Makerspace in School - Experiences from a Large-Scale National Testbed

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Abstract
Digital fabrication and making are increasingly being used in formal and informal learning environments. However, while many of these initiatives often start from a grassroots perspective, with little coordination on a national level, we now present a study on the first part of a large-scale national testbed for Makerspace in schools (Makerskola). The project embodies a series of issues that arise when a maker approach is applied to a geographically widespread national education context. The results of this study are based on an analysis of the extensive project documentation and first-hand experiences. The findings focus on the on-going experiences with initiating and running a large-scale national testbed in Sweden, involving more than 30 formal actors and hundreds of active partners in a national educational landscape.

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Digital fabrication, Making, Education.

ACM Classification Keywords
H.5.2. Information interfaces and presentation: User Interfaces – Theory and Methods, User-Centered Design

Figure 1: Activities in the Makerspace in School project

Introduction

As the digitalization of society evolves, knowledge of how computers, programming, computational thinking and digital fabrication affect society is of rapidly growing importance. Today, education should provide all children with the opportunity to not only use digital technologies, programs and code, but to also design and develop them. Without these competencies it seems hard to fully understand the nature of today's digital society, and these kinds of competencies will be even more important in the future. ICT mediates many of our everyday social interactions, and it has become a central part of our entire societal construction, our industrial and working life, our production of knowledge and a tool for creativity and innovation. This is why we need to foster a technological literacy that differs from computer classes aiming to prepare for future office work [2]. Knowledge about ICT as a material is important to understand what ICT is [5, 6], what qualities it has, what code and programming is, and how ICT can be combined with design thinking in education [11]. According to Blikstein, digital fabrication and making inherit the potential to be a new chapter in the process of bringing powerful ideas, literacies, and expressive tools to children [1, 2].

The maker movement emerges from the DIY tradition, with activities organized from a bottom-up perspective, and led by grassroot innovation. The physical representation of making, or maker culture, is the makerspace - traditionally a community-operated physical space where people with common interests create do-it-yourself projects together, using technology, digital art, science, computers, etc [10]. The ideas of digital fabrication and spaces for creativity and innovation have been adopted in many contexts and are now a recurring phenomenon all over the world. The typical makerspace is equipped with the necessary tools for every aspect of the technology development process, or digital fabrication, and documentation for a wide range of applications in formal and informal education [3].

However, there are several critical elements that need to be in focus for digital fabrication to be successful in education: digital tools, community infrastructure, and the maker mindset [9]. One further element that needs to be present is a curriculum and digital strategy in education that provides a framework for teachers and schools to connect to. The Swedish government is currently proposing new laws and new digital strategies for education in Sweden, from preschool to vocational education. Within the new proposal, that seems to be implemented during late 2016, it is suggested to introduce programming from primary school for all students, along with a range of other activities and content. Furthermore, descriptions on how to implement these strategies point towards applied practices and maker-oriented approaches as important aspects in the proposals.

In this paper we broaden and expand on the above mentioned elements by discussing initial findings from running a national large-scale test bed for digital fabrication and making in Swedish education. These findings are based on a single case study of the national Makerspace in School project in Sweden. The paper is structured as follows: The next section provides an introduction to our case and the background necessary for understanding the context of the large-scale national maker initiative in question. This is followed by an introduction to our research

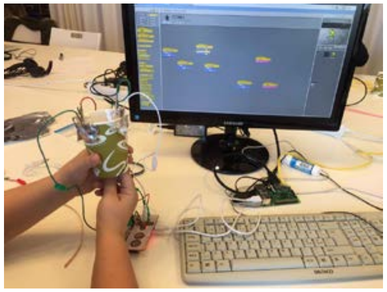

Figure 2: Maker activities

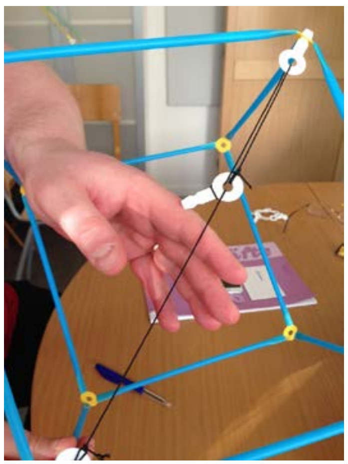

Figure 3: Strawbee activities in special education

method. The case study itself is structured around the authors' and project leaders' analysis of the project documentation and first hand experiences with the project. In the final section, we draw out themes and considerations from our study and discuss these in light of literature on digital fabrication in education.

