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From the Makerspace to the Web: Creating Knowledge Resources from Fabrication Activities

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ABSTRACT

This paper presents an overview of the research I am conducting as part of my PhD studies. The goal of my research is to describe and better understand the barriers to the creation and reuse of fabrication knowledge resources and to explore technological interventions to remove these barriers.

CCS CONCEPTS

• **Human-centered computing** → **HCI theory, concepts and models**;

KEYWORDS

fabrication, documentation, tutorial, portfolio, workshop, maker culture, DIY

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1 RESEARCH SITUATION

I am a PhD student at Sorbonne Université, Paris and I just finished my 2nd year on a 3.5 years funded PhD program, under the supervision of Yvonne Jansen and Gilles Bailly. I work in close relationship with the Sorbonne's Fablab as I give courses and workshops there.

In my research, I am interested in the creation and reuse of fabrication knowledge resources in makerspaces. However, due to the pandemic, places like these had to close, which made it difficult to study the topic in the field. For the last 2 years, I instead focused on aspects that can be studied from afar, adopting a more holistic approach on the topic of fabrication knowledge by conducting online studies, analysing literature from the domain, and building prototypes at home. On my last year, now that the places are opened again, I plan to study the behaviours and workflows of makers in the fabrication workshops regarding the creation and reuse of knowledge resources by designing and evaluating new tools informed by my previous research and results.

From attending the Graduate Student Consortium at TEI'22, I hope to get senior advice on my current work approaches and directions, to benefit from researchers and designers experiences

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and perhaps raise discussions on how technology, data, automation, and the peculiar case of fabrication workshops can get along.

2 CONTEXT AND MOTIVATION

Makerspaces and more generally fabrication workshops are places that gather people around machines, tools and materials to design, build, repair, prototype and invent things [6]. In parallel of the different projects and activities happening inside these places, makers create, share, search and use knowledge about fabrication methods, tips, techniques and previous DIY projects [14]. These knowledge exchanges happen directly when people talk, share tips between each others, get curious about one's project. But a big part, however, happens indirectly, often digitally by the mean of project documentations, portfolios, social networks or tutorials, or when makers leave traces for themselves to reuse later [33]. Creating and using a fabrication knowledge resource is a complex activity. It takes place in parallel of a fabrication activity, happening before, during and after a project, while the maker can be in different places inside or outside the workshop. The knowledge resources can be of different forms and consequently require the use of different tools to capture, edit, transmit and use or display the resource.

Therefore, providing tools to support makers during this whole process is crucial. While a number of systems and tools have been already proposed to support makers in specific situations, there are still many situations where these tools are not well adapted. Indeed, there is a wide variety of activities happening in a space like fabrication workshops and different reasons and manners to create content about a fabrication project. It remains a challenge to propose approaches generic enough yet effective to realistically be considered as a widely fitting solution to support all makers. The goal of my project is to study this thematic of knowledge about fabrication and DIY activities, by focusing on how it happens inside the fabrication workshop. I intend to understand the ways makers work in these places, their methods and objectives for producing and using knowledge and to explore which approaches could fit the peculiar space of fabrication workshop. This would help with the process of leaving traces of one's work, support the creation and sharing of knowledge and bring back existing knowledge inside the place. To do this, I consider the variety of profiles of makers and the different kind of activities they can do in a fabrication workshop, as well as the whole set of reasons for creating and using fabrication and DIY knowledge.

3 BACKGROUND AND RELATED WORK

3.1 Understanding DIY knowledge and makers

With the wide availability of internet access, DIY culture has taken a new dimension with people forming communities on forums to

exchange tips and hacks online [6, 14]. Today, people share their DIY projects on their personal websites, on dedicated platforms such as *Instructables* and on social networks, with a variety of motivations such as enabling others to reuse these resources to get inspired, apply some parts of an idea to their own project or reproduce a method or an object [14, 15, 20, 24, 29]. More generally, makers create knowledge resources about their fabrication projects to keep track of their work for themselves [21, 33], or to share a technique or a method with others. Their motivations can be altruistic as part of the philosophy of open knowledge, to gain recognition, visibility and feedback from peers, or to gain money [13, 15, 18, 25]. Sometimes, the fabrication places can demand that makers produce knowledge from their projects as a support of learning or to enable assessment [4, 5, 11, 23], or because it's part of the policy of the place, for example in the case of Fablabs [7]. However, producing knowledge resources from one's physical activity is not a easy task. During the fabrication, it requires to switch focus from the actual work to the knowledge capture, and thus is costly and can be forgotten [33]. In addition, while working, makers are busy with their hands and it can be difficult to hold a camera to take a picture or a video [2]. The process of creating knowledge support also happens after the activity, and makers have to retrieve their content, use many tools to edit and to author a support that will be reusable by themselves or others [29]. Due to these difficulties, the resulting resource can lack details or quality, making it difficult to reuse for reproducing a method [31]. Sometimes they do not include the different attempts that are important to get feedback along the project [29] in some contexts or even not made at all [33].

