The Future of Places for Production – Probing Into Domestic 3D-Printing

Oliver Stickel

Univ. of Siegen, Germany oliver.stickel@uni-siegen.de

Liga Letina

CUBE Systems liga.letina@gmail.com

Maarja Mõtus

Estonian Academy of Arts maarjam@gmail.com

Abstract

We propose a design for an experimental study into how digital fabrication technologies - exemplified by 3d printing - might affect the domestic space and change the home (back) into a place for selective production, empowering users. As the means for this futuring effort, we describe a very open initial field study in which 3d-printers and accompanying design probes are deployed into 10 households for six weeks after which, based on the probe returns as well as data from interviews and observations, a more narrowed down long-term study would be planned.

Artis Rams

Kairi Osula

kairio@tlu.ee

University of Latvia

contact@artisrams.com

Tallinn University, Estonia

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Introduction

This short paper is the result of a group project during the course on research methods in HCI during Tallinn Summer School 2014. The topics for the group projects were guite broad, ours ending up being Space, Place, Threshold [16], encouraging us to work on the domestic space, associated practices and the related emerging or future changes with a focus on HCI. Our group decided to concentrate on Making and related digital fabrication technologies in the home (see Fig. 1) and to design a study around this topic. The reason behind our choice is this: Digital fabrication technologies like 3d printing carry in them the opportunity to transform the home (back) into a place of production, potentially liberating and democratizing certain aspects of the production and consumption of consumer goods like replacement or spare parts, household goods, customized objects as well as opening up new avenues for co-creativity and collaboration in the home as well as transcending it. In this sense, such technologies can change certain thresholds separating the home from the professional or industrial world outside, much like the Personal Computer did for the purely digital domain in what we now call the *Digital Revolution*. We argue that *now* is the time to inquire in such trends due to the rapid development in (personal) digital fabrication technologies which become more and more affordable



and end-user friendly as well as the increased mindshare of such technologies, especially 3d-printing, in the non-geeky realms due to increasing coverage in mass media publications. For the operationalization of such an inquiry, we argue for a qualitative, probebased approach spread over a broad range of households since there has been a very limited body of scientific work in this sector up until now. In the following sections, we will give a brief overview about the related state of the art, 3d printing and our reasoning behind choosing this technology, subsequently going more into detail about our actual study design, the proposed probe and concluding with a brief reflection and outlook.

Fig. 1: Sketch: 3d printer in the home State of the Art

While of course Do-It-Yourself (DIY) has been around for a long time, it has gained a significant amount of traction in recent years in private and semi-professional environments [6] labeled as *Making*, mainly through the accessibility of digital fabrication technologies which enable people with a relatively small amount of formal training to design, modify, make, anr/or share even complex objects [13]. This trend also seems to gain traction in a huge variety of fields, ranging from education [1] up to DIY-Biology [7]. Making is also growing as a field for study: Neil Gershenfeld, the founder of the first Fab Lab / Makerspace continues to emphasize the importance of Making and the opportunity of the Maker scene to disrupt the way production and consumption works in modern society (namely, with a focus on mass-production) and empower the consumer through access to personal production, replication and customization [3,4]. Since amateur / semi-professional digital fabrication nowadays is often associated with dedicated

organizations like Makerspaces, these spaces are also being researched as innovation incubators as well as regarding their social, material and economic practices and impacts [e.g. 4]. There is also ongoing investigation into appropriation processes regarding digital fabrication technologies and community forming around it [10]. Interestingly, this also led to tentative insights into how digital fabrication technologies might serve as boundary negotiating artifacts to form and/or foster communities, creativity and conversation in more private spaces [11].

However, there is a gap in research regarding exploratory empirical work into how digital fabrication might affect actual end-users at home which is an important domain given the long-term perspective of pioneers like Gershenfeld [3] who predict widespread personal fabrication at home in the future. The lack of research in this specific domain might be attributed to the very rapid developments in recent years as well as the changing landscape in available machinery as we will explain in more depth in the next section.

