), where we live in a world in which anyone can make anything anywhere (Gershenfeld 2005). Social scientific analyses of the practices emerging in these workshops have started to emerge (cf. Kohtala/Bosque 2014; Nascimento 2014; Fleischmann/Hielscher/

DOI 10.14361/dcs-2017-0104

Merritt 2016); however, less evident within these studies are questions relating to how interactions between people and technologies in grassroots digital fabrication workshops relate to wider social and environmental changes implied in some of the claims – something that this paper examines.

In trying to understand the interactions between people and technologies in grassroots digital fabrication workshops, I focus the paper on how "fabbers" domesticate digital fabrication technologies within their workshops. The literature on domestication draws attention to the "social dynamics that occur between different groups of users" and interactions with technologies after the point of purchase (McMeekin/Southerton 2012: 345). To date, however, most of the work has concentrated on domestication processes within people's home, rather than considering these interactions within wider social networks (such as FabLabs) (Haddon 2007). Such investigations potentially play a key role when examining how interactions between people and technologies sit within broader social and environmental changes.

Following the ideas from the literature on domestication, the paper examines the interactions between "fabbers" and technologies within digital fabrication workshops. Specifically, this paper addresses the following research questions: how do the interactions between "fabbers" and digital fabrication technologies play a role in developing workshop practices, and how do they relate to broader social and environmental changes? With these research questions in mind, the analysis draws on a literature review on digital fabrication and empirical evidence gathered through interviews and participant observations in FabLabs, in particular drawing on an in-depth case study of FabLab Amersfoort.

The section "Domestication of technologies: The domestication approach" introduces the literature on the domestication approach more broadly, before the section "The domestication of digital fabrication technologies in FabLabs" outlines these ideas in the context of digital fabrication in FabLabs. The next section outlines the methodological approach of the study, drawing on an in-depth case study on FabLabs. This is then built on in the section to detail the domestication process and associated negotiations played out in FabLabs, providing insights into the practices emerging in digital fabrication workshops. The last two sections discuss the significance of examining the interactions between people and technologies in daily life and offers concluding reflections on the role of these engagements within broader social and environmental changes.

Domestication of technologies: The domestication approach

The domestication approach is derived from the anthropology (Douglas/Isherwood 1980), media studies (Bausinger 1984; Lull 1988) and consumption (McCracken 1990) literature. It has concerned itself with exploring people's relationships with technologies and their integration into daily routines: how people

use technologies in their daily lives. Earlier studies mainly examined the role of televisions in people's home lives (see, e.g., Hobson 1980; Lull 1988): how they watched television and evaluated it (Haddon 2007). Later on, this research was broadened out, influenced by the arrival of a variety of information and communication technologies (ICTs) in people's homes (such as Silverstone/Hirsch/Morley 1992). Researchers were keen to open up their investigations, not only focusing on individual's relations with ICTs but also examining the relations between household members (e.g. investigating gender issues [Lie/Sørensen 1996], including the examinations of conflicts and negotiations over their use [Haddon 2007]).

Influenced by Norwegian researchers, the approach was increasingly linked to concepts derived from the social shaping of technology literature (Silverstone/Hirsch/Morley 1992; Sørensen 1994; Lie/Sørensen 1996), a body of work engaged in the exploration of organisational, cultural and political factors that shape the design and implementation of technologies (Haddon 2011). Researchers were interested in examining how people make sense of technologies, asking questions such as how they experience technology, what these technologies mean to them and how do people engage with technologies as part of their daily routines (and even reject them) (for a review, see Haddon 2011: 200). The co-shaping of technologies and people was frequently the focus of these studies, examining how the shaping process continued once technologies were used and consumed and "why and how technologies emerge in the form they do" (Haddon 2011: 312). Researchers have put therefore less attention on the consequences of technologies entering people's lives, that is "if and how technologies 'empower' us" (Bakardjieva 2005; Haddon 2011: 316).

At the time, in particular, Norwegian researchers argued for moving domestication studies beyond investigations of the home and individuals' interactions with technology (Lie/Sørensen 1996; Haddon 2007, 2011). The development of portable ICTs (such as the mobile phone) encouraged researchers to "think more about how the domestication framework could be expanded to consider interactions with these wider social networks outside the home" (Haddon 2003, 2004, 2007: 28). As argued by Haddon "the home is by no means the only place where ICTs are used" (2011: 314). Domestication is performed by individuals or groups in different settings like households or workplaces, but it may also be done by institutions and other collectives (Sørensen et al. 2006: 4).

Although academics have dedicated less attention to investigating interactions between technologies and people outside the home, some studies have emerged, for instance, examining Internet training courses (Hynes/Rommes 2005), activities of hackers (Hapnes 1996) and Internet-based social networks (Lally 2002; Ward 2005). Researchers were interested in finding out how activities and courses outside the home intervene in the domestication process of computers (Hynes/Rommes 2005), for instance, would they increase the researchers' knowledge of "how consumers of computer technology proceed to develop their patterns of use" (Hapnes 1996: 121). Here, the domestication approach is often not only concerned

with the relationship between people and things but also how they sit within broader cultural, social and economic aspects (Oudshoorn/Pinch 2005).

Domestication phases

Domestication commonly refers to the incorporation of technologies into daily routines, transforming "unfamiliar, exciting, and possible threatening things" (Oudshoorn/Pinch 2005: 14) into familiar ones. Such an approach attempts to move away from the idea of a passive, adaptive consumer and aims to examine what happens when technologies are "consumed" and used (Sørensen 1994). Here, the incorporation of technologies is considered to be part of a dual process where technologies can redefine existing routines and daily life activities shape these technologies over time (Oudshoorn/Pinch 2005).

> The users/consumers make active efforts to shape their lives through creative manipulation of artefacts, symbols, and social systems in relation to their practical needs and competencies(Lie/Sørensen 1996: 9).

The domestication process has been divided into several phases, including appropriation, objectification and incorporation to conversion (Silverstone/Hirsch/Morley 1992). Others, such as Sørensen, Aune and Hatling (2000), have argued against specific successive phases and advocated the use of four domestication dimensions when examining the integration of technologies into daily life. Such dimensions are part of a

> [m]ulti-dynamic process in which the artefact must be *acquired* (that is, bought or made accessible in some other way), *placed* (that is, put in physical space as well as in mental space), *interpreted* (in the sense that it is given meaning within the household or the local context, and given symbolic value to the outside world), and *integrated* into social practices of action (Laegran 2005: 82).

The consumption of technologies requires symbolic work in which the meanings associated with them get interpreted and adapted into existing patterns of daily routines and cognitive work where people have to learn about the technology and develop certain skills to use and integrate it (Lie/Sørensen 1996).