The Case - Makerspace in School

The large-scale national Makerspace in School project started in 2015 and will continue until 2018. Geographically distributed all over Sweden, approximately 30 local education authorities (e.g. municipalities), businesses, science centers and academic partners are involved in the project. The aim is to contribute to the development of new subject matter specific methodology based on the creative use of new as well as existing technologies, but also to develop an understanding of how these technologies affect and mediate the ways we live and how our societies work on a more fundamental level. Challenging young people to explore the boundary between analog and digital resources also means combining theoretical and practical work, in line with what happens in for example crafts, but in an even broader context. The project provides opportunities to develop and disseminate best practices in the field of maker culture between teachers, schools and local education authorities, who over time has the intention to improve our schools' educational activities in general and provide input for future curriculum development.

The project is coordinated by two project leaders, but the main activities are taking place in the hundreds of schools from the participating partner municipalities and organizations, all over Sweden (see Fig. 2 and 3). The project coordination is foremost about ensuring communication channels, organizing some common events, and acting as support for materials, activities, knowledge exchange, inspiration, technology expertise, etc. Central to the implementation in the project is to establish a number of test beds where the methods, equipment and logistics can be evaluated. More specifically, this means that individual teachers or teacher teams in a school work with students to:

- Explore the idea to recast a school's craft environment to a makerspace
- Introduce programming, coding and computational thinking
- Work creatively with Internet of Things and electronics
- Explore and reflect on how new technologies are affecting and mediating society, work, play and life in general, including how it affects the basis for democracy, etc.

The project also places great emphasis on human resource development. A number of so-called "Maker Days" for knowledge sharing between teachers and school leaders will be organized, in which also stakeholders outside the partner group are welcome to participate.

The government's ongoing mission to the National Agency for IT strategies for both pre- and primary schools as secondary and adult education is under development and in referral. The ongoing process indicates that the project Makerspace in School will be able to support the more operational implementation of parts of these strategies, in cooperation with the project partners. The Makerspace in School is funded by Vinnova, which is the Swedish innovation agency working under the Ministry of Enterprise, Energy and Communications.

Method

To study the initial experiences from the first half of the Makerspace in school project, we adopted a single case study approach [12]. The study of this project has so far generated large amounts of qualitative data of different forms (such as first hand experiences, field notes, written documents, video conferences, web documentation, web resource bank, photo and video documentaries and summaries of events) as well as some quantitative data (such as e.g data on numbers of participants and geographical location). Analysis occurred in the following iterative stages: first, all material was analyzed by the project leaders in order to summarize the state of the project, but also to detect possible hindrances and enablers which were then summarized and discussed among the authors. Thereafter, all critical elements were gathered in order to determine higher-order categories, possible overlaps, and refinements. After defining the higher-order categories we returned to the data in order to determine whether the most important lessons-learned were captured or whether additional categories were needed. From the analysis, key findings were extracted, discussed and written up. This finally led to the structure presented in this paper. The authors belong to the Swedish research group IDAC - Gothenburg working group for interaction design and children. All three of the authors' organizations are official project partners, and one of the authors is a main project leader.

Analysis of the current state of the project

Below we will describe the summary of the state of the project, based on an analysis of the project documentation and first hand experiences by the project leaders from the Makerspace in School project. The analysis is related to the following topics: communication, activities and experiences.

Communication

In order to be able to work with a large-scale testbed, with a nationally distributed project group, the majority of the project's processes and resources are digital. The following communication channels are used:

Informal Interaction: The informal interaction between the over 600 participants currently connected to the project is in a Facebook group. The posts vary from reports of project activities, to inspiration such as tips and tricks, as well as more formal project information. The interaction is characterized by a rather high level of communication, with around two daily postings from various members.

