

## FABLABS IN DESIGN EDUCATION

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### ABSTRACT

The third industrial revolution, triggered by Internet communication and renewable energies, can be experienced in so-called FabLabs that empower users to ‘make almost anything’. Although this does not change the need for designers to have making and prototyping skills, there is no doubt the revolution impacts the design profession in terms of skills required and design methodologies and practices. So, what does this mean for design education? In the current work, we elaborate upon the role FabLabs can play in design education. We developed an elective course and reflect upon the lessons learned in this particular course, but also how the peer learning enhanced a lab community. Interestingly, the FabLab became an interface to the city, a creative hotspot open to practicing, making, co-creation and participatory design skills.

*Keywords: FabLab, education, making, prototyping, tools, DIY*

### 1 INTRODUCTION

The first industrial revolution in the 19th century was triggered by the introduction of steam-powered technology and gave a great impulse to the development and production of goods at low prices, whereas the second industrial revolution in the 20th century was triggered by oil-powered and electric technology leading to automation and mass production. A third industrial revolution is happening right now, triggered by Internet communication and renewable energies [1]. Rifkin [1] describes how the five-pillars of the third industrial revolution will cause a new economic paradigm, from hierarchical to consumer power, creating thousands of businesses and fundamentally change the way we conduct business. Good examples of consumer power are affordable digital manufacturing machines that are connected to the Internet. These machines do not require huge capital investments; the owner-maker is re-emerging. Being digital, these machines reconnect designing and manufacturing, and can be seen as the comeback of the designer-producer [2].

Ten years ago, these machines started to become available to the general public in so called FabLabs (fabrication laboratories), an outreach programme of the MIT’s Centre for Bits and Atoms. A typical FabLab is equipped with laser cutters, cnc routers, 3D scanners and printers, and 3D milling machines, but also electronics workbenches and microcontroller programming tools [3][4]. This interdisciplinary set-up and a solidly integrated peer-learning and DIY (do-it-yourself) approach empower FabLab users to ‘make almost anything’. There are over 150 FabLabs around the world and over 15 FabLabs in the Netherlands open to students, local inventors, designers, tinkerers, innovators, small businesses and entrepreneurs [5].

The designer-producer DIY revolution impacts on the design profession in terms of skills required as well as design methodologies and practices. FabLabs offer capabilities to everybody, which have until recently been reserved to a few professionals only [6]. This does, however, not change the need for designers to have making and prototyping skills – to the contrary: it is fair to assume that designers will be supposed to be even more proficient in using these possibilities. They will be expected to handle the development, prototyping and integration of microelectronics and programming equally well.

## 2 APPROACH

What does this mean for design education? What role can FabLabs play in design school's curriculum? Internationally various styles of FabLabs have been developed. Two out of three FabLabs are affiliated to institutions such as community colleges and universities [5]. Correspondingly, the function of FabLabs in education is quite broad, reaching from basic STEM (science, technology, engineering, and mathematics) education in general and early encounters with design to the use of the labs as ideation and prototyping spaces in higher design education. Next to that it stimulates critical debate on material use and conceptual design issues.

The FabLab addressed in the current work, started from educational needs in Higher Vocational Education in the field of Communication and Media Design, Media Technology, and Computer Science. It can be described as a FabLab+ with an emphasis on electronic and sensor devices, Internet of Things, and Open Data. The lab is a prototyping workshop for students in the first place, though it is also an interface to the city; a creative hotspot open to all citizens which enables co-creation and participatory design. In other words, it is truly a learning environment for practicing, making, co-creation and participatory design skills.

Equally important to providing the technical capabilities, we are concerned at providing appropriate methods to employ these capabilities. These methods are fundamentally rooted in the human centred approach of design thinking, as popularized by Tim Brown [7]. We tentatively termed these methods 'agile rapid prototyping' – the name indicating that we borrowed both from design (prototyping) and software engineering (agile) but sufficiently distinct from 'rapid prototyping' which in design is used as a synonym for 'additive manufacturing' technologies. Those methods essentially entail working on projects in short iterations that include designing, physical prototyping and (end-user) testing. In software engineering, as an example, the Scrum framework developed over the past years as the agile approach for getting work done [8]. The advantages of the Scrum framework are more and more recognized by other disciplines [9].

In our design education we make use of the FabLab in both structured and unstructured formats—including electives, minors and applied research projects. Methodically design education in our lab focuses on the new challenges of interdisciplinarity, proficiency in rapid prototyping technologies, the mastery of agile design processes, and co-creating meaningful designs together with real stakeholders [10].

## 3 FABLAB ELECTIVE

The present FabLab provides an infrastructure for experimenting with sensor technology, digital manufacturing, and open data. In order to fully exploit the FabLab in our design education all students, or at least a critical mass, should be able to use the machines and materials of the lab on their own. Also students need to learn to create and use (physical) prototypes in a safe and confident way. To empower these students we recently developed an elective course called 'FabLab: What Do You Need to Make (Almost) Anything'.