Negotiations and conflicts associated with the domestication phases

To be able to go beyond the relationship between people and things, Lie and Sørensen (1996: 12) have further pointed towards the need to study the various "conflicts and negotiations" that are integral to the domestication process. These can include negotiations between household members and the politics of the home, for instance, discussions (and the creation of rules) around the appropriate

use of a technology (Silverstone/Haddon 1996). For them the challenge within investigating the interactions between people and technologies is to demonstrate how meanings are produced through the negotiation processes that take place (Lie/Sørensen 1996).

> Of course when one looks at such conflicts from a macroscopic point of view, they may appear idiosyncratic and without relevance, like ripples in a large wave of change. However, we will argue that, in the final instances, everyday struggles and negotiations may have important effects on the shaping of technology and its "consequences" (Lie/Sørensen 1996: 11).

As argued by Hapnes (1996: 121, 122), who studied the activities of hackers, the domestication approach helps to build an understanding of the "continuous negotiations with human and non-human elements" and "how meanings are created through the negotiation processes that take place."

> To domesticate an artefact is to negotiate its meaning and practice in a dynamic, interactive manner. This implies that technology as well as social relations are transformed (Sørensen/Aune/Hatling 2000: 240).

Making use of the domestication approach to study the activities in FabLabs draws attention to how "fabbers" proceed to negotiate and develop digital fabrication technologies' patterns of use. As argued by Smith et al. (2013), understanding the way social relations, digital technologies and workshop practices co-produce different socio-technical configurations of digital fabrication is paramount in order to be able to critically examine how such diverse configurations relate to broader social and environmental changes. All configurations will include certain interests and value judgements that give priority to certain issues over others (such as inclusion and/or sustainability), containing several possibilities for digital fabrication.

The next section briefly outlines digital fabrication in FabLabs.

The domestication of digital fabrication technologies in FabLabs

FabLabs are places where an object can be produced, from its idea to its digitalisation and its final physical shape (Büching 2013). They can be found in many major cities around the world and make up a global network of labs. They share projects and knowledge through social media and meet up physically at international events. There are currently about 440 FabLabs across 60 countries. Although there is no formal process of setting up a FabLab, all of them have evolved from the first lab that was established as part of the Massachusetts Institute of Technology's (MIT) Interdisciplinary Centre for Bits and Atoms course, entitled "How to Make (almost) Anything" in 2002 (Gershenfeld 2005). FabLabs are conceptually embedded in a common set of requirements. This includes a common set of

digital technologies: computer numerical control (CNC) milling machines and routers,[1] three-dimensional (3D) printers,[2] laser cutters,[3] hardware tools and electronics. They also incorporate a shared FabLab Charter, that is a document that outlines the shared values of labs. This charter outlines some of the key objectives behind the FabLab network,

- Fablabs are a global network of local labs, enabling invention by providing access to tools for digital fabrication [...].
- Fablabs share an evolving inventory of core capabilities to make (almost) anything, allowing people and projects to be shared (see FabWiki 2012 for a full list of objectives).

Over the past few years, FabLabs have attracted increased attention from media, the general public, government, businesses and academia (Gershenfeld 2005). Digital fabrication technologies are said to play not only a techno-economic role in the near future but will also influence other social fields (e. g. work and home), in particular, when they are located in community-based workshops (Walter-Herrmann/Büching 2013). Analogies are being made with the developments of personal computers to demonstrate the potential impacts of FabLabs. They foster collaborative, open and inclusive forms of innovation; decentralised manufacturing; and democratic access to digital fabrication technologies through a variety of labs (see Smith et al. 2013 for a full overview); hence they are associated with, for example, notions of empowerment (Walter-Herrmann/Büching 2013), open source (Pearce et al. 2010) and commons-based peer production (Benkler 2006). Some academics and fabbers have referred to the labs' potential to create post-consumer sustainable societies (cf. Schor 2010).

Such claims have created a hype around digital fabrication, which sometimes risks extrapolating and inflating claims without considering participants' own activities, aims in setting up spaces and motivations for joining these labs. A recent special issue on "Shared Machine Shops" in the *Journal of Peer Production* was more cautious about such coverage on digital fabrication and stated that "Fablabs are not the seeds of a revolution" (Maxigas and Troxler 2014). Little social science research has gone into studying such claims in relation to practices on the ground, in particular, how the domestication of these digital fabrication technologies within FabLabs addresses the claimed wider social and environmental issues. Although, as argued by Nascimento (2014), digital fabrication technologies are not neutral, notions of empowerment, openness and sustainability are not neces-

1 A computer numerical controlled milling machine uses rotary cutters to remove materials from a digital file.

2 A 3D printer is a technology that allows people to make three-dimensional solid objects from a digital file through additive manufacturing processes.

3 A laser cutter is a technology that uses a laser to cut materials from digital files.

sarily inherent in them or the labs where they are used and domesticated. Within the labs, the technologies get interpreted and adapted into existing patterns of daily routines where "fabbers" have to learn about these technologies and develop certain skills to use and integrate them.

Studying the activities of hackers, Hapnes (1996: 148) regards them as "a form of socio-technical experimentation." They transcend the divide between design and use; as argued by Oudshoorn and Pinch (2005: 16), "the process of production is not complete until users have defined the uses, meanings, and significance of the technology." FabLabs can be investigated in a similar light. They are actively involved in challenging and creating the boundaries of digital fabrication, frequently at the intersection of commercial and not-for-profit activities, through using, adapting and integrating digital fabrication technologies into the daily running of a lab. The domestication phases draw attention to examining technologies in use, practices and social relations in context, making visible the diverse set of socio-technical configurations that "fabbers" experiment with and (potentially) make up digital fabrication in the future. Such an investigation highlights the kind of technologies, practices and social relations that support some configurations over others that are linked to wider social and environmental issues.

Methodology: Researching grassroots digital fabrication in FabLabs

In the context of digital fabrication, the paper investigates concepts derived from the domestication literature in relation to the FabLab phenomena. Such an approach draws attention to the diverse set of technologies, practices and social relations that coexist in relation to digital fabrication technologies. The findings presented here are drawn from a mixed-methods qualitative research study into the FabLab network.[4]

I conducted an in-depth case study of a FabLab, called "FabLab Amersfoort," based in the Netherlands. Different from the majority of other labs, the people from FabLab Amersfoort describe themselves as a "bottom up grassroots FabLab" with the following aims: (1) "We want to become a sustainable Fab Lab" and (2) "[w]e plan to have our whole lab open source as soon as possible" (FabLab Amers-

4 The data for this paper were collected as part of the Centre on Innovation and Energy Demand (CIED) Transformative Social Innovation Theory (TRANSIT) projects. The TRANSIT project has examined a diverse set of grassroots initiatives to be able to develop a theory of transformative social innovation. CIED investigated the drivers and barriers to low-energy innovations. The author has been a research fellow on the TRANSIT project from January 2014 until April 2015 and in the CIED from October 2013 until now. During this time, she conducted and analysed the empirical work into the FabLab network.

foort website, http://www.fablabamersfoort.nl/en). Drawing on a list of FabLabs provided by the Fab Foundation, I looked at the local websites of FabLabs to get familiar with the labs' aims, activities, projects and technologies used. The sampling of the case study therefore draws upon an extreme case sampling strategy. Within this research, an extreme sample is characterised by its engagement in notions of open source and sustainability and attempts to empower people through collaborative working. Such characteristics are key when wanting to explore between people and things in the labs and how they sit within broader cultural, social and environmental aspects.