3.2 Designing for DIY knowledge and makers

Different approaches have been explored to support makers when creating knowledge resources. Some of them focus on integrating the gathering of content during the activity, for example in the case of assembly. Some systems tend to automate the capture of the fabrication process by the mean of sensors on the pieces [28], computer vision [10], or augmented reality to author tutorials [32]. However, these approaches are very specific to the material used. For example, it would be difficult to use the same approaches with activities for which the objects are unknown, and imply more complex manipulations such as soldering or doing circuitry on a breadboard. Some systems are aimed to be installed as "documentation stations" inside the workshop, providing cameras to capture an object [12, 27], a series of steps [30], or include a modular toolkit to take pictures and videos from different angles [9]. These approaches have the advantage of freeing the hands of the maker and to make the knowledge capture less inclined to be forgotten, but these solutions are limited to rather small objects or workbench activities. Other systems imply to equip the maker with sensors to capture or recognize the activity [16, 22] or even the expertise of the maker [8], or with head mounted cameras to capture from the first person point of view [3]. If not questioning the invasive and privacy aspects of those approaches, equipping all the makers in the space with such systems can be very expensive and maybe not suited to many fabrication workshops. Producing knowledge resources happen during a whole project that can often take weeks or months, and some approaches developed tools aimed to facilitate the integration of the captured

content inside a document, automating some parts of the editing process [17], enabling feedback along the project [26] or generating step by step web-based documents or videos [3]. These approaches are promising but often limit the maker to the use of the platform itself, although they might want to publish their work in different platforms, already popular among a particular community [19].

3.3 Discussion and positioning

We saw in the previous section that researchers have gone a long way studying the phenomena of knowledge creation and sharing in the context of fabrication, identifying problems at different levels and providing approaches to support makers confronted to these problems. However, it appears that much of the approaches and systems I found in literature tend to focus on a specific community of practices (such as crafters, hobbyists, electronics, learners...), on a specific kind of activity (3d printing, assembly,...), or a specific kind of purpose in knowledge creation (tutorials, assessment portfolios, project documentation). While these approaches may address the issues found in the specific context in which they were developed, they are difficult to generalize to more generic forms.

People do a broad range of different activities in the workshop going from soldering, to programming, computer aided design, ceramics, to laser cutting. During their journey, they can move a lot, changing from a workstation to the other, sometimes dealing with messy environments or having their hand dirty. This can impact their way to interact with the tools they use to create content while working. Moreover, the activities themselves can lead to different approaches regarding the type of content to capture, for example sometimes video is the best way to illustrate a process rather than pictures [2]. Makers may not use the same tools to capture small manipulations on a workbench and painting a table. Some work have been exploring the way workshop are physically organised [1] and the impact of object size on the best way point of view from which to capture visual content [3]. The vast majority of the tools to support knowledge creation inside the workshop tend however to focus on a specific kind of fabrication activity or context. In addition, some of these systems make use of technologies that might be expensive, or maybe make people feel uncomfortable or invading their privacy. I think that literature is missing a closer look on how people actually capture content or make records depending on the activities they are doing in the workshop, and that an analysis of the different aspects that matter when capturing or recording might help designing better systems.

On a higher level, I found a lot of published articles studying habits and designing tools for knowledge resources, but most of them are focusing on specific cases of fabrication knowledge resources like tutorials, documentations, portfolios. Makers can have different objectives to create and use knowledge resources, and depending on the reasons to make a support, the way to build it and then reuse it might differ. Most of the systems to support makers acknowledge issues regarding one specific objective for creating knowledge resources but are not suited for other purposes. Also, I found that a big part of the systems aimed to support makers on knowledge creation are not made to be used for other purposes. At the end, all of these knowledge resources have in common that they are a representation of a fabrication activity and have at some point

to be made inside the workshop, leading to overlapping challenges for the makers. I think that by better understanding the objectives of the different knowledge resources and identifying the challenges related to them we can inform the design of better systems for fabrication workshops.

4 THESIS STATEMENT

Exploring the habits and providing tools generic enough inside the workshop to fit different activities and purposes in knowledge creation might lead to more effective approaches for the work of all makers, and help them to create richer and more reusable content and resources. From that statement I highlighted 4 research questions that I am exploring during my PhD.

