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MAKERIET: A NORWEGIAN UNIVERSITY MAKERSPACE

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ABSTRACT
In this paper, we review the existing state of current Norwegian university makerspaces, and what is unique and common to all of them. The participating makerspaces will help discover the impacts they have on education, research, society and innovation rates, as well as the best practices. The paper will highlight experiences from *Makeriet*, a pilot makerspace at Oslo and Akershus University College of Applied Sciences (HiOA) at the faculty of Technology, Art and Design (TKD), a highly multidisciplinary faculty, that encapsulated technology, art and design disciplines.

Keywords: Makerspaces, engineering education, multidisciplinary, cross disciplinary, project-based learning.

1 INTRODUCTION

We are in a time with rapid cultural and technological changes that influence how and what we learn. These conditions require an adaptive education system that changes with the status quo and facilitates iterative learning. Engineering education traditionally introduce students to basic scientific facts that help explain the world we live in and beyond. To become a thinker and innovator students would additionally need to practice and develop skills that can be used to design, prototype and execute on new ideas. In this way, the students will not only develop the necessary skills that might be obsolete by the time they get into the workplace, they will also be given the right to learn how to respond to a situation when they are not prepared. University science labs are disciplined, structured and scripted. We therefor need to create an environment that forces the students to become independent, self-disciplined and self-structured, so that they can really learn how to learn and explore the world around them.

The Maker Movement is one solution to this problem [1,2,3]. It's a growing movement of hobbyists, designers, engineers, hackers and artists collaborating and working with traditional and modern tools for woodworking, sewing, soldering, rapid prototyping and programming to create objects for all purposes. It goes beyond the traditional workshop environment offering a unique culture of learning that is hands-on, peer-to-peer and openly shared. The rise of the movement is closely related to the rise of Makerspaces, also referred to as hackerspaces and FabLabs. They empower users with tools, necessary training and support for developing and creating their own prototypes. The spaces are shared, open and inviting, so that amateurs and professionals can work side by side. In universities, makerspaces have many benefits, such as increased motivation and self-esteem of students, empowerment, deeper learning and interdisciplinary teamwork, as well as being the space for creativeness and inventiveness [4].

In this paper, we review the existing state of current Norwegian university makerspaces, and what is unique and common to all of them. The participating makerspaces will help discover the impacts they have on education, research, society and innovation rates, as well the best practices. The paper will highlight experiences from *Makeriet*, a pilot makerspace at Oslo and Akershus University College of

Applied Sciences (HiOA) at the faculty of Technology, Art and Design (TKD), a highly multidisciplinary faculty, that encapsulated technology, art and design disciplines.

2 BACKGROUND

When the price of prototyping tools, such as laser cutters and 3D printers, dramatically dropped, rapid product development suddenly became available for normal people as well as engineers and industrial designer. Gershenfeld and colleagues at MIT were the first to use rapid prototyping tools in a low-cost lab, and created what is now known as FabLab. FabLabs shortly became a global movement in the beginning of 2000s, and later in 2005, the MAKE Magazine, a monthly publication targeted towards makers was created. Soon after, the Maker Faire was launched in California, where ordinary people could publicly show off their inventions and products.

In Norway and all over the world there have always been makers without the label. Omega Verksted, a student run workshop for engineering students at the Norwegian University of Science and Technology (NTNU) in Trondheim was founded in 1971 and has since then been the place for anyone in Trondheim to build anything from tesla coils to waffle machines. Åpen Sone at the University of Oslo (UiO) was founded in 2011, together with other popular public makerspaces like Bitraf, Hackerspace Oslo and Fellesverkstedet. And since then the number of makerspaces has reached 40, spread around the country in libraries, on campuses, national science centres and other public spaces. 18 makerspaces are under development, so by the end of 2017 the number of makerspaces will reach almost 60 [5].

Evidence of interest and growth can be seen over the past three to four years through the rising number of makerspaces, new maker events like Maker Faires, Restart parties, 3D-printing festivals, launch of maker organizations such as Norway Makers and a growing interest from foundations and large corporations willing to fund and open up spaces across Norway.

Makerspaces operating inside campuses should also be at focus, since there is a growing need for more practice-based engineering complementing the theoretical focus. The movement will have a disruptive impact on traditional education institutions, both in terms of learning methods, student motivation and creativity, innovation rates but also campus culture and society.

2.1 Impact on education

Potential impacts maker culture can have on the education models come from the benefit of working with physical models. The hands-on experience of making and remaking prototypes allows the student to focus on the process of creation and not just the end product, which carries perhaps a greater value. In such a setting, problem-solving skills, teamwork skills, presentation skills and communication skills are naturally developed, which are skills not necessarily developed in a traditional university setting [6]. Makerspaces can thus help foster skills that are hard to fit into the curriculum.

Transforming students into creators will also give them a sense of achievement and ownership. Multiple failures and reiterations force them to be creative and adaptive, seek advice from their peers and get feedback, which is important for learning [7].