The case study comprises an in-depth site visit, including participants' observations during the FabLabs opening hours (which were noted down in detailed notes, such as interactions with the technologies), 25 informal face-to-face conversations with fabbers in the lab (such as FabLab managers, visitors to the lab and members of De War) and four more formalised interviews with the two founders, Julia and Jan, and two long-term members who played a role in developing the lab. Interview questions were based on gaining in-depth narratives of the historical developments of the lab and its technologies, aims and governance structure, projects conducted, networking activities and future aspirations. Various web-based materials, comprising videos and presentations, were added to the analysis (such as talks presented by the founders, the FabLab website and newspaper articles). The case study was published as an "innovation history" (Hielscher 2015), charting the history of the FabLab and outlining its day-to-day running. The evidence gathered in this way was coded (using Nvivo), analysing the development of the FabLab network and FabLab Amersfoort and, in particular, aspects of governance of the lab, networking activities, social learning and narratives of technologies in use. The research team has published specific aspects of this analysis elsewhere (Hielscher 2015; Smith/Hielscher/Fressoli 2015).

In addition to conducting the case study, the analysis was supported by research that was aimed at gaining an overview of the global FabLab network through participant observations at FabLab events and within European FabLabs and in-depth interviews with fabbers. Participant observations were carried out at the international Fab10 conference in Barcelona 2014. In addition, ten labs were visited in the UK, Portugal, Germany, Spain and the Netherlands throughout 2013 and 2014 (see Smith/Hielscher/Fressoli 2015 for a detailed description). During this time, the research team was able to gain an overview of the structure of the network, including internal debates and activities, and observe some of the interactions with digital fabrication technologies. In addition to informal conversations, 13 interviews with fabbers active in the network were carried out. This consisted of two university researchers, seven practitioners who are involved in the organisational aspects of the network and four practitioners who are involved in the local activities of FabLabs and/or regional networks.

This paper draws on the four domestication dimensions (Sørensen/Aune/Hatling 2000) to interrogate the conflicts and negotiations integral to the domestica-

tion process (Lie/Sørensen 1996). The relationship between fabbers and grassroots digital fabrication technologies in FabLabs and associated practices is examined through operationalising the four domestication dimensions: acquiring, placing, interpreting and integrating. Conflicts and negotiations are highlighted and further interrogated in relation to wider claimed changes linked with digital fabrication in grassroots digital fabrication workshops. Several negotiations can then be identified, but the ones of interest to this paper are linked to two of the slogans derived from the global FabLab network: (1) "how to make almost anything" (Gershenfeld 2012: 42), and (2) "democratising access" to technologies (Gershenfeld 2012: 48), as they are frequently linked to possible wider social and environmental changes. The next section presents some of the key findings from this examination.

Findings: Domestication of digital fabrication technologies in FabLabs

This section examines the domestication of digital fabrication technologies in the FabLab Amersfoort to draw out how fabbers acquire, place, interpret and integrate the technologies into the lab. The Dutch FabLab Amersfoort opened officially in 2010. It was created to support a group of activities under the "De War" collective based in an old factory in Amersfoort. The FabLab concept was an extension of some of the making activities in which they were already involved, but they liked the idea of encouraging other people to become more familiar with these technologies and creating networks of makers empowered to shape their own lives and environments. The people from De War did not necessarily agree with the €40,000–100,000 price attached to setting up a FabLab. Therefore, with a few friends, they went about creating a FabLab in a week and with about €5000, developing a grassroots approach to setting up and running a lab within the global FabLab network (for a more detailed description, see http://fablabamersfoort.nl/sites/default/files/Fab%20Lab%20Instructable.pdf).

Domestication dimensions

Acquiring: Self-building digital technologies in collaborative projects

Several distinct digital fabrication technologies need to be *acquired* to be able to set up a FabLab, as set out by the FabCharter. The acquisition of such technologies requires an initial cost of €40,000–100,000 in capital equipment. Most of the Fablabs within the network followed this model and secured external funding to be able to acquire their set of technologies. Similarly, the people of De War approached several possible benefactors. Conversations went on for months,

but funding never actually materialised. Not feeling deterred by these potential setbacks, they looked for alternative ways to set up their lab, resulting in self-building and self-assembling most of the technologies to keep costs low.

It all started off with a laser cutter, that is a technology that uses a laser to cut materials, which they found on an online auction website and could afford to buy. Five people put their own personal money together to acquire the technology. The laser cutter enabled the group to build their own 3D printer, CNC router and small PCB milling machine, as it could cut out the necessary parts for the other technologies to be built. Johan,[5] a regular visitor to the lab, and a team of fabbers, for example, built the CNC router. He was a regular visitor to the FabLab and asked whether he could use some of the technologies to build his hobby robots; in exchange he offered to build the CNC router. Johan used to be a machinist in his professional career and was used to building complex technologies. Six other fabbers from the lab joined him, making it a collaborative project that took over 1.5 years before the CNC router could be used.

Materials for the self-built technologies came from receiving donations and asking around for free parts, often relying on second-hand materials. Other equipment such as workbenches, computers, soldering stations, and so on had to be acquired for a low-cost price. To be able to keep costs low, they often had to rely on open-source software and hardware, for example, openly available mechanical drawings, circuit layout[6] design data and software source codes[7] to avoid expensive licences and labour costs by building and coding the technologies themselves:

> Yes, and it's also in having no money that we relied mainly on open-source software and hardware… it was pure necessity. So we didn't have any viable other options (Julia and Jan, interview, October 30, 2014).

Open-source hardware and software repositories created by several global networks (such as the Free Software Movement) were helpful in gaining access to design plans and guidelines to build the technologies. Existing local networks connected to De War, for instance, the OpenTOKO workshops, a series of "open knowledge" get-togethers, provided an influx of people interested and skilled enough to interpret these plans to assemble the technologies. Previous activities within De War and associated networks played a vital part in pursuing alternative approaches, rather than relying on external funds to acquire the digital fabrication technologies.

5 All the names from all of the fabbers have been anonymised.

6 A circuit diagram is a graphical representation of an electrical circuit.

7 A source code is a collection of computer instructions that is written by programmers using human-readable computer language. The code specifies the actions to be performed by a computer.

Placing: Do it yourself look and attitude

The self-building (and adapting) of the digital fabrication technologies determined more and more how they were *placed* into the lab, that is how people started to display the technologies and identified with them. Once the laser cutter arrived in the lab, a few of the fabbers tried to make sense of its workings by adding new electronic parts to the technology so that the existing closed-source software could be replaced with an open-source one.