Formal communication: There are around 120 members responsible for the projects more formal processes, and they communicate through Trello. However, the use of Trello still needs to be developed further. One step in this direction is an instructional video explaining how to use the different digital resources as well as for what purpose, which has been published on the project archival website. So far, the use of Trello serves mainly for initiating and coordinating subjects to be discussed in video conferences.

Project information: A website is used for more static information [8]. It also contains links to the digital archives and libraries [7].

Video conferencing: Regular conferences are held in Google Hangouts, in which members of the project get the opportunity to deepen discussions. The conferences are initiated on message boards in Trello, advertised on Facebook and newsletters, and published on project websites. So far, about 10 meetings have been held with between 3-7 participants. The number of viewers in retrospect is greater. The past three months, about 400 people have seen one of the project Hangouts.

Project formal news: The project has a digital newsletter with general information for registered project members, which today is about 150 contact people located at over 30 different organizations.

Archive: A website is serve as a web-based knowledge bank and a digital archive that will cater for the project's results survival after completing the project [7]. The archive is divided into activities for school subject specific matters, such as chemistry, music, mathematics, etc, but also into school forms; pre-school, elementary school, after school, high school, special education, and informal learning. The archive is still under development, but so far also include information about products, suppliers, project members, instructional videos, a library, information about the project and about maker culture, etc.

Project milestones, deliverables, and activities

The operations of the project processes are developed at the expected rate, though some team members carry out more operations than others. Some team members will possibly leave the project because they have not so far met the minimum requirements for operation, such as e.g. investing sufficient number of hours in relation to what was agreed from start. Other players, however, is in line to become involved in the project. For instance, activities and meetings within the area of special education has just recently started, and will hopefully inspire to generate more activity now when it is initiated (see Fig. 3). In March 2016, there are five new stakeholders to the project. The project is basically process-oriented, with a few clearly specified milestones and activities:

Maker Days: One milestone is the implementation the teacher and school leader conference Maker Days once a year. The next run of this conference is planned for in October 2016, and will build on the experiences from the first version held in 2015.

Teacher education partnership: The project is in dialogue with the formal teacher education to create opportunities for teacher training and the school to take part in the development and ongoing work. If the teacher education should be able to contribute to train teachers who have skills that match the needs of the labor market, assumes a partnership. And now when the new school law comes into force and the school begins with new knowledge content, teacher training is a prerequisite for good continuity. The project intends to support teacher training in the development of knowledge.

Maker culture and programming activities: Most activity in the first half of the project has been in preschool and early elementary school years. This is probably because it is easier to do interdisciplinary and thematic work in those environments. The project has currently conducted maker culture and programming workshops as regular activities in 13 municipalities. The establishment of the maker space as the physical environment has begun on a limited scale in a small number of municipalities. There are seven established environments around the country, with particular expertise in maker spaces, maker culture and programming, and with the ability to disseminate and share their expertise. Today there are environments in preschools in four municipalities. The project has about 15 elementary schools committed to different extents. In some places it is a teacher team, in others the entire management of the municipality involved. Special education schools are creating a test environment between three school municipalities. High schools have started, but to a limited extent, in three places.

Experiences

Today there are limited quantities and types of technology, materials and methods available concerning maker space and programming with established technology and software vendors and distributors. It stands clear in the project documentation that almost all of the participating school principal's report on procurement and contract difficulties, which prohibit them from acquiring the required tools and materials. The project has therefore initiated a documentation process around this which can later on support the project partners. This information will be published in the project's web based archives. Also, a test bed where methods, materials and models can be explored for further development of the maker space in schools is under development.

Efforts to create a continuity around communication, dialogue and knowledge sharing in the project is ongoing. As presented above, a virtual platform for further networking and development of the Makerspace in School project is under development through Trello and the project website [8], as well as the development of a web-based knowledge bank [7]. However, there is a reported need for different perspectives and forums in the project. For instance, the information and documented activities in the digital archive are structured into school subjects and school forms, as there is an outspoken need from teachers to share knowledge and experiences from within certain subjects or school forms. This is also shown in e.g. the increased engagement for more specific themed conference discussions rather than those of general nature. Throughout the project, a very specific need has also been raised by the participating organizations, namely the need for school leaders to have separate video conferences discussing issues related to strategies and management of maker activities.

