Digital Fabrication for Educational Contexts

Dennis Krannich, Bernard Robben, Sabrina Wilske
University Bremen
Bibliothekstraße 1
28359 Bremen
{krannich,robben,wilske}@tzi.de

ABSTRACT

In this workshop we present the concept of digital fabrication and discuss how this novel and diverse approach can be applied for educational contexts.

Categories and Subject Descriptors

K.3.1 [**Computers and Education**]: Computer Uses in Education; J.6 [**Computer-aided engineering**]

General Terms

Design, Human Factors

Keywords

Fab lab, digital fabrication, education

1. DIGITAL FABRICATION

„In the past, shoes could stink. In the present, shoes can blink. In the future, shoes will think.“ – Neil Gershenfeld

The origin of fab labs (fabrication laboratories) derived from the „Center of Bits and Atoms (CBA)“ at the „Massachusetts Institute of Technology (MIT) in Cambridge (USA). The founder of this new movement is Neil Gershenfeld. In his book „Fab“ he describes the (coming) revolution on our desktop computers and defines a fab lab as „a connection of commercially available machines and parts linked by software and processes we developed for making things“ ([1] p.18). The specialty of this concept is the use of digital manufacturing machines that have been used almost exclusively by industry. These machines are either semi-professional devices or low-budget reproductions of industrial-sized machines, whereas their production quality can compete with its industrial counterparts. Typically, a fab lab consists of a laser cutter to cut out two-dimensional shapes – that can also be assembled into three-dimensional structures – a sign cutter to plot flexible electrical connections and antennas, and a 3D-printer to print out three-dimensional artifacts and precision parts. Additionally, micro-controllers can be used to give artifacts a kind of logic by making them respond to interactions. The fab lab setup is intended to be flexible to replace parts of it with parts made within the fab lab and eventually reproduce the lab‘s components itself. Since their invention, fab labs have spread all over the world and gained more and more attention by the public.

The main objective of fab labs is to enable people to create almost anything. Fab labs enable us to explore how we can represent a functional description of a system by physical forms and in reverse to which extent a functional description of a physical system can be abstracted.

2. THE CHANGE FROM INDUSTRIAL-SIZED MACHINES TO PERSONAL DIGITAL FABRICATION

Similar to the transformation from main-frames to personal-computers, there is a shift from industrial-sized machines to personal digital fabrication. This does also involve the production process in general. Techniques like rapid-prototyping and rapid-manufacturing gain more importance, not only for professionals. And consequently new opportunities for business and education arise.

Accordingly, the term ”do-it-yourself” does not reflect anymore on tinkering by means of handicraft work, but in the sense of generative production: Nearly any designed shape can be “printed out automatically”. We design and construct on the computer and transform the created artifacts from the digital-virtual world into the real-physical one. With these new production techniques and methods, we can develop physical prototypes to explore and evaluate functionality, usability, and user experience on one side, and create small series of products that can easily be changed to suit individual styles on the other side.

The traditional production process started with hand-drawings that were transferred into hand-made physical models out of wood or clay for visualization. Also technical drawings were developed on drawing boards by hand. The assembly line of mass production was rigid and inflexible. This changed with the introduction of Computer Aided Design (CAD) and Computer Integrated Manufacturing (CIM). Technical drawings became complex 3D-models. Programmable Logical Controllers (PLCs) made Computer numerical control (CNC) machine tools possible. Produced with CAD methods, 3D-models facilitated complex simulations in two areas: computer simulations of the production process and simulations of the functionality of the produced products. Engineers tried to create computer simulations in virtual three-dimensional space to explore the product from every angle and to zoom into details.

With the availability of digital fabrication technologies the production process changes once again. Today, it is rather the tendency to step out of the computer and make the virtual objects ”be-greifbar” (graspable and tangible). We may still start with hand-drawings (they are still very important for brainstorming and rapid-visualization) but our main work is done on the computer. We use CAD or vector programs for exact constructions and can easily print them out, either into two or three dimensions. For that purpose, we can use different materials, ranging from paper over wood and acrylic glass to ABS- or PLA-plastic. Additionally, computer simulations help us to understand and investigate material strength and weight. The computer also helps us to calculate the optimal balance between stability and weight.

Since computers and software are affordable for almost everyone in the developed countries, we can now realize our ideas, even in our own homes. We can construct things that we have dreamed of and that solve our particular problems. We do not have to accept what others have built for us and do not depend on professional companies anymore. We can now produce single and unique artifacts, instead of small series or going into mass production. In general, digital fabrication enables a faster and affordable realization of ideas.