This change to the software was marked through a visible switch on the technology where the fabbers can choose to use either the open-source or closed-source option by pulling a knob on the laser cutter. With the laser cutter in place, the fabbers could cut out the wooden frame for the open-source 3D printer, called Ultimaker, before self-assembling the printer during a self-build class at another Dutch FabLab where they received the rest of its parts. Other technologies, such as the PCB milling machine, started to become a continuous self-assembly project where it sometimes could be used in the lab but most of the time was in a state of improvement and repair.

Once the "fabbers" assembled the 3D printer parts, the development of the technology did not stop there. A programming language was developed so that the 3D printer could transfer digital drawings into 3D shapes. Julia remembers the time when they had post-it notes all around the printer. The fabbers noted down all the results of the conducted experiments around the possible settings for it. In particular, Max, who is interested in programming software for hardware technologies, took on board the task to programme it so that it would become easier to use, that is become user-friendlier.

Whilst building the technologies, fabbers who were interested in open-source software programming and hardware self-assembly mainly used the lab. Nowadays, the technologies are adapted so that they become user-friendlier for the daily running of a FabLab where anyone would be able to use them. Each technology had to go through a similar process of reprogramming, creating manuals for its use and changing the look of the technologies so that anyone coming into the lab, even with little knowledge of digital fabrication, could use them to build and make their own things.

Interpreting: FabLab Amersfoort's relationship to the "outside" world

Open-source, user-friendly and sustainability ideas have determined the overall design of the labs and its technologies through, for example, using self-cut, reused and second-hand materials and designing particular signs. Such ways of self-building the hardware not only made it easier to practically modify the technologies but also shaped the ways people *interpreted* them in relation to the labs' developing aims:

> We use mostly self-built and open-source machines. We plan to have our whole lab open source as soon as possible [...]. The focus of Fab Lab Amersfoort is on recycling of materials. We want to become a sustainable Fab Lab (Amersfoort FabLab website, http://www.fablab amersfoort.nl/en).

These aims have also shaped FabLab Amersfoort's relationships to the FabLabs network and local communities in Amersfoort. Fabbers at FabLab Amersfoort have set up "FabFuse," an annual international conference to share their knowledge about setting up and running a grassroots FabLab (i. e. mainly based on self-build technologies). The FabLab team has published several documents to outline its approach. In addition to documents, the FabLab is engaged in sharing its project ideas and design files with other labs in the form of FabMoments[8] (Troxler/Zijp 2013), building on its FabPublication[9] ideas.

Although links to the global network exist, over the years FabLab Amersfoort has become a place where "fabbers" broadened out the aim of "personal fabrication to make (almost) anything" (Gershenfeld 2005) to ideas coming from sustainability, open source and collaborative working. The Transitielab that was established shortly after setting up the FabLab is an example of trying to combine personal fabrication ideas with Transition Town ambitions, and in the process broadening the FabLab approach. Projects have fallen under the topics of sustainable energy and food. Combining these ideas and practices has not, however, been straightforward. For Julia, setting up a FabLab was about experimenting with sustainability solutions, collaborative working and community building, but soon after opening it up she felt that most of the people who came into the lab were not interested in sustainability ideas; they were more keen on printing out their designs on the 3D printer and never to return to the lab again.

Integrating: Everyday patterns of use in FabLab Amersfoort

As part of the process of opening up the lab to the local communities and the FabLab network, "fabbers" continuously reinterpreted the technologies and design of the labs, shaping the ways they are *integrated* into the lab: used, understood, maintained, including what is made in the lab and who is part of it.

Nowadays, a newcomer coming into the FabLab would find various computers connected to self-build digital fabrication technologies, mainly run on open-source software. When spending some time in the FabLab, it becomes apparent that even for a person who has used these technologies, the open-source and self-build technologies and their use can, at first, be rather daunting. For instance,

8 FabMoments are detailed project descriptions conducted in a FabLab. They create a repository that is often put on the labs' website.

9 FabPublications is the name of FabLab Amersfoort's FabMoments. It can be found here: http://fablabamersfoort.nl/en/fabpublications.

computer files produced on proprietary software at home, including mechanical drawings to be printed on the 3D printer, often need to be converted into formats that can be read by the open-source 3D printer. Using the self-build, open-source 3D printer therefore requires knowledge and skills that can be developed only whilst engaging with it. Newcomers need to invest time and effort to use these technologies, which partly require people to believe in the values and practices that they represent.

Open-source ideas, as made visible and integrated in the technologies, needed to be constantly balanced against making them user-friendly for newcomers. "Fabbers" developed diagrams and hung them on the walls that show how the hardware and software is connected with each other and how to make use of it. Each technology and project built and conducted within the lab is further made accessible by documenting its development on the FabLab Amersfoort website, in the form of a "FabPublication," that is a template to share projects, including manuals, making descriptions and links to resources. During the weekly open days, at least one experienced fabber is in the lab, either working on his or her own project or helping others to get started. Such active steps of interpreting the technologies to be able to make them accessible for all are combined with an appreciation of self-taught learning.

> You will have to at least try and figure things out yourself or with fellow visitors before approaching the lab manager (Julia and Jan, interview, October 30, 2014).

The FabLab is founded on strong enthusiasm for autodidacticism (FabFuse event August 8–10, 2014). In particular, for Julia, being an autodidact is connected to feeling empowered, something that is important for her to translate into ways of making in the lab. There is a supportive environment in which people support each other and collaborate on projects; nonetheless, more experienced fabbers are keen for people to work things out by themselves. Jan has affirmed this attitude by stating that he is keen for the FabLab not to become a 3D printer "copy shop" (Interview, August 19, 2014), but a place where everyone is expected to contribute to sustaining the lab.

As already seen earlier, practices in the lab and attached values have steadily become more formalised. In addition to starting to document projects as a way of exchanging open-source ideas, people are asked to work autodidactically and give up some of their time to maintain the lab. Nowadays, when entering the FabLab, people are asked to pay €50 to be able to use the FabLab that they can earn back through sharing their design in the form of a "FabPublication" or conducting maintenance or repair work (i.e. the "work-flow" rules). The FabLab users are not obliged to earn back the money but instead are able to pay for their visit. Informal ways of working with each other, engaging with the technologies and developing the aims of the lab, have become more formalised over time.