Digital Fabrication and 3d printing

"The revolution is not additive versus subtractive manufacturing; it is the ability to turn data into things and things into data." [4]

This quote captures digital fabrication in its core: It is about being able to produce items from digital representations by – essentially – simply pushing a button (and vice versa, if necessary). It also captures one other central aspect: Digital fabrication is not just about additive production technologies like 3d-printing but also about CNC-Milling, Laser-Cutting or even computer-controlled knitting. Through the expiration of certain patents and recent interest from the DIY community which subsequently also made the jump to the industry, 3d printing merely emerged as the flagship technology for amateur or semi-professional digital fabrication for now. Through this trend, 3dprinters undergo guite rapid developments and constantly drop in price – as of mid-2014, we can buy 3d-printers for about 300 USD and there are crowdfunding campaigns for even cheaper machines, undercutting the 300 USD mark, making it very affordable. Coverage in mass media [e.g. 5] is also steadily on the rise, spreading mindshare about this technology and its implications. Furthermore, we now see initiatives to make the erstwhile rather intimidating looking 3d-printers – think lots of open gears, hot parts, open wiring and complex software – more approachable, e.g. by hiding a lot of the "raw" technology, creating more streamlined, UX-centered control software as well as a focus on the device's aesthetics. One might point at the "hacky" RepRap Mendel [14] vs. the streamlined Mod-T [15] to illustrate this development. So, while the technologies still have their kinks and are far from perfectly adapted for endusers, we argue that we are now at the point for scientific inquiries *in the wild* as to what actually happens after introducing 3d printing technologies (as the spearhead for digital production) into the home, how it changes the practices and values associated with the domestic space and if and how it might foster new forms of (trans-) domestic collaboration and communication.

Study Design

To inquire into the issues explained above, we propose a cultural probe study [2] with certain elements inspired by Experience Sampling (ESM) [8]: We are intending to introduce household size, i.e. roughly 20*20*20cm printing area, 3d printers into 10 different households with different demography. The printers would be accompanied by a Probe Kit (described below) to playfully engage the users and foster documentation and ESM would be used to remind participants to utilize the probe components which would be intended to capture as much situated context as possible about how participants use the printer and how it might change practices and values associated with the home. A help-line for technical questions or errors would be available throughout the study.

The study duration would be limited to six weeks for the first phase (with four interviews / observations during this phase), subsequent deeper analysis would follow, after which would be decided if / how to proceed in the long-term.

Method rationale

Cultural Probes [2] are engaging, playful packages comprised of different instruments - e.g. postcards, diaries or cameras – which are intended to be used and filled out by the participants in order to elicit a rich set of materials. Those materials can then be used by researchers / designers in order to find inspiration and deeper understanding of the use context -"inspirational data", als Gaver et al. [2] put it. Such an engaging and more playful or provocative tool seems like a good fit with 3d printing which also seems to be associated with a lot of playfulness [10] as well as the - for now - very open field we intend to explore. ESM [8] on the other hand is basically a way to ask participants at regular intervals or specific events to fill out some sort of diary or diary-like structure by way of a beeper or similar instrument. In our case, we would

adapt it to encourage the participants to engage with the probe (see below) whenever they activate the 3dprinter in an attempt to foster continuous participation.

As a whole, methodologically, our study is designed to be very open, explorative and, hence, qualitative. However, this might change in later phases (see *Timeline*) – should we be able to work out categories and more detailed impulses or directions for digital manufacturing in domestic spaces, the development of quantitative, broader research methods based on those results might be very relevant given the anticipation of widespread domestic digital fabrication as well as its impact at some point in the future.

Participants

We propose to carry out our study in a country with high technology adoption (e.g. the Netherlands) since the intention is to glimpse as far in digital making at home as possible. However, we do not intend to work with very early adopters or experts with assumed heavy preconceptions (e.g. Industrial Designers, Hackers) – such characteristics hence form exclusion criteria. Given the very broad anticipation of widespread domestic digital fabrication, our proposition entails participants from: Single households, shared living, young couples without children, families with children and student households. We suggest two households of each category (in case some participants don't return probe material).

Timeline and method

We suggest this as a basic timeline for the study:

Before: Recruitment, including brief interviews to match participants to the criteria above.

Day 1: Introductory workshop in situ at the homes intended to introduce the 3d printers, answer open questions by the participants as well as give the researchers insight into the households and their characteristics by way of interviews. Subsequently, participants are free to use the printer as they wish for the first week.

After Week 1: In-Situ interviews after the initial novelty and appropriation phase.

After Week 4: In-Situ interviews to inquire into possible change as well as to check in on the participants. After Week 6: Collection of the probe returns. Subsequent preliminary analysis, then probe artifactsupported in-depth interviews based on the first analysis and subsequent in-depth analysis. Long-term: Based on the results of the first six weeks, informed decisions about if and how to approach the topic on a long-term basis (e.g. simply extending the open study or narrowing it down to certain categories found in the data) would be made.

During the whole time, based on the workshops, interviews, helpline data as well as the later probe analyses, we suggest building up a Grounded Theory [12] of domestic digital fabrication since there is no such theory as of now which is why the application of a "deep", data-driven method seems very appropriate.