As a consequence of this, we now have very close links between the virtual and the real product, enabling us to be more creative and to focus on constructing innovative concepts. Our assumption is that these close links offer new chances for educational purposes to make design and engineering more transparent. The transformations from hand drawings to 3D-models and real products become graspable in a new creative way. People willing to learn, especially young people, can experience and reflexively understand the entire process of developing products.

Since some of the production technologies are still too expensive for private use, fab labs provide the opportunity to create communities in order to share knowledge, resources and machines. Having in mind the intention of open-source, the products developed within a fab lab are freely available to the whole community. Thus, people can share and discuss their ideas and models within the worldwide fab lab network as well as use or modify existing constructions.

3. WORKSHOP CONTRIBUTIONS

In this workshop we want to discuss the concept of digital fabrication and demonstrate how this novel and diverse approach can be applied for educational contexts. Participants will discover and discuss the possibilities and impact of different digital fabrication technologies. This workshop is intended for practitioners of digital fabrication as well as newbies. We address the design, use, and evaluation of digital fabrication technologies for educational contexts by covering the following topics: tools and technologies (3D printing, laser cutting, etc.), educational concepts, experience design, open innovation, best practices, dissemination and establishment, and local and social practices.

The first contribution ”Seeing Solids via Patterns of Light: Evaluating a Tangible 3D-Input Device” by Ben Leduc-Mills, Halley Profita, and Michael Eisenberg describes pilot tests of a prototype device for three-dimensional input called the UCube; briefly, this device permits spatial input to be conveyed "by hand", by turning on (or off) elements of a volumetric array of lights whose positions are then sent to a desktop computer. The purpose of the UCube is to allow users – especially students and novices with little experience of 3D design – to create a wide variety of three-dimensional shapes without the need for complex modeling software. In this paper, the authors describe tests of the UCube with middle-school students, focusing on the ability of students to visualize and model solid forms employing the device. The authors use the results of these pilot tests to ground a wider-ranging discussion of (a) how the device itself might be further developed, and (b) more general issues in designing systems for interactive three-dimensional input and fabrication.

The inclusion of the computer in fabrication processes that were previously mostly operated by hand (or in some cases not possible at all) also asks for new skills in order to participate and take advantage of current developments. Institutions like fab labs, equipped with a broad range of computer controllable machines, are forefront in making these means of innovation accessible to people. Still, the challenge lies in attracting a diverse public and providing necessary support – this especially becomes important when working with children. The second contribution ”Educating for Digital Fabrication in fab labs and Beyond” by Irene Posch, Karim Jafarmadar, and Roland Stelzer gives an insight into children workshops held at the local fab labs and proposes strategies how educational activities in the field of digital fabrication could be stretched beyond the lab in order to reach broad inclusion and accessibility.

The research project “Subject Formations and Digital Culture” (SKUDI is short for “Subjektkonstruktionen und Digitale Kultur”) is searching for new subject formations that are developing with regards to societal changes and new media- and technologies-based social practices. In their position paper ”A fab lab Learning Scenario for Young Adults” Julia Walter-Herrmann, Corinne Büching, and Heidi Schelhowe describe the links between the fab lab movement and its history to the research project SKUDI. One part of the project SKUDI is to implement learning scenarios for young adults that give them a meaningful exposure to technology. One of the conducted workshops focuses on fab lab. In the paper they describe this fab lab workshop, its pedagogical implementations as well the evaluation design.

4. CHALLENGES AND OPPORTUNITIES

Starting from the submitted contributions, the objective of the workshop is to discuss the following questions and to postulate first hypotheses:

- Why are fab labs important for education?
- How can fab labs support educational objectives?
- How can we use the transformation from a digital model into a real physical artifact to understand the production process and its related learning matters?
- What kind of tools can we use? How do they relate to hand drawings?
- Under what conditions can fab lab technologies support the understanding of the production?
- When do these technologies allow to copy models / infringe copyrighted material? What can we learn from these effects? On the one side, we have to preserve our own ideas and to avoid dependence on technology, on the other side, allowing this assistive support gives us the opportunity to focus on more important aspects (e.g., basics of mathematics vs. using the calculator).
- What is the relation between two-dimensional and three-dimensional models? Does the two-dimensional printer allow for a better understanding of three-dimensional space? Or does a 3D printer limit the understanding of basic construction concepts?

In conclusion, it is important to be able to understand the transformation between the two-dimensional and three-dimensional world and the link between virtual and physical world.

5. REFERENCES

[1] Gershenfeld, N. 2005. FAB: The Coming Revolution on Your Desktop - From Personal Computers to Personal Fabrication. Basic Books, New York, NY.