Negotiations within domesticating dimensions

When examining the domestication of digital fabrication technologies within FabLab Amersfoort more closely, it becomes apparent that the domestication of these technologies is associated with several negotiations. As pointed out by Sørensen, Aune and Hatling (2000: 240), "to domesticate an artefact is to negotiate its meaning and practice in a dynamic and interactive manner." This section draws out some of these negotiations apparent in the previous domestication process and links them to broader social, technical and environmental ideas associated with the FabLab network. Several negotiations can be identified, but the ones of interest to this paper are linked to two of the slogans derived from the global FabLab network (as shown in Table 1): first, making (almost) anything, that is "how to make almost anything" (Gershenfeld 2012: 42), and second, democratising access to novel production and consumption technologies, that is "democratising access" (Gershenfeld 2012: 48), as they are often linked to wider social and environmental changes implied in the slogans.

Although the aim of giving anyone the possibility of accessing digital fabrication technologies to make almost anything is followed by all FabLabs, when examining the domestication process it becomes apparent that these efforts are sometimes far from straightforward to pursue. People within the lab have to negotiate, first, who is able to use the FabLab, for instance, mediating between user-friendly technologies and open-source ideas, and, second, for what purposes should the technologies be used, for instance, mediating between free experimentations and social and environmental practices. Investigating these negotiations associated with "providing access to all to make almost anything," the different socio-technical configurations of digital fabrication and associated constellations of the social networks become visible.

How to make almost anything

The slogan of "how to make (almost) anything" seems to suggest that what is produced within a FabLab is not fully debated or questioned. It is the potential of making almost anything with digital fabrication technologies that seems to be of interest, that is "attitudes more engaged in experimenting for the sake of experimenting, or yet making something only for the sake of using for instance the newest tools" (Nascimento 2014:). Although such attitudes exist, some of the FabLabs actively pursue a variety of social, economic and environmental aims (Smith/Hielscher/Fressoli 2015).

From the start, the initiators of FabLab Amersfoort wanted to explore issues of sustainability in their lab. To be able to do this, some of the digital fabrication technologies were partly made out of reused and recycled materials. Moreover, they have encouraged projects in which people could develop sustainable design ideas or product service systems, but these projects have been rare in

Slogans Associated with FabLab Network	Negotiations: Acquiring	Negotiations: Placing	Negotiations: Interpreting	Negotiations: Integrating
How to make almost anything	Creating open-source and self-assembly technologies needs to be negotiated with buying technologies and owning them.	Experimenting with the technological possibilities of digital fabrication needs to be negotiated with creating technologies that help people to make their own things and realise their projects.	Using the lab to make your own sustainable products needs to be negotiated with experimenting with digital fabrication technologies for the sake of it.	Advocating self-taught learning to empower people needs to be negotiated with becoming a copy shop where people just print their things and leave.
Democratising access	Developing the technologies within technological knowledge networks needs to be negotiated with encouraging an active participation from local communities within these processes.	Continuously modifying the digital fabrication technologies in the lab needs to be negotiated with maintaining and keeping them up so that fabbers can use them on a regular basis.	Sole ideas of personal digital fabrication need to be negotiated with broadening out the approach to wider interpretations, for instance, of sustainability.	Experimenting with digital fabrication technologies for the sake of it needs to be negotiated with making technologies that are user-friendly and can be used by all.

Table 1: Negotiations associated with the domestication dimensions of digital fabrication technologies within FabLabs

the lab. During a session on FabLabs and sustainability at a FabFuse event, Julia explained how frustrated she felt once she realised that the people who come to the lab have mainly been interested in printing out one particular design, never to return to the lab again or experiment with the self-build technologies, rather than actively think about exploring sustainability ideas in making. According to a study conducted by Kohtala and Hyysalo (2015: 334):

Those competent and interested in assessing environmental impacts were different people from those competent and interested in keeping track of rapidly evolving new technologies and materials for making.

As opposed to self-build, open-source practices, activities surrounding the issues of sustainability are rather rare within digital fabrication labs (Kohtala and Hyysalo 2015). Open-source ideas are currently more strongly interlinked with the development of digital fabrication technologies through sharing design and software ideas on collaborative platforms (e.g. through GitHub[10]). Various groups already engage with these technologies in their spare time through self-building processes, documenting them widely on the Internet to share their learning, even beyond the FabLab network. Such activities have shaped the ways digital technologies are acquired, placed, interpreted and integrated in the lab. Not only can they be connected to wider social and technological goals (Söderberg 2013) but also they can be linked to ideas of having fun with the tinkering process and testing the limits of technologies (Smith/Hielscher/Fressoli 2015).

Although such practices engage in questions such as "Why does technology need to be closed, owned and seamless?," "Why could most technologies not be designed for people to build, hack and fix them?," and "What is the role of digital fabrication within current mass production systems?," they do not seem to question what types of things should be made with digital fabrication technologies, that is the wider social and environmental role of the material outcomes of digital fabrication. The products produced as part of the Transitielab in FabLab Amersfoort could often have been as easily created without digital fabrication technologies, raising questions about the role of FabLabs in wider social and environmental changes.

The domestication process demonstrates that notions of sustainability (and potentially other social and environmental goals) are not inherent in the technologies and the lab. They might allow affordances towards incorporating such notions but are not actively integrated in socio-technical configurations in the lab such as the design of the technology. Moreover, groups of fabbers who engage in sustainability activities are still rare (Kohtala and Hyysalo 2015). It seems that some notions (such as open source) associated with FabLabs can be more readily incorporated within the daily practices of the lab because they can more readily link to existing social networks, whilst some others (such as sustainability) need to be more actively embedded in the socio-technical configurations of the labs.

10 GitHub is a collaborative platform for anyone who wants to develop software within peer-to-peer networks.

Democratising access

Over time, open-source ideas and practices have become an integral part of the FabLab through self-building digital fabrication technologies, whilst developing associated rules, diagrams and signs. Such efforts have configured fabbers' interactions with the technologies and led to adjustments in their designs, for example, through an open-source switch. However, these endeavours, as demonstrated by the domestication process, frequently need to be negotiated: attempts to make the lab and its technologies accessible to all, that is making them more user-friendly, need to be negotiated with activities that are pushing the boundaries of open-source digital fabrication (Söderberg 2013) and self-replicating technologies (Jones et al. 2011), or even with pursuits of experimenting with these technologies for the sake of engaging with novel technologies (Nascimento 2014).

Significant attempts are being made in the FabLab to work more collaboratively and ease the integration of newcomers; however, there seems to be little overlap between the people who want to build and develop the technologies and newcomers to the lab. Some of the people who have developed the technologies have even started to look towards other technological communities (such as Hackerspaces) where they can pursue their interests of exploring ideas of open source or professionalise their activities by setting up start-up companies and therefore rarely come to the lab. This has meant that the FabLab has struggled to find enough people who could run the lab; share their knowledge; and build, repair and maintain the technologies. In addition, newcomers have to follow rules and interpret diagrams, as developed by the fabbers who built the technologies.