In this course students were asked to build their own smart object – an object using electronics and programming to create interaction. Using open source technologies students were enabled to build their own working prototype. Students would not build a perfect product, but a series of prototypes that leads to an alpha version of a smart object. Core of the elective is to empower students by teaching them simple processes and using publicly accessible information and technology (open source) to develop prototypes with a minimal amount of time.

### 3.1 The Course

Expertise and knowledge from different disciplines, both in the curriculum as in the educational background of the students, is addressed in this course. The interdisciplinary approach embraces rapid prototyping in terms of agile management. The FabLab course is open to all students from our university of applied sciences. For first and second year students the course time does not conflict with other courses. Consequently only first and second year students have taken part in the FabLab elective. The course's duration is ten weeks and students receive two credits (ECTS) when they successfully complete the course. For most of the students this course is their first experience with electronics and design.

Moreover, as we consider peer learning an essential part for creating a community in the lab, students are encouraged to brainstorm together and to evaluate each other's work. This way students not only learnt from their own work and mistakes but also from their peers'.



*Figure 1. Peer learning during the course FabLab*

The course is divided into seven topics during the ten weeks, inspired by the course “How To Make (Almost) Anything” at MIT by Neil Gershenfeld [11]. These topics are 1) The method of agile rapid prototyping, 2) Mechanical drawing and building, 3) Circuit boards and electronics, 4) Microcontrollers, 5) Input and sensors, 6) Output and activators, and 7) Communication.

Every week a different topic has been discussed and students work on a corresponding prototype. The last three weeks are reserved for personal coaching and developing of the alpha prototype. Each lesson had the same structure. We started with a global view of the lesson and the goals for that week. Before any new material was given we created space for peer review of the developed prototypes. Once they reviewed each other's work we introduced the subject, for example circuit design, with some practical examples and demonstrator projects. After these introductory we created a jamming environment, where students could experiment with the subject as a hands-on learning activity. Because of the diverse backgrounds from the students they were able to help each other learn at an exponential manner.

### **3.2 Results**

Initially we organised two classes a year, though the enormous amount of interest forced us to run the course parallel three times a week each quarter. In other words, instead of two classes a year, we now offer 4 times 3 classes, which is the maximum amount of classes per quarter. Each class contains maximum 15 students. Every class started with 15 students and a long waiting list.

The educational background from the students of the first two quarters (all three classes) were: Communication & Multimedia Design, Arts & Crafts, Computer Science, Media Technology, Industrial Product Design, Communication, Maritime Technology, Electrical Engineering and Mechanical Engineering. At the end of the course students were asked to rate the themes of the course based on how relevant it was for them. As shown in Figure 2 most students (n=72) find the course relevant. Most students started in the second and third quarter enrolled due to a positive recommendation of a classmate.

Some reactions of the students after finishing the course: “The world is my canvas thanks to this course, I now can create everything I can imagine” (student Media Technology), “I discovered a whole new field of design in this course which I otherwise never would have found” (student Arts & Crafts), “The topics were not new to me, but the way we worked with each other is a new experience for me.” (student Computer Science) “I did not know that I was capable to do things like this.” (student Communication & Multimedia Design)

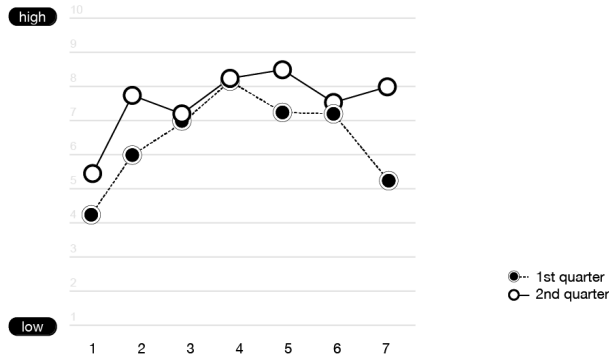


Figure 2. Relevance of the topics (as rated by students)

At the end of the course an exhibition is organized showing the alpha versions of students' (physical) prototypes (see Figure 3 for an example). Students from all classes assess each other's work during this exhibition.

