First Steps in the FabLab: Experiences Engaging Children

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ABSTRACT
Fabrication Laboratories (FabLabs) all over the world aim to provide widespread access to computer controlled machines for personal fabrication. However while they are enjoying increasing popularity worldwide, there is little understanding of children's interactions with technologies in FabLabs and how to support them. In this paper, we reflect on our experiences running five out-of-school workshops in the Vienna FabLab over the period of half a year with 50 children aged 10 to 14 years old. We introduce the workshop activities and trace how children's assumptions developed throughout the workshop towards the technologies. The insight gained from this work is a valuable first step for future developments engaging children with digital fabrication technologies.

Author Keywords
Children, Digital Fabrication, FabLab, Technological Literacy

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K.3.1 [Computers and Education]: Miscellaneous – Computer literacy;

INTRODUCTION
We are living in a world increasingly shaped by technological procedures and digital devices. In order to actively participate in such a world, we increasingly need to be able to both understand and to use these technologies confidently and competently. The advent of Fabrication Laboratories (short: FabLab) opens up the possibilities for engaging in the production of these technologies directly, making the equipment and materials for such digital fabrication available beyond the borders of a few highly specialized companies and research institutions and putting them into the hands of the general public. In doing so, it is hoped that a widespread, diverse and personally relevant creation and use of technology can be fostered (Gershenfeld, 2005; FabLab FAQ, 2012).

Children and young adults thus form a very special target group among FabLab users; at the same time they often have different needs than older students, adults or professionals using the laboratory's infrastructure. While learning in a FabLab is mostly peer-to-peer based and building on the ideas or interests people bring to the lab, this approach is applicable only to a limited degree to children. They often are completely new to the lab and presented technologies, and do not have any prior knowledge about the infrastructure, machines or what they could eventually do with them.

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To date research and literature about children's work in FabLabs is limited and mostly focusing on learning outcomes related to school curricula (Dlodlo and Beyers, 2009). Children's engagement at the pre-high school age is particularly underrepresented. Studies have shown though that experiences made at this stage have an especially important impact on future careers (Maltese and Tai, 2011).

In this paper we report on out-of-school workshops in a FabLab that we developed and ran for children aged 10 to 14 years old. We wanted to create a setting not specifically associated with the school curriculum, but open for children to explore the FabLab potentials across disciplines.

Our focus is on the use of generally available software programs and machines in the FabLab, and providing an introduction to the lab's core capabilities: two- and three-dimensional design and creation, electronics and programming. The aim was for children to get an overview of both the potential and challenges of the technologies and to be able to use them in a technically and creatively challenging way for the creation of personally relevant artefacts over the duration of the course. We observed the children's exposure to the introduced technologies and analysed their activities and evolving assumptions as basis for future work in the field.

BACKGROUND
The concept of FabLabs, as coined by Neil Gershenfeld at the Massachusetts Institute of Technology, has spread out to public spaces in urban and rural areas all over the world - spanning a network of over 100 listed labs. All of them share core capabilities in order to realize projects. This includes: computer-controlled machines such as laser cutter, milling machines and sign cutter, 3D printing devices, as well as electronic workspaces and necessary programming tools. Comprised under the name of digital fabrication, they create material objects from digital files and together with consumable materials they form an infrastructure to "make (almost) anything" (Gershenfeld, 2005). This has been made possible within the last few years because the capabilities of digital fabrication tools have been increasing as their cost decreases, making certain models available to individuals or small communities (Mota, 2011).

Accompanying this, there is increasing interest in providing access to digital fabrication technologies in educational contexts, for example through libraries, museum, and in schools (Posch et al. 2010, Eisenberg and Buechley, 2008). Research in adjacent fields has shown, that providing a setting that allows children to work with new technologies according to their personal interests is crucial for engaging experiences that they can relate to their everyday life (Blikstein 2008, Katterfeld et al. 2009). However, while there is evidence of individual projects that children were able to realize in a FabLab setting (Mandavilli 2006), there is little general understanding of children's interactions and expectations around such technologies.