Within the FabLab network, open-source, self-built activities have been associated with attempts to create alternatives to mass manufacturing and proprietary software and hardware tools (Söderberg 2013) that are characterised by collective actions towards creating innovations. As highlighted by the domestication process, such activities require knowledge about soldering, mechanics, electronics and programming that might be daunting to a newcomer to these activities (Fleischmann/Hielscher/Merritt 2016). What does it mean to make digital fabrication technologies accessible and, in the process, democratise their use are questions that are negotiated within the domestication process of digital fabrication technologies within FabLabs.

As the examination of FabLab Amersfoort has shown, such negotiations shape existing social networks and socio-technical configurations (and conception of proper use) where some people decide to leave the lab. This departure of people makes collaborations between fabbers and newcomers more difficult, and some technologies cease to function (at least for a while) because they are no longer worked on or maintained. Still, some fabbers stay and even come back whilst newcomers arrive and take up the challenge to actively engage in these negotiations, creating manuals, diagrams, signs and technologies that allow for several activities to exist. These sometimes compromise some of the initial open-source, self-built design features or design features that make the technologies more user-friendly.

Discussion

The focus of the paper has been the examination of the domestication process, relating to digital fabrication technologies within FabLabs. This investigation has revealed several negotiations associated with the domestication of these technologies and how they relate to wider social and environmental changes. Indeed, the analysis draws attention to two specific issues: first, the dynamics of social relations between social groups and networks within daily production and consumption patterns and, second, the relationships between technologies and people within daily practices.

Social relations and networks within everyday practices

The domestication dimensions shed light on how meaning is given to digital fabrication technologies through building, using and modifying them. As argued by Nascimento (2014), digital fabrication technologies are not neutral: they are linked to the social processes in which they are created and used (Pinch/Bijker 1987). The self-building of the digital fabrication technologies attracted a group of people, and associated practices to the lab, skilled enough to engage in these activities. Efforts from some of the fabbers to make the technologies user-friendlier further shaped the design of the technologies and associated socio-technical configurations. With the arrival of newcomers and the mixing with other local groups (such as the local Transition Town initiative), negotiations started to emerge surrounding the usability of the technologies and the purposes of their usage, changing the social-technical configurations of the lab, including its practices and technologies (see Table 2 for a detailed outline of the negotiations associated with the domestication dimensions that raise broader social and environmental issues).

As pointed out by Harwood (2011: 86), "the flexibility in the interpretation of a technology leads to various social groups emerging, each holding their own views about the problems and their solutions." It is, however, not only the emergent social groups that are of interest when thinking about wider socio-technical changes but, in particular, the negotiations between these social groups. In FabLabs, the social groups come together within a physical lab of producing and consuming whilst actively negotiating: first, who is able to use the lab, for instance, mediating between participation, knowledge exchange and user-friendliness and, second, for what purposes should the technologies be used, for instance, mediating between open-source, experimentation, social and environmental practices.

These negotiations reveal the diverse facets of social associations and possible socio-technical configurations associated with digital fabrication technologies. For instance, in relation to providing access to all, the domestication process does not simply draw attention to the binary division between those with or without

access but to the forms of exclusion and inclusion based on the design of the technology and the skills needed to engage with them. Keeping the social groups and aims of the lab diverse seems to be key when wanting to explore wider material pluralities of digital fabrication and their possible configurations that are further discussed in the next section.

Slogans associated with FabLab network	**Wider issues: Acquiring**	**Wider issues: Placing**	**Wider issues: Interpreting**	**Wider issues: Integrating**
How to make almost anything	Why does technology need to be closed, owned and seamless? Why could most technologies not be designed for people to build, hack and fix?	What social, political, cultural and economic roles can grassroots digital fabrication technologies play in current production and consumption systems?	What should be the role of social and environmental issues within grassroots digital fabrications? Will FabLabs move towards intensified consumption?	How can FabLabs empower people to participate and engage in socio-technical developments associated with current production and consumption systems?
Democratising access	Who is represented in FabLabs and is currently participating? Who should participate in developing grassroots digital fabrication technologies? What kind of knowledge and experiences are needed?	How does peer-to-peer networking need to be organised and structured so that anyone can take part? How can these networking possibilities revolutionise current means of producing and consuming to make it more democratic?	What kind of FabLabs could enable widespread participation in sustainable design, production and consumption? How can FabLabs work with local communities to generate conditions for sustainability in society?	What does it mean to design user-friendly grassroots digital fabrication technologies that can be used by all? How can (or not) these user-friendly technologies revolutionise current means of producing and consuming?

Table 2: Negotiations associated with the domestication dimensions raise wider social and environmental issues

Experimenting with socio-technical configurations

The domestication dimensions of digital fabrication technologies within FabLabs make it apparent that these labs blur the boundaries of design, production and consumption. Digital fabrication technologies are built, taken up and used whilst things are designed and produced with them. In the process, these technologies are domesticated into the daily practices of the lab, for instance making them user-friendly, accessible and inclusive. At the same time, they play a part in shaping the routines in the lab through facilitating the conduction of collaborative activities and open-source hardware projects.

The routines are reproduced to make digital fabrication technologies meaningful where in fact design, production and consumption itself can be perceived as a contested terrain. Such negotiations are based on the following questions: Why does technology need to be closed, owned and seamless? Why could most technologies not be designed for people to build, hack and fix them? What social, political, cultural and economic roles can grassroots digital fabrication technologies play in current production and consumption systems? (see Table 2). The negotiations derived from the domestication dimensions demonstrate that different socio-technical configurations (such as open-source design and self-build fabrication technologies) that make up digital fabrication are possible.

Such socio-technical configurations can develop differently within FabLabs, depending on some of the developing aims and outcomes of these negotiations, for instance encouraging entrepreneurship, building community resilience, exploring sustainability issues, experimenting with digital fabrication technologies and facilitating learning by doing within education institutions (Smith/Hielscher/Fressoli 2015). Through the active engagement in these negotiations, grounded in regular interactions with digital fabrication technologies, FabLabs grow to be places where diverse sets of socio-technical configuration of digital fabrication become visible and practiced. Such configurations open up several technological pathways for digital fabrication, including the potential considerations of social, political and environmental goals and alternatives to current mass production and consumption systems.

Some socio-technical configurations have been more readily incorporated and negotiated within the daily practices of a FabLab (such as the use of open source technologies and collaborative working to create self-build technologies) and possibly in larger-scale digital fabrication processes, whereas others (e.g. sustainable design ideas) need to be more actively embedded in the technologies and practices of the labs. A deeper analysis of these dynamics might therefore be necessary to build an understanding of the various user and technology interactions within digital fabrication, that is socio-technical configurations and potential for wider social and environmental changes.

Conclusions

The research questions were: how do the interactions between "fabbers" and digital fabrication technologies play a role in developing workshop practices, and how do they relate to broader social and environmental changes? In seeking answers, the paper drew on concepts from the domestication literature to examine the research questions.