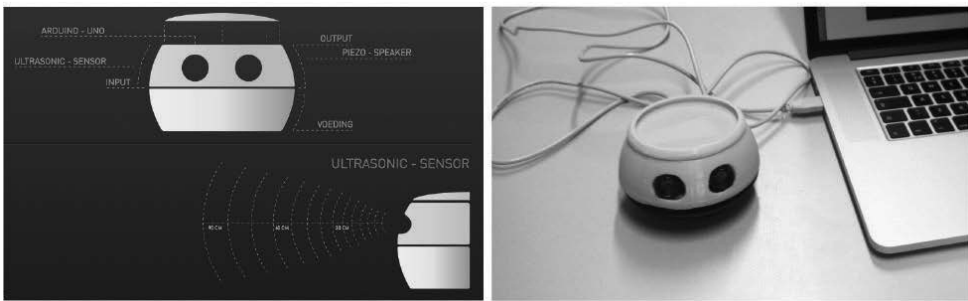


Figure 3. Alpha prototype 'stuff protector' by one of the students

#### 4 LESSONS LEARNED

Current insights not only show that the FabLab course enables students to use the FabLab machines and materials, but also that it empowers students to accelerate their ideation and invention processes. Interestingly, students develop near-professional prototypes using the laser cutter and 3D printer. Though, we also discovered that students found it hard to create prototypes in the initially planned time. Overall students had to put in more effort and time to create a prototype they were proud of. Another challenge found, which was true for most of the students was that learning from mistakes did not happen that much. Students knew that something went wrong, but did not debug their errors in order to advance their learning process and distinguish broad overview and deep insight. Next to that students do not see making mistakes as normal learning behaviour even when copying tutorials.

After the evaluation of the first quarter we made some changes in lesson 7, communication. Technical students found the topic communication extremely relevant, but other students found this topic to complex and not relevant for their prototype. Therefore we decided to redesign this theme to a more flexible lesson with different topics were students could work on independently. In this way we were able to customize the lessons for different levels of engineering and designing.

Not only students that followed the FabLab course are working in the city lab. Currently, the FabLab almost succumbed due to its success; more and more students find their way to the FabLab. It can be concluded that the course has been a catalyst; current students are increasingly active, creative, and innovative. To enable students to use the FabLab we hired students as stewards of the lab. We educated these students to be experts of all machines and materials. Now these students educate other students to become stewards as well.

The FabLab not only attracts more students, the interface to the city seems to work out as well. The fact that the FabLab's doors are said to be open for anyone, does not automatically mean everybody will find their way to the lab, especially when people do not have a reason to do so. We have organised various co-creation events, such as hackathons and prototyping workshops mostly related to our Open Data Initiative. Interestingly, not only creative professionals or peer students came to the lab and consequently used the workshop equipment, also newcomers visited the lab. For example, primary schools came as part of their 'technasium' education aiming to inspire and challenge young people to study science and technology. Similarly, a network organization of businesswomen contacted us for a Technology Safari. Mothers together with their daughters participated in a workshop on DIY jewellery.

Currently, trial workshops on 3D printing are being tested with youngsters from a SES neighbourhood who dropped out the educational system [12]. In these workshops they are made familiar with different open source tools such as: 1) Thingiverse, an crowdsourced collection of open designs created for 3D printing and laser cutting; 2) Tinkercad, an open online 3D modelling tool to create personal designs for 3D printing and laser cutting; 3) Instructables, an online How To and DIY community where people share their inspiring projects and inventions, and 4) the Ultimaker 3D printer at the current FabLab, which is an open source, affordable, and easy to assemble 3D printing machine. Results and observations from these workshops are very promising. It shows that people without any prior knowledge can easily participate and finalize their own design in the FabLab. With this latter example we address the potential of young digital natives by co-creating with them a means for their empowerment through a peer-to-peer talent development platform, aiming on the one hand to increase the level of participation of the youth in their local environment, and on the other to allow them to self-promote their value through using open technologies.

## 5 CONCLUSIONS AND FUTURE WORK

The FabLab approach has a great power to attract people, particularly students, to get their hands "dirty" with digital manufacturing. It demonstrates how the gap between product design and electronics can be bridged in an easy and attractive manner. This effect has been found elsewhere as well [3, 4, 13, 14] and can easily be replicated. As more labs begin to develop that route – the FabLab at the university of Cergy-Pontoise near Paris just got three diploma courses accredited [15], the FabLab in Zurich is providing a digital fabrication course for design classes at the University of Applied Sciences and Arts, ZHdK, Zurich [16] to name a few – it becomes important not to re-invent the wheel but to share experiences and efforts. There is also room to integrate and further develop distributed design studio approaches [17].

More work is also needed to integrate and develop the FabLab approach in primary and secondary education, as our preliminary experiences and projects elsewhere [e.g. 18, 14] have demonstrated. It seems even more interesting and promising to investigate the emerging development of higher and vocational education outside traditional curricula. Massive Open Online Courses have the potential to displace incumbent education, "[t]here is a new world unfolding and everyone will have to adapt" [19]. With the online version of Gershenfeld's course, the FabAcademy [20], there is already such a diploma course, delivered by MIT. This route is highly promising and challenging at the same time to avoid the tendency of schools to "change the change before change changes the school" [14, 21].

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