OVERVIEW OF THE WORKSHOP

In order to study children's activities and assumptions about FabLabs and technologies, we invited them to come to the lab for a two-day long workshop. In total five workshops were held. Observation of the children during their work, analysis of the artefacts created and a questionnaire filled out at the end of the workshop are the basis for an exploratory research study into the development of their practical experiences and assumptions while at the FabLab. We see this as a first approach to identify dominant aspects of children's activities at the lab and inform future research in the field.

The workshop provided a framework for the exploration of FabLab infrastructures and technologies. Essential elements included (i) using free and platform independent software to ensure potential transferability to other labs as well as schools and home (ii) producing results participants could take with them regarding dimension and costs to increase personal relevance and (iii) providing contextual information of current and future fields of applications to convey an idea about its importance beyond the lab.

There is no existing model to work from for how to run a FabLab workshop for children, so the process to be described here is itself an exploration. In order to give a comprehensive - yet suitable for young users – overview about a FabLab' possibilities, we designed the workshops to consist of four individual modules. The time scheduled did not allow for in-depth explorations, so the focus for each of the modules was to provide first experiences: Introduction to 2D and 3D design and fabrication, printed circuit board (PCB) fabrication and assembly, and software programming. All modules focused on a practical output produced by the participants that they could take with them. Stretching over two days, five hours each, we set up four different tasks: Using Gimp (gimp.org) and Inkscape (inkscape.org) to generate a motif of their wish, cut it out on the vinyl cutter and print it in on a T-Shirt; Using SketchUp (www.sketchup.com) to make a 3D model and print it out on the commercial 3D printer (Stratasys Dimension); Using electronics via the production and assembly of a PCB for a Drawdio, an electronic circuit translating electric resistance into frequency/sound (Silver, 2009); and using software programming, specifically using Scratch, a programming language targeted at young users (http://scratch.mit.edu/).

Each module started with an introduction to the technologies to discuss basic questions and problems beforehand. It served to present the students with a spectrum of relevant areas of application, providing a scope beyond the actual usage within the workshop and allowed for questions and discussions about the technologies introduced. In the practical part they worked in teams of two to help out each other and to think together about the projects that each would subsequently work on individually.

Study method

During the workshop we gathered data to allow us to explore (a) if the provided software and hardware tools prove suitable for children workshops (b) if children can make personal use of the technologies and (c) what insight we can get into children's assumptions evolving from their engagement in the FabLab.

We asked participants at the beginning to present themselves to the group, including their expectations of the workshop and prior experiences in working with computers. At the end of the workshop, each participant presented again, showing what he or she had made during the workshop. At the very end, we distributed a one-page questionnaire, containing a few yes/no, multiple-choice and open-ended questions about their experiences. Qualitative data was gathered through participatory observation, notes taken during the introduction and the workshop sessions, short interviews with the participants and documentation of the works produced. The data was analysed qualitatively, looking for emerging themes and issues. To present the results we have used substitutes for the children's names to keep their anonymity. Quotations are translated from the original language to English and written in italics.

In total we recruited 50 (35 (70%) male and 15 (30%) female) participants aged 10 to 14 years old through the distribution of flyers and media publicity for the five workshops. All participants attended both days of their workshop.

RESULTS

Overall the workshops were very positively received and examples of the children's work can be seen in Figure 1. For 43 (86%) participants it was the first time in the FabLab, the rest had already attended an earlier workshop or took part at a tour through the lab. All children said that they had worked with computers previously, most commonly in the context of school, educational software and preparing presentations, as well as playing games and using the Internet. 8 (4%) reported having basic programming experiences. Very few could say what they expected from the workshop or from a FabLab in general.