- Which tools and media makers use currently when they capture their work and how does this vary across activities?
- What are the objectives and challenges when creating and using fabrication knowledge resources?
- What are the different dimensions to consider when designing systems to capture content from fabrication activities?
- What kinds of properties of a system influence the practices in the creation of knowledge resources in fabrication workshops ?

5 DISSERTATION STATUS

To explore these questions, I have adopted different methodologies including an online study, a literature survey, a framework, and the design of a prototype. The projects summarized in subsection 5.1, subsection 5.2 and subsection 5.3 are currently under review for publication.

5.1 Which tools and media makers use currently when they capture their work and how does this vary across activities?

In 2021, we ran an online study resulting in 60 responses among makers from all around the world. The purpose of this questionnaire was twofold. The first part was made of 19 questions aimed to gather insights from the current habits of makers when capturing content while working inside a makerspace. Participants had first to pick the activities they are used to do in a workshop (woodworking, CAD, 3D printing, ...) and were asked about general habits regarding documenting. They were then asked questions about the two activities they create the most frequently content from and asked about the tools, habits, advantages and problems they could encounter while capturing content while doing these activities. Results showed for instance that makers will create different kinds of records depending on the activity they do, as shown in [Figure 1].

5.2 What are the objectives and challenges when creating and using fabrication knowledge resources?

To explore this question, we made a literature survey and extracted the objectives and challenges associated with knowledge resources in fabrication workshops. Through an analysis of the different types of knowledge resources, we identified 4 objectives [Figure 2]:

- Represent a fabrication project, which is common to all

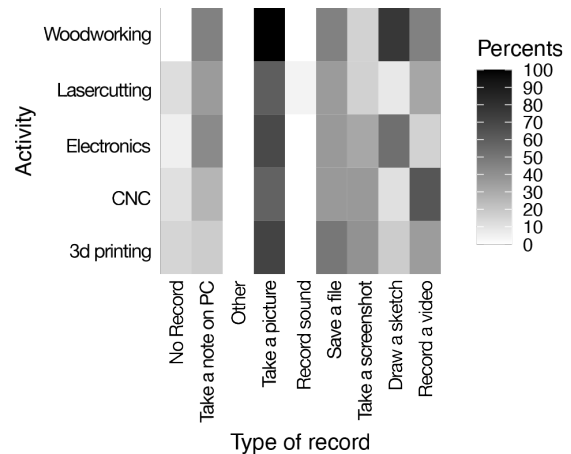


Figure 1: We ran an online survey resulting in 60 responses to better understand the practices of makers when capturing or recording content while doing different activities in the fabrication workshop. This visualisation illustrates responses to the question what kind of records participants generated depending on fabrication activity.

- Allow the reuse of one’s work
- Support reflection
- Communicate and showcase one’s work

For each of these objectives, we extracted the main challenges faced by makers. Finally, we discussed how to use these objectives and challenges as a framework for designing and/or evaluating technologies for creating knowledge resources.

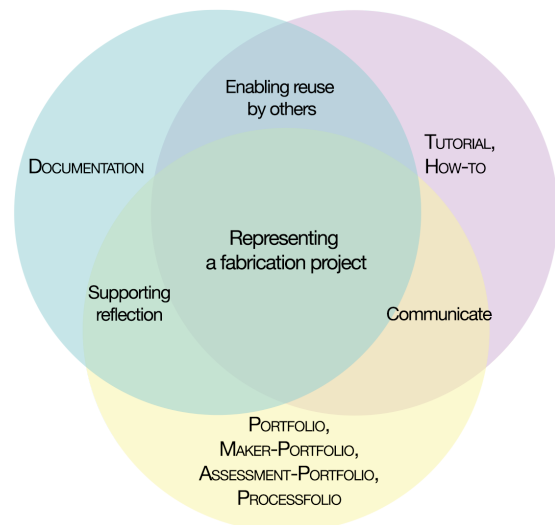


Figure 2: This graph shows how the creation of knowledge resources can be understood as Objectives instead of Terminologies.

