Open Making in FabLabs as a Multidisciplinary Course of Study

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Abstract
Our educational system aims to create specialists of different disciplines, who gain extensive knowledge in their field, are well trained and target-oriented. But at the same time, they are limited by the scope of their discipline. FabLabs are open places at which people of different backgrounds and perspectives get together, share their ideas and co-work on given problems. The social environment creates an openness, which does not exist in Universities. This position paper intends to trigger a discussion about changes in the educational systems by the use of FabLabs and its spirit.

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Education of Digital Fabrication; Fab Lab; Open Design.

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Motivation
Makers have existed long before the word was known as it is today. For example, my grandfather was one of them. As a farmer he was able "To Make (almost) Anything" by himself, to quote the words of Neil Gershenfeld [1]. He built the family home, the stable, repaired and modified the tractor for multiple purposes,

and built things such as a threshing machine without instructions or plans, etc. He did so because it was needed. He was taught to be able to do all this, by his parents and also by the society of his time. It was common practice for people to build (today, we say 'Make') things on their own. Many people already had a versatile perspective on given problems. Driven by their needs, they developed a variety of skills and widened their expertise. They were able to understand problems of different fields in a far-reaching manner.

Today, the situation has changed. We are much more specialized and less diversified. Our educational system around the world creates skilled specialists. Of course, it is advantageous to have specialists. They gain extensive knowledge in their field, are well trained and target-oriented. But at the same time, they are limited by the scope of their discipline. There are various attempts to foster interdisciplinary work in education, but this is still different to the situation in FabLabs.
"A Fab Lab is a technical prototyping platform for innovation and invention, providing stimulus for local entrepreneurship. A Fab Lab is also a platform for learning and innovation: a place to play, to create, to learn, to mentor, to invent." [2]

In educational contexts, cooperating disciplines are often chosen by a manner of similarity in thinking, process, or based on a specific design goal. At the end, it is again predetermined which disciplines work with others. This can be seen as 'predetermined-interdisciplinarity".
FabLabs work differently. The randomness by which people of different backgrounds get together comprises a new quality, which is not predetermined. This emerges from the social environment in a FabLab, which facilitates multidisciplinary exchange between people.
The effect of the diversity among these people is also remarkable. Hierarchy, based on age and profession are almost non-existent. This uniqueness creates an equitable situation. People act across educational barriers, share their knowledge and work together and at the same time – or because of this – people are open and honest. They articulate their deficits without shame, i.e. 'even' professors ask students for help and vice-versa. This openness of the human spirit is different to typical educational contexts, such as in Universities.

I believe, we need to reconsider the way we teach at Universities, and FabLabs can be an instrument for that change. The basic idea is to establish an environment that allows as many people as possible to get together and to share their knowledge in an equitable manner. From the educational perspective, we have to foster such a way of thinking, to create openness and acceptance for other perspectives across skill-barriers and hierarchies.

But why in a FabLab? Of course, the focus of FabLabs is to create physical objects. Even though many study programs not primarily focus on production of such, many relate at least to the usage of them. A better understanding of modern technologies to create products can help and can create new perspectives on the own field of work (some examples will follow).

Time has changed and so have the tools. Today, we are equipped with new tools that do not just provide new feasibilities, but also easy (or at least easier) access to complex production techniques. This enables us to

create high quality and complex products even without being an expert, i.e. in engineering or production. That's part of the individuals' revolution of digital fabrication – of being able "to make almost anything".

Digital fabrication is production through software (2D-Design, 3D-Design, parametric and generic design, programming, etc.) and combines the modeling process with the fabrication process. This includes additive and subtractive manufacturing techniques. The product is created with support of computer and computer-controlled machines. The tools provided for this, handle the complexity of machining and computing and scale down the need for comprehensive engineering, computing or design skills.

In addition to core production, today's tools also provide us with opportunities to combine it with computing. Internet of things has become a buzzword but becomes accessible to everyone. Platforms such as Scratch, Lego-Mindstorms, Processing, Arduino, etc. provide a low entry threshold/ hurdle free, so that even kids can use them and start creating their own complex systems or products. Of course, tools scale up in complexity (and therewith also capabilities) but can still be used by a wide range of people, similar to the development of tools for design and machining.

In consequence, it can be said, that a wider range of people can potentially create even very complex systems as a team or individually.

The situation is similar to the past, even though the tools and possibilities of production have changed in complexity. The important fact is, that people are being enabled to make things on their own 'once again'. And to maximize the impact, this needs to be supported as much and as early as possible. It needs to be part of our educational system in a multidisciplinary manner.

Being able to make things – to make almost anything – starts to make people think and act more extensively. In addition, they are also driven by the openness of the community by sharing projects and perspectives.

To approach this, we already did some interdisciplinary courses at our university that bridge the perspectives of the diverse disciplines, i.e. design, psychology, economics, electrical and mechanical engineering, biology, logistics and computer science. First achievements can be named, that yield new perspectives on certain topics (that vary from technical to methodological focus):

- Psychologists, economists and computer scientists developed new approaches for the use of FabLabs in a) human resource management and personnel recruitment, and b) corporate age-management to address the challenges of shortage of skilled professionals and the demographic change.
- Usability engineers, psychologists, designer and software engineers developed a new procedure based on a combination of creativity methods, digital manufacturing, prototyping tools and usability testing to optimize the early user experience design of interactive hardware systems.
- Designer, usability engineers, biologist, economists and computer scientists analyzed and developed sustainable solutions for a tiny home, build small-scale prototypes of the home's sub-systems and develop documentation that serves as an open

source repository for reproduction, with focus on sustainable technologies.

Besides the above study course results, we also offer training on digital fabrication for student of all faculties. Unless these courses are also open to many disciplines, the focus is more on teaching digital fabrication skills rather then making use of the multidisciplinary perspectives.
Additionally, within the last two years, we offered nearly thirty K12 courses to introduce STEM in different ways. Even here, we make use of the community impact by involving students of our university and to cause overlap with the public opening hours of our FabLab. This, by serendipity, creates knowledge exchange between people of diverse skills and backgrounds.
Along with that, we also offer the Fab Academy program at our University, in which people "will learn how to envision, prototype and document your ideas through many hours of hands-on experience with digital fabrication tools. We take a variety of code formats and turn them into physical objects." [3]

Provocative Statement

During the workshop, I will discuss how to dismantle barriers: Technical inability should not hinder people; instead, they can expect extensive support and will be able to solve their problems with the help of the community, and simultaneously extend and diversify their skills.

The challenge for the future is to manifest this kind of multidisciplinary work in an open curricular for all the study programs at Rhine-Waal University of Applied Sciences.

About the Author

Karsten Nebe is full time professor for Usability Engineering and Digital Fabrication (since 2011) at the Rhine-Waal University of Applied Sciences, Faculty of Communication and Environment in Kamp-Lintfort, Germany. He has worked as an Usability Engineer since 2002 and did his doctoral thesis in the field of integrating usability engineering and software engineering [10]. He is currently the head of the degree program "Usability Engineering, M.Sc." and an active member of various DIN, ISO/IEC working groups related to HCD. Since 2014, he is the director of the FabLab Kamp-Lintfort. The FabLab Kamp-Lintfort is a facility of the Faculty of Communication and Environment and *zdi-Zentrum Kamp-Lintfort* at Rhine-Waal University. On 600 square metres it offers a unique environment for makers providing extensive, state-of-the-art professional hardware, software and tools. It serves as a drop-in centre for multidisciplinary collaboration, and the university's broad range of technical topics is an excellent basis for inspiration. Its mission is to manifest digital fabrication at all levels of education and training.

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