In the post-workshop questionnaire, answered by 40 participants, 36 (90%) of the children indicated they liked the workshop very much, 4 (10%) liked it. 38 (95%) said that they learned something new. Asked about their favourite project most of them pointed to the making of the T-shirt, followed by the electronics project. Only a few (3 each, 7.5%) stated they did not like programming and 3D creation. Possible reasons for that are exemplified below. Almost all stated that they learned something new at the lab. Alongside the specific individual projects they mentioned*: "new technology", "what exists and how it works", "working with things", "technology is easy", "interesting to understand physics"*.

All participants answered positively about wanting to come again to the FabLab. When asked what they would like to do when returning, the answers were very mixed: about a quarter had specific plans for what projects they would like to continue or repeat: *"continue programming our game", "designing a new T-shirt", "extending the design of the T-shirt"*. Another quarter had concrete ideas, different from the project that had been realized during the workshop, among them: *"making a chess-game", "making mini-speakers", "building a robot", "building a 3D printer"*. The rest was evenly split between those wanting to *"learn something new" "invent things"* and those not having a clear idea what they would like to do next.

Expectations and Assumptions

Children mostly made fan T-shirts of games, movie characters or sport clubs they liked, their pet or other objects of special personal interest. The discussion of their work gives an insight into how participants could relate new technologies to be potentially relevant for them: Adam, 12, making a computer game themed shirt: *"I could make many of them and then sell to my friends. I guess they all would love to have a shirt like this"* an idea he was not alone with. Celine, 13, though was more sceptical about this: *"Couldn't you easily fake brands like this? Isn't this illegal?"*

The 3D objects that the children created included models of (dream) houses, modelled game characters and small ornamental objects. While it was the technology most marvelled at and most discussed among the children, some also showed quite a critical attitude towards it. Questions apparent across all groups involved costs and potentially printable objects and how they might eventually be present in their future lives. Emily, 11: *"Will 3D printers eventually be so small that everybody will have one at home?"* Fred, 12 *"Yeah! We'll never have to go shopping again!"* George, 10 *"Will then everybody just sit at home and print out things?" "… but nobody would like to have this made out of plastic…"* Hugh, 12 *"… then you can also print out bad things... What if someone uses 3D printers to print out weapons?"* We consider this active interest triggered in the general discussion crucial for children to get an understanding and be motivated to learn through using the proposed technology. This especially became apparent when they started to reflect on the potential influences for future jobs.

The electronics module allowed the least freedom for personalization in the making. The children were following instructions on how to make and solder the PCB and were only free in drawing and playing their own "instrument" once it was finished. This is in contrast to programming Scratch, which gave them greater choice to make games and applications following their own ideas.

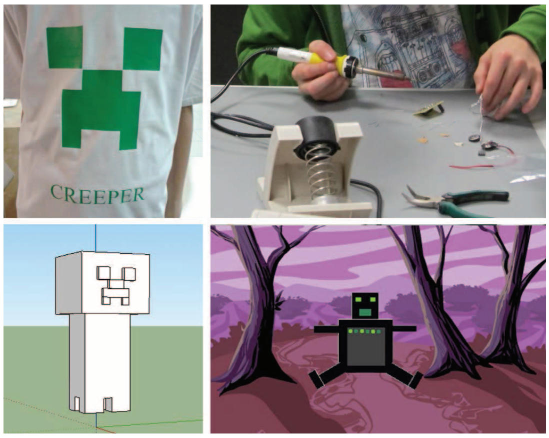

Figure 1. Projects from Noah, 13: T-shirt showing the head of the computer game monster "creeper", soldering, 3D model of "creeper" and a game including a similar figure.

DISCUSSION

Reflecting on the design of the workshop modules themselves, the responses from the children, supported by our own observations, indicate that the workshop provided a right level of complexity for participants. In general, they could handle the tools well after the short introduction. The resulting artefacts showed that the participants were also able to make personal relevant use of the presented technologies. They succeeded in extending existing hobbies and preferences using novel approaches of digital fabrication routines. Still, differences among the individual tasks can be noticed and these can be accounted for in terms of expectations being met and in personalized outcomes.