Cross- and multidisciplinary approaches help in the creation of new products that benefit the positive growth of societies. Cross-disciplinary means viewing one discipline from the perspective of another. Multi-disciplinary means people from different disciplines work together, each contributing with knowledge specific to their discipline [8]. Makerspaces can be both cross- and multidisciplinary but also intradisciplinary, meaning they can focus around one discipline. In cross- and multidisciplinary settings students will not only gain experience from different fields, but also learn to communicate with people from different disciplines.

By bringing makerspaces to university campuses, the maker culture can help shift the focus from teacher-centred education to a more student-centred one. With a greater emphasis on peer-to-peer learning and project-based learning, the teachers can play the role of a facilitator that connects them to right tools, training, people and environment to thrive in.

2.2 Impact on Innovation

Digital fabrication tools can be used to accelerate prototyping and design cycles, helpful in any product development process that could result in an innovation [4]. Learning these types of tools in a controlled and safe environment empowers and motivates students to tackle a design challenge, with or without the help of their peers. Entrepreneurship has had a growing focus in Norway, a country with an economy highly dependent on oil prices, so integrating entrepreneurship with education will surely prepare students for emerging economies and diverse workplaces.

Makerspaces encourage students to be free and explore what they like and do not like. Designing and making objects for any purpose is motivating, and this type of motivation benefits the students' ability to persist in the face of challenge [9]. For an innovation to truly find place, multiple design iterations, prototyping and testing is required, and for that grit and passion must be present.

A makerspace also provides opportunities for innovation when groups of people from different disciplines are given the chance to work together in cross or multidisciplinary and practice-based projects.

2.3 Impact on Society

The maker movement could help engage marginalized groups like youth, the older generation, low-income families, refugees and immigrants. In Norway, outreach programs like "Jenter og Teknologi", ENT3R, IT-camp for girls and Kidsa Koding, as well as events like Girl Tech Fest, 3D-printer festivals and Maker Faires help bring making to the public and increase STEM visibility.

There will be an increasing need for engineers in the future, and recruiting youth to engineering and design programs would help relieve the coming pressure. Makerspaces can, by showcasing the creative, rewarding and fun parts of engineering to children and youth, be a key player in the recruiting and marketing efforts of education institutions. Making the space open for the public, arranging guided tours and inviting the public to exhibitions and workshops could have a big impact over time.

2.4 *Makeriet* at HiOA

A focus group of staff and students from the TKD faculty at HiOA met at the end of 2015 to create a draft with needs, vision, activities and content for a makerspace. The draft was later presented to faculty management in April 2015, which then decided to financially support the space. At the beginning of 2016 a makerspace was established in a lab, formerly used by engineering students attending the study program Medical Technology at the Mechanical, Electronics and Chemical Engineering department. The focus group had the desire *to collaborate with other disciplines* in the practical use of digital techniques like 3D printing, construction, electronics and e-textiles. The main needs of the students were *to work in multidisciplinary projects, feel the pleasure of mastery, and to develop innovative ideas and projects.* With these needs in mind, it was decided to pilot the makerspace on medical technology engineering students. In the development of medical devices and applications, different disciplines and skills are required to perform, so it was hoped that they would bridge the gap between students from different disciplines. Examples of such disciplines in only the design phase are electrical, chemical, mechanical, health practitioners, user groups and manufacturers.

Introductory classes and workshops introduced students to 3D-modelling, 3D-printing, soldering, and programming. This helped create more fun and creative projects like mind controlled hand prostheses and heart rate monitors using light. Students reported positive feedbacks on the pilot, even though they found it challenging to adapt to the culture of making. After the initial semester, we gained some momentum and started acquiring more equipment after seeing how the popularity grew. Students for example demanded more tools and work areas designed for easier realization of electronics projects. During the opening year, the number of enthusiastic and maker-passionate students grew, which helped spreading the maker culture at HiOA.

3 METHODS

Norway has 8 universities and 13 university colleges, in addition to several private higher education institutions. The first phase of this investigation was to discover all the institutions that have a makerspace. This was accomplished by using the list of existing higher education institutions in addition to the list of Norwegian makerspaces, updated by Norway Makers. As shown in Table 1, 14 university makerspaces were discovered, where two are in a startup phase.

After the discovery stage, a questionnaire was developed to collect qualitative and quantitative data on the state of Norwegian university makerspaces. Answers from 13 makerspaces were recorded, and analyzed.