5.3 What are the different dimensions to consider when designing systems to capture content from fabrication activities?

We explored these questions with two approaches. First, we identified different dimensions describing the capture of fabrication related content from literature, and provided a framework to illustrate these dimensions. We made our analysis with the 5W+H, enabling us to describe the capture of content according to:

- **Why:** the different reasons to capture content
- **What:** the kind of data to capture, such as images, videos, sound, contextual information or metadata
- **How:** the devices or sensors used to capture
- **When:** the moment when the capture is made, before when planning or sketching, during the activity or after.
- **Where:** the location from which to capture (user attached, environment or tool)
- **Who:** The degree of automation of the capture control

Based on the dimensions we had identified, we created a concept of modular actuated units based on connected cameras that we illustrated with sketches and animations in a video [Figure 3]. This concept is a fleet of cameras that are connected to a local repository and offer different options, enabling the mobility of the maker or not by being worn on the head or being fixed on the machine and offering different options such as tracking and following a tool.

On a second part of the previously mentioned online study (subsection 5.1), we showed the video to participants and asked them feedback about it. The second part of the questionnaire was made of 19 questions including some focused on one specific activity (the one participants said creating the most frequently visual content about). This work was made during the quarantine episode, making it impossible for us to make a real evaluation of a set of prototypes in situ. However, results and feedbacks from participants were useful as a formative study, informing the design of a prototype that would come later.

5.4 What kinds of properties of a system influence the practices in the creation of knowledge resources in fabrication workshops?

On my last 1.5 year, I plan to refine and elaborate my prototypes mentioned in subsection 5.3 for capturing content from fabrication activities based on the insights I gathered from the online formative study [Figure 4]. Then I will explore the impact of this system on the makers workflow by installing it in my local Fablab, and maybe offer a new tool for fabrication workshops and designers. To do that, I plan to run interviews among makers willing to use the system during their projects to gather feedback on their experiences alongside weekly observations of the makers inside the Fablab with the system in place. I will as well interview managers of the workshop to gather their opinion on such a system inside their place. In addition, if possible, I would try to measure the impact of such a system on the knowledge resources by comparing the ones made with and without the system. Ideally, I would compare them according to the different objectives and challenges I identified in subsection 5.2.

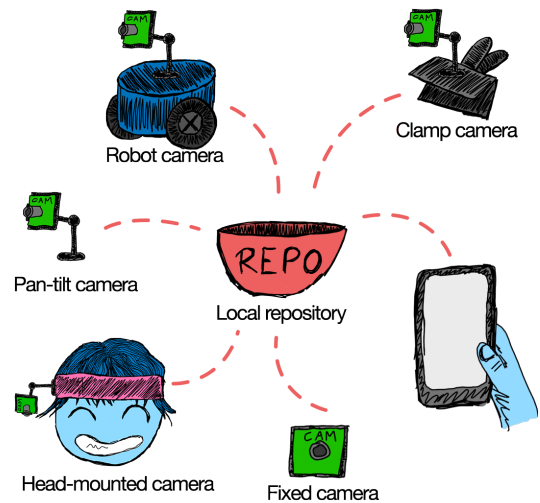


Figure 3: A design concept based on a fleet of actuated units based on connected cameras was inspired from the different dimensions of our framework to capture visual content from a variety of activities and situations.

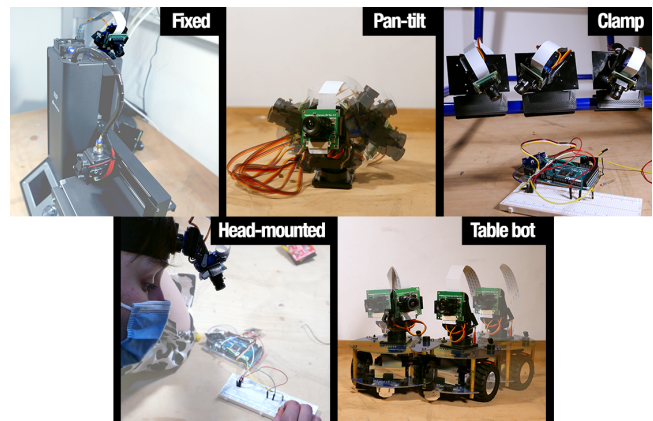


Figure 4: A first generation of prototypes inspired by our design of connected camera-based units is intended to be evaluated with a user study in the field

6 CONCLUSION

In my work, I study the creation and reuse of fabrication knowledge resources, by better understanding 1) the objectives of makers in the creation and use of fabrication knowledge resources, 2) their habits and difficulties when creating these resources and 3) how these habits and difficulties can vary across situations such as activities or fabrication workshops. By doing that, I intend to understand which properties of a system aimed to be installed in a fabrication workshop would succeed in helping and supporting makers in the creation of knowledge resources.

I'm hoping that this article will generate discussions around the different objectives behind fabrication knowledge resources

and provide feedback on the general approach. I'm also hoping to raise discussions around automation, the impact and suitability of technology inside the peculiar space of fabrication workshops.

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