Children's feedback showed that the creation of their 2D design was appealing on many different levels: the software provided was understandable and manageable, individual steps and underlying technical necessities were comprehensible, and they could make something they would not have been able to do otherwise. On top of that, the result was something of personal meaning and direct use for them - and could meet or even exceed their expectations. They commented on their work with *"it exactly looks as I expected it to be"* some even noted, that it looks *"even better then I would have thought"*, being surprised they could actually manufacture something that looked *"like it was bought from a shop"*. Also making the PCB and soldering the Drawdio left participants with a result that matched their expectations, which might be a reason why those two activities were the most liked.

Compared to that, 3D creation was less satisfying for some participants. Designing a model posed more difficulties and the software could not always fulfil the expectations of the children. This especially became apparent when they designed models that were unprintable due to technical failures not apparent in the design. Also the 3D printed results often could not stand up to the expectations of the children. Considering time and costs involved, we could just print out a small exemplar for each child, all out of the same colour - white plastic. As a consequence 3D printing seemed to be more interesting for how it works rather than the actual use they could make of it. A similar issue became apparent with programming. Having only limited time available resulted in some ideas not being realized to the extent they hoped. In our observation, the children who stated at the beginning that they liked playing computer games had clearer goals and motivations to design their own game and so to continue working on it outside the workshop. Overall programming produced most split opinions between those really engaged and those not interested at all – an observation also reflected in the questionnaires.

Another key aspect was the personal use participants could make of the created artefacts. One specifically noted, "*I could turn a boring shirt I was almost never wearing, into something self-made of high quality.*" Almost all put their shirt on directly after making it. They also made plans for when and how they could demonstrate and use the Drawdio at school. Not all of them saw actual use in their 3D models though and most programmed games were not finished by the end of the workshop. Mary, 13, stated: *"making the T-shirts was definitely the most fun… because you can come up with your own ideas"*. When asked whether this was also the case in 3D designing and programing she said: *"Yes, but you can not wear them… if I could wear the 3D print, that would be great!"*

CONCLUSION

In the absence of other accounts of designing FabLab workshops for children, the account of our five workshops provides indicators from which we can start to develop principles for engaging children as digital fabricators. We are aware too that being an introductory workshop it covers just part of actual possibilities at a FabLab and also that the choice of what could be done was narrowed by the module tasks we proposed. Still we argue that it points to some interesting aspects about the potential of children's activities in the lab.

In using widely available software products we could compile a workshop giving participants a valuable first experience in a FabLab. Results suggest that a FabLab can be a place of great interest for children in terms of learning about, and learning by engaging with emerging technologies. Ideas about projects they want to do next and reflections on the realized projects also indicate that they are able to transfer learned skills and experiences. An especially crucial factor for the children's sense of satisfaction appeared to be the technical challenge and mastery of the task and the personal engagement associated with the result. To our surprise they showed little awe of the new technologies but quickly went from a first excitement to a critical reflection about how they might be influential in their future.

The software proved suitable for the target group at large, however screen based 3D design also posed considerable challenges especially for the younger users. This showed that there still is need for more intuitive interfaces offering direct integration with digital fabrication technologies. Comparing the children's reactions towards 2D and 3D creation, we suggest that the vinyl cutter and laser cutter are the most relevant for acquainting younger users with the potentials of emerging personal production technologies. This is because they have comparatively simpler routines for creating adequate data and a wider range of processible materials, resulting in higher personal satisfaction. Essentially, FabLabs can bridge technological and creative competences and could become an important element in future education.

Comments from the participants about wanting to come back to the lab also showed that introductory workshops are not enough. Once interested, there is a big demand to continue working and developing their own ideas. While this is an outcome we hoped for, it asks for new strategies for how to enable children to work more independently in a FabLab – especially relating to technology and security issues. Future work of interest therefore includes how to best support children's self-directed interaction with digital fabrication technologies as well as how such labs can be used to support children's technological literacy and learning in general.

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