Considerations for large-scale digital fabrication in education

In the above presented analysis of the Makerspace in School project, we have found several considerations for initiating and running a large-scale national project on establishing digital fabrication in education. Here we will focus on two of them: procurement practices and the teacher and leader perspective.

Procurement practices

Most of the schools and municipalities involved are bound to strict rules and processes for procurement. As much of the tools and materials of digital fabrication are new to these schools, there is a threshold for carrying out proper procurement. During discussions, several suggestions for more easy access to materials have come up, such as e.g. new recycling policies for municipalities when handling electronic waste, develop standard models for procurement, and continuous updating of laws on procurement practices. Another suggestion has been for municipalities to partner up with companies that are involved in procurement and develop educational materials when creating pedagogical scenarios.

Despite the problems with procurement in the project, several prototype setups of makerspaces have been tested over time in different contexts from the beginning of the project, and several more are planned for. Procurement practices when investing in technology for education can have a major effect on how a field develops [4]. To speed up the process of providing future makerspaces with tools and materials within a shorter time frame, while keeping the level of administration at a minimum, it may be beneficial to identify the common tools and materials needed to design and develop a makerspace for an educational context. This list can be iterated together with the businesses who have won procurement bids for providing technology to these contexts. By addressing the business stakeholders, and providing them with the same lists of tools and materials, there is an opening to create a market with actors already within the system.

In order to lower the entrance hurdle to start up digital fabrication initiatives in public educational contexts, the design of standardized maker kits for education would be preferable. These can be divided into different categories, depending on the level of complexity, e.g. one for starting up, one for extending, subject specific, etc. These kits should be designed based on national procurement bids and local conditions. Once a number of standardized maker kits have been developed, partnerships with companies that can handle the distribution of the kits could be established. This partnership can bring down costs, increase accessibility to equipment, and make makerspaces more feasible for education institutions to start up digital fabrication.

The teacher and leader perspectives

There is a great variation in engagement and level of activities among the project partners. Therefore, participants have multiple times indicated a need for separate training of teachers and school leaders, in order to gain some confidence in this area, as several participants have run into problems with insecureness from both teachers and school leaders. The aim with digital fabrication and making in education is to better support learning and working in the area between the physical and digital world, which may raise awareness of and interest in science and technology among children and their teachers [1]. However, the participants have experienced that digital fabrication and making are not prioritized by leaders and colleagues who do not have knowledge in this field themselves, because they do not think there is any support in the curriculum. The leaders thus ask for support in judging the teachers' knowledge in the area, while the teachers ask both for competence development in making and digital fabrication, but also in coordinating and developing interdisciplinary teaching. Teachers also, express a need for the schools to develop a transdisciplinary approach between subjects, in order to make use of the available knowledge and materials at hand. Therefore, there is a need in the project to support and run separate tracks for teachers and school leaders, in extension to organizing common activities. In the Makerspace in School project, this is supported by e.g. separate video conferences for leaders, and during the Makerdays conference there are activities and workshops dedicated around a leader perspective.

Although we have defined and focused on two considerations in running a large-scale project on digital fabrication in education, this list is not exhaustive. However, we hope our experiences may guide and support others who intend to engage in large-scale projects of this character.

Conclusion

In this paper, we have sought to contribute to the discussion associated with a digital fabrication and maker approach to education with a large-scale national perspective. We have been involved in a series of digital fabrication and design thinking initiatives in education for more than a decade. The makerspace in School project is the largest of these initiatives, and is strongly grounded in a maker approach. From a research perspective, we have studied this case in order to understand what it takes to run a national large-scale testbed in this area. Given the emphasis that is often placed on the role of the grassroots initiatives to implement digital fabrication in formal education, taking on a coordinating perspective of a common national perspective is less common. The findings from this case study suggest that there is good reason to examine this perspective further. As is clear from the analysis and considerations, the experiences point to a couple of concerns that are seldom discussed in digital fabrication in education; procurement practices, and separated support for both teachers and school leaders. Well aware of that this list is not complete, it is the hope of the authors that other researchers, practitioners or decision makers may find inspiration in our findings.

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