In analysing the interactions between "fabbers" and digital fabrication technologies, the close-knit relationships between them as well as the influence of associated social networks become apparent. Through self-building, adapting and using digital fabrication technologies and creating, for instance, design features and manuals, the technologies are integrated into the day-to-day running of the lab. These activities co-produce ways of working in the workshop and links to social networks associated with open-source ideas. Other ideas, ambitions and practices require more work and experimentation to integrate in the lab. The domestication process is not straightforward. Several tensions emerge when ways of adapting and using digital technologies and associated practices are brought together with other FabLab ambitions, that is providing access to all to make (almost) anything. Several negotiations transpire in which practices and technologies need to be reconfigured and influence the constellations of the social networks.

Such negotiations associated with the interactions between people and technologies might be of interest to scholars working on grassroots digital fabrication workshops for several reasons. First, these negotiations bring to light diverse, possible socio-technical configurations linked to the use and design of digital fabrication technologies and associated practices (which can be easily missed when purely focusing on the diffusion of technologies). Manuals, social networks and design features can encourage and enable certain practices and vice versa. Such diverse configurations of digital fabrication are of particular interest to scholars wanting to investigate or pursue issues of sustainability, peer-production, open source and inclusiveness within wider social and environmental changes (see, for instance, Kohtala/Hyysalo 2015). It might be critical that research on grassroots digital fabrication workshops examines the diversity of socio-technical configurations and how they address social and environmental issues to be able to highlight possible interests and value judgements that give priority to certain digital fabrication practices over others, rather than focusing on single issues (such as sustainability).

Second, an analysis of the negotiations provides key insights into the ways fabbers attempt to materialise their thoughts, ambitions and practices. Although it has been acknowledged that explorations concerned with wider social and environmental goals do not seem to be inherent in digital fabrication technologies (Nascimento 2014), interactions between the technologies and fabbers and associated socio-technical configurations allow for such issues to be problematised. In relation to inclusiveness, the domestication dimensions not simply draw attention to the binary division between those with or without access but to the forms of exclusion

and inclusion based on, for example, the design of the technology (and lab) and the skills needed to get engage with them. The wish and aim to open the FabLab for all is something that needs to be actively integrated into the lab and mediated with other practices. Through materialising and investigating these ambitions, "fabbers" and academics have the potential to draw attention to "forms of exclusion and inclusion" and find socio-technical configurations that address these issues in novel ways.

Further, when thinking about how to provide support to grassroots digital fabrication workshops and engage in their activities as a policymaker, technological developer, and so on, it is important to not only think about pragmatic drivers of how to promote and scale up novel socio-technological innovations developed in workshops, but also recognise them as spaces of experimentation (as similarly argued by Hapnes 1996) as they make negotiations surrounding, for instance, who should get involved in digital fabrication and what should be produced with these technologies visible. These negotiations allow for varying socio-technical configurations and conceptual ideas associated with digital fabrication to develop. They embody varying practices of making and designing, interpretations of digital fabrication, technological designs and ways of acting on questions relating to novel ways of producing and consuming. Such socio-material experimentations, as highlighted by the domestication dimensions, have therefore got an intrinsic value, in particular, when thinking about wider social and environmental ambitions that require early investigations into the possibilities of digital fabrication.

Finally, whilst I have found the domestication approach to be helpful in shedding light on the ways digital fabrication technologies are integrated into FabLabs, the findings show that wider social networks and their activities also play a key role in influencing how technologies are used and adapted in the workshop. Fabbers draw on wider networks (such as the Free Software Movement), associated activities (such as self-assembly of technology practices) and software and hardware repositories (such as GitHub) to domesticate digital fabrication technologies and create practices within their own lab. Future research on domestication could think not only about different settings than the home (Haddon 2007) when progressing the domestication approach but also about the role of wider social networks and their activities in contributing to local domestication processes outside the home.

Acknowledgements

The work was supported by the UK EPSRC through the Centre for Innovation and Energy Demand (CIED; http://cied.ac.uk/; grant number EP/KO11790/1). The author would like to thank the people from FabLab Amersfoort for their participation in this research, Diana Wildschut and Robert Byrne for their valuable comments on an earlier version of this paper, and my colleagues on the project, Adrian Smith and Mariano Fressoli.

List of references

Bakardjieva, Maria (2005): "Domestication Running Wild. From the Moral Economy of the Household to the Mores of Culture." In: Thomas Berker/Maren Hartmann/Yves Punie/Katie Ward (eds.), Domestication of Media and Technologies. Maidenhead: Open University Press, pp. 62–79.

Bausinger, Herman (1984): "Media, Technology and Everyday Life." In: Media, Culture and Society 6(4), pp. 343–352.

Benkler, Yochai/Nissenbaum, Helen (2006): "Commons-based Peer Production and Virtue." In: The Journal of Political Philosophy 14(4), pp. 394–419.

Büching, Corinne (2013): "A Universe of Objects." In: Walter-Herrmann, Julia/Büching, Corinne (eds.), FabLab: Of Machines, Makers and Inventors. Bielefeld: transcript, pp. 105–122.

Douglas, Mary/Isherwood, Baron (1980): The World of Goods: Towards an Anthropology of Consumption. Harmondsworth: Penguin.

"Fab Charter", April 19, 2016 (http://wiki.fablab.is/wiki/Fab_Charter).

Fleischmann, Katja/Hielscher, Sabine/Merritt, Tim (2016): "Making Things in Fab Labs: A Case Study on Sustainability and Co-creation." In: Digital Creativity 27(2), pp. 113–131.

Gershenfeld, Neil (2005): FAB: The Coming Revolution on Your Desktop – From Personal Computers to Personal Fabrication. New York: Basic Books.

Gershenfeld, Neil (2012): "How to Make Almost Anything. The Digital Fabrication Revolution." In: Foreign Affairs 91(6), pp. 42–57.

Haddon, Leslie (2003): "Domestication and Mobile Telephony." In: James Katz (ed.), Machines that Become Us: The Social Context of Personal Communication Technology. New Brunswick: NJ: Transaction Publishers, pp. 43–56.

Haddon, Leslie (2004): "Information and Communication Technologies in Everyday Life: A Concise Introduction and Research Guide." Oxford: Berg.

Haddon, Leslie (2007): "Roger Silverstone's Legacies: Domestication." In: New Media and Society 9(1), pp. 25–32.

Haddon, Leslie (2011): "Domestication Analysis, Objects of Study and the Centrality of Technologies in Everyday Life." In: Canadian Journal of Communication 36(2), pp. 311–323.

Hapnes, Tove (1996): "'Not in their Machines.' How Hackers Transform Computers into Subcultural Artefacts." In: Merete Lie/Knut Holtan Sørensen (eds.), Making Technologies Our Own? Domesticating Technology into Everyday Life. Oslo: Scandinavian University Press, pp. 121–150.

Harwood, Stephen (2011): "The Domestication of Online Technologies by Smaller Businesses and the 'Busy Day.'" In: Information and Organization 21(2), pp. 84–106.