Ethics

Our study would necessitate no deception, invasive procedures or other highly critical ethics aspects. The participants can and should be fully informed, briefed and informed consent can be given. Data like photographs or artifacts are created by the participants, can be reviewed by them and either handed back to the researcher or not. One more critical







Fig. 2: Probe Sketch

aspect arises in case of the participant families with children. However, since the children are under the care of their fully informed parents, the final decision as to how to involve them falls to them – however, during all phases we as researchers would have an ethical obligation to pay special attention to the children as well as the related data.

Probe Description

Our probe is intended to be engaging as well as to foster engagement and documentation of this engagement with the 3d printer. To achieve this, we propose the following components (see also Fig. 2):

3d printer

This obviously has to be the centerpiece. We hesitate to point at a specific model because the market is constantly changing but it would probably have a build envelope of roughly 20*20*20cm with the device itself being roughly similar to a bigger microwave oven. The model should be streamlined, as user-friendly and as simple as possible. The same goes for the accompanying control software which, for the study would be installed on the available IT infrastructure in the respective home which is why the 3d printer should be WiFi-enabled. An ample supply of consumable material (probably PLA plastic) should also be supplied.

3d scanner

To give users the option to replicate items, e.g. broken household spare parts, a 3d scanner should be included in the kit. Ideally, this would be tightly integrated into the 3d printer, maybe even on a hardware basis so that the printer also can function as a scanner. This would depend on available hardware on the market at the time of this study. A disjointed, highly technical UX of 3d scanning like at the time of writing is, however, not desirable and if no more user-friendly device is on the market, one might consider not including a 3d scanner into the kit at this point.

3d printer manual

A playful, easy to understand manual for the printer for reference purposes. This manual should be designed or at least expanded on by the researchers themselves in order to connect it in its style, rhetoric and depictions to the rest of the probe.

Fact-Sheet about the study

A brief overview (e.g. as a poster) about why we are conducting the study (briefing) with encouragements to capture whatever the participants deemed important around having and using the 3d printer at home. Like the manual, this should be designed to be connected with the rest of the probe. Emphasis also has to be placed on the fact that there are no "errors" or "failures" – if some participants will not like the printer or just not use it, this is a result, too.

Sample prints

A set of multiple sample 3d prints (e.g. drawer handles, Lego-like toys or customized smartphone cases), accompanied by fact-sheets are intended to serve as inspiration and tangible objects to spark discussion.

Software package

The software package (loaded onto a thumbdrive with a 3d-printed, customized cover) would be composed of the 3d printer control software as well as very easy entry-level 3d-modeling tools (from experience, we suggest CubeTeam and TinkerCAD), each accompanied by a brief manual in case the participants wish to

engage in 3d-modeling themselves and not just use / modify / customize pre-existing 3d models. This also should be accompanied by links to digital fabrication repositories like Thingiverse.com where such models can be downloaded, shared or even modified for free.

Smartphone

Smartphones for the household members with an accompanying diary-like app (similar to DayOne on iOS) which enables textual as well as media-enriched entries about domestic 3d printing are one form of documentation we would like to make available to our participants. The phone would also be the device to send out ESM-motivated notifications to please document anything relevant if the 3d-printer is switched on - since all those devices are connected to the home WiFi, technically, this is guite feasible. Similar reminders could be sent out in case no printing has taken place in a specified amount of time. The smartphone can be replaced by just the app if household members want to use their own phone. The diary app should include short suggestions on what to capture, e.g. the printing process itself, persons who gather around the printer, the preparation of the model or the surroundings.

Printer's guestbook

A journal-like book in which participants who are not keen on ore able to document everything via phone can use more traditional media. Given the apparent crowdforming effects of 3d printers, guests also could leave their impressions here. Similar suggestions as in the app should be included.

Polaroid

Similar to the reasoning behind the guestbook, a polaroid enables non-smartphone based picture taking as well as annotating, scrapbooking (e.g. in the guestbook), etc.

Reflection and Outlook

With our proposed study, we plan to explore the chances, opportunities, emerging practices and possible disruptions of domestic digital fabrication by utilizing 3d printing as its spearhead technology. One might argue that such a very open study design might not be focused enough. We would argue that there simply is not enough data as of now to do anything else – of course experts have argued about the possible impacts of domestic digital fabrication for a few years now but that can never be a complete substitute for actually doing fieldwork with participants without as many preconceptions, professional involvement or other factors in stake. A further argument might be made regarding the question if such technologies are actually ready for mass-market domestic deployment. To this, we would answer that as of mid-2014, they are probably not completely ready – but they are developing in this direction *very*, *very quickly* which is why now is the time to plan such a study as ours and to carry it out as a means for short-term futuring, to base further design implications on as well as to foster preparation for the possible impacts of domestic digital fabrication on economic, political, power, educational and of course the domestic domains.

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