Hielscher, Sabine (2015): "FabLab Amersfoort, De War: An Innovation History." Brighton: Science Policy Research Unit.

Hobson, Dorothy (1980): "Housewives and the Mass Media." In: Stuart Hall et al. (eds.), Culture, Media, Language. London: Taylor and Francis, pp. 93–102.

Hynes, Deirdre/Rommes, Els (2005): "'Fitting the Internet into Our Lives': IT Courses for Disadvantaged Users." In: Thomas Berker/Maren Hartmann/Yves Punie/Katie Ward (eds.), Domestication of Media and Technologies. Maidenhead: Open University Press, pp. 62–79.

Jones, Rhys/Haufe, Patrick/Sells, Edward/Iravani, Pejman/Olliver, Vik/Palmer, Chris/Bowyer, Adrian (2011): "RepRap – The Replicating Rapid Prototype." In: Robotica 29, pp. 177–191.

Kohtala, Cindy/Bosque, Camille (2014): "The Story of MIT-Fablab Norway: Community Embedding of Peer Production." In: Journal of Peer Production p. 5 (http://peerproduction.net/issues/issue-5-shared-machine-shops/peer-reviewed-articles/the-story-of-mit-fablab-norway-community-embedding-of-peer-production).

Kohtala, Cindy/Hyysalo, Sampsa (2015): "Anticipated Environmental Sustainability of Personal Fabrication." In: Journal of Cleaner Production 99, pp. 333–344.

Laegran, Anne (2005): "Escape Vehicles? The Internet and the Automobile in a Local-Global Intersection." In: Nelly Oudshoorn/Trevor Pinch (eds.), How Users Matter. The Co-construction of Users and Technology. Cambridge, MA: MIT Press.

Lally, Elaine (2002): At Home with Computers. Oxford: Berg.

Lie, Merete/Sørensen, Knut Holtan (1996): Making Technology Our Own? Domesticating Technology into Everyday Life. Oslo: Scandinavian University Press.

Lull, James (1988): World Families Watch Televisions. London: Sage.

Maxigas/Troxler, Peter (2014): "Editorial Note: We Now Have the Means of Production, but Where is My Revolution?" In: Journal of Peer Production, 5 (http://peerproduction.net/issues/issue-5-shared-machine-shops/editorial-section/editorial-note-we-now-have-the-means-of-production-but-where-is-my-revolution).

McCracken, Grant (1990): Culture and Consumption: New Approaches to the Symbolic Character of Consumer Goods and Activities, Bloomington: Indiana University Press.

McMeekin, Andrew/Southerton, Dale (2012): "Sustainability Transitions and Final Consumption: Practices and Socio-Technical Systems." In: Technology Analysis & Strategic Management 24(4), pp. 345–361.

Michael, Mike (2000): Reconnecting Culture, Technology and Nature: From Society to Heterogeneity. London: Routledge.

Nascimento, Susana (2014): "Critical Notions of Technology and the Promises of Empowerment in Shared Machine Shops." Journal of Peer Production p. 5 (http://peerproduction.net/issues/issue-5-shared-machine-shops/editorial-section/critical-notions-of-technology-and-the-promises-of-empowerment-in-shared-machine-shops).

Oudshoorn, Nelly/Pinch, Trevor (eds.) (2005): How Users Matter. The Co-construction of Users and Technology. Cambridge, MA: MIT Press.

Pearce, Joshua M./Morris Blair, Christine/Laciak, Kirsten J./Andrews, Rob/Nosrat, Amir/Zelenika-Zovko, Ivana (2010): "3D Printing of Open Source Appropriate Technologies for Self-directed Sustainable Development." In: Journal of Sustainable Development 3(4), pp. 17–29.

Pinch, Trevor/Bijker, Wiebke (1987): "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other." In: Wiebke Bijker/Thomas Hughes/Trevor Pinch (eds.), The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology. Cambridge, MA: MIT Press, pp. 17–50.

Schor, Juliet (2010): Plenitude: The New Economics of True Wealth. New York: Penguin Press HC.

Seyfang, Gill/Smith, Adrian (2007): "Grassroots Innovations for Sustainable Development: Towards a New Research and Policy Agenda." In: Environmental Politics 16(4), pp. 584–683.

Silverstone, Roger/Haddon, Leslie (1996): "Design and the Domestication of Information and Communication Technologies: Technical Change and Everyday Life." In: Roger Silverstone/Robin Mansell (eds.), Communication by Design: The Politics of Information and Communication Technologies. Oxford: Oxford University Press, pp. 44–74.

Silverstone, Roger/Hirsch, Eric/Morley, David (1992): Information and Communication Technologies and the Moral Economy of the Household. In: Roger Silverstone/Eric Hirsch (eds.), Consuming Technologies: Media and Information in Domestication Spaces. London: Routledge, pp. 15–31.

Smith, Adrian/Hielscher, Sabine/Dickel, Sascha/Söderberg, Johan/van Oost, Ellen (2013): "Grassroots Digital Fabrication and Makerspaces: Reconfiguring, Relocating and Recalibrating Innovation?" In: SPRU Working Paper, Brighton: University of Sussex.

Smith, Adrian/Hielscher, Sabine/Fressoli, Mariano (2015): "Transformative Social Innovation Narrative: Fablabs." In: TRANSIT: EU SHH.2013.3.2–1 Grant agreement no: 613169.

Söderberg, Johan (2013): "Automating Amateurs in the 3D Printing Community: Connecting the Dots between 'Deskilling' and 'User-friendliness.'" In: Work Organisation, Labour and Globalisation 7(1), pp. 124–139.

Sørensen, Knut Holtan (1994): "Technology in Use: Two Essays in the Domestication of Artefacts." In: STS Working Papers 2/94, Trondheim, Norway: Senter for Teknologi og Samfunn.

Sørensen, Knut Holtan et al. (2006) (eds.): Domestication Of Media And Technology. Berkshire: Open University Press.

Sørensen, Knut Holtan/Aune, Margrethe/Hatling, Morten (2000): "Against Linearity: On the Cultural Appropriation of Science and Technology." In: Meinolf Dierkes/Claudia von Grote (eds.), Between Understanding and Trust – The Public, Science and Technology. Amsterdam: Harwood Academic, pp. 240, 241.

Troxler, Peter/Zijp, Harmen (2013): "A Next Step Towards FabML: A Narrative for Knowledge Sharing Use Cases in Fab Labs." Paper presented at the Fab9 Research Stream, Yokohama, Japan, August 24 2013.

Walter-Herrmann, Julia/Büching, Corinne (2013): FabLab: Of Machines, Makers and Inventors. Bielefeld: transcript.

Ward, Katie (2005): "Internet Consumption in Ireland – Towards a 'Connected' Life." In: Roger Silverstone (ed.), Media, Technology and Everyday Life in Europe. Aldershot: Ashgate, pp. 107–123.