Table 1. 14 Norwegian university makerspaces discovered

University	City	Makerspace Name
NTNU (Norwegian University of Science and Technology)	Trondheim	Hackerspace NTNU
NTNU (Norwegian University of Science and Technology)	Trondheim	Omega Verksted
NTNU (Norwegian University of Science and Technology)	Gjøvik	Designverksted
NTNU (Norwegian University of Science and Technology)	Ålesund	Fablab NTNU
NTNU (Norwegian University of Science and Technology)	Trondheim	Entreprenørskolen
NMBU (Norwegian University of Life Sciences)	Ås	Idedrivhuset
NMBU (Norwegian University of Life Sciences)	Ås	Eik Ideverksted
UiO (University of Oslo)	Oslo	Åpen Sone
HiOA (Oslo and Akershus university college of applied sciences)	Oslo	Makeriet
HiOA (Oslo and Akershus university college of applied sciences)	Oslo	Produkt Design verkstedene
HiØ (Østfold University College)	Halden	HiØ Makerspace
Westerdals Oslo School of Arts, Communication and Technology	Oslo	Westerdals Makerspace
AHO (The Oslo School of Architecture and Design)	Oslo	AHO verkstedene
UiS (University of Stavanger)	Stavanger	Didaktisk Digital Verksted DDV

4 RESULTS

The Makerspaces answered questions regarding the management of the space, how it is financed, what their target groups are and if the space is located on campus. They were also asked questions on how often the space is used by faculty for education and research purposes. Additionally, they were questioned on their degree of being multi- or cross-disciplinary, if they have any success stories, what their biggest challenges have been and on the existence of informal/formal partnerships with organizations, companies and outreach programs. The answers are presented in Table 2, Figure 1, and discussed in the next section.

Table 2. Answers regarding finance, management and membership

Makerspace name	Location	Membership	Management	Financing
Omega Verksted	On Campus	Free for everyone	Student run	Sales and workshops
Fablab NTNU	On Campus	Free for everyone	Student & faculty run + specific staff	Department and industry
Hackerspace NTNU	On Campus	Only students & employees	Student run	Department
NTNU Entreprenørskolen	On Campus	Only students & employees	Student & faculty run + specific staff	NTNU and NOKUT
Designverksted	On Campus	Free for everyone	Student & faculty run	Department
Åpen Sone	On Campus	Free for everyone	Student & faculty run + specific staff	Sparebankstiftelsen DNB and department
Product Design Workshops	On Campus	Only students & employees	Specific staff	Department
Makeriet	On Campus	Free for everyone	Student & faculty run	Faculty
Eik Ideverksted	On Campus	Only students & employees	Student run	Sparebankstiftelsen DNB

HiØ Makerspace	On Campus	Only students & employees	Student & faculty run	Department
Westerdahls Makerspace	On Campus	Only students & employees	Student run & specific staff	University
AHO Verkstedene	On Campus	Only students & employees	Specific staff	University
Didaktisk Digital Verksted DDV	On Campus	Only students & employees	Specific staff	University

Figure 1. Showing the degree of being multi- or cross-disciplinary, of utilization of the space for education, research, marketing and recruitment purposes

5 DISCUSSION

Review of the data indicates some interesting trends with university makerspaces. It seems like the most common choice of management is a combination of student run and specialized support staff. For example, Åpen Sone is run by students and support staff, in addition to faculty members. Some however are purely student initiatives, like Omega Verksted that has a 45 year of experience with making. Their financing model also reflects this, since they are financed through food, drink and event sales. It often takes a lot of time for new makerspaces to become self-driven. Goodwill and support from the users are key for survival. But most of the makerspaces investigated are financed either by the university itself, foundations and organizations, or a combination. For new makerspaces this is not surprising, but there are financial models that can also help minimize the need for external support. Industry collaborations are an example, where a makerspace can help prototype for business owners and even entrepreneurs. Fablab NTNU has acquired some machinery through industrial projects.

It should also be noted that all makerspaces are free to use by students and staff, and almost half are free to public. This is great news, since a makerspace should welcome students and faculty from all departments, not just people from their own department. This openness is also visible by the overwhelming majority of makerspaces that consider themselves as cross- or multidisciplinary. This is important for the learning environment and for maintaining the space as a creative and fun place. At Makeriet for example, there was a project where students studying fashion needed help with designing and 3D printing their own buttons for a school project. An engineering student from medical technology volunteered to help, and became their teacher and guide. The student later reported that it was an interesting way of applying 3D-printing, and that it helped him think about the possibilities with the technology. Eik Ideverksted reported that the maker culture has *helped break down academic walls* and Westerdals reported *More interdisciplinarity between students and faculties.* These are further proof that a makerspace should embrace all disciplines.

A surprising finding is that most spaces do not contribute to research. Research is not always a focus point for makerspaces where freedom to play is often highly valued, but experiences from Makeriet shows that students are interested in research, and that involving them in research projects is helpful for both the researcher and the student. NTNU Entreprenørskolen reports that *students help, guide, and inspire each other through impressive achievements. The sharing culture is highly developed*. A lot of startups also have their roots at makerspaces. Omega Verksted, Hackerspace NTNU, AHO workshops, Eik Ideverksted, Produktdesign workshops, Åpen Sone and NTNU Entreprenørskolen all report of startups coming out of their spaces. Fablab NTNU reports a greater *stimulus for creating as well as understanding of pleasure and sorrows of making things.*

The data shows that makerspaces are highly used for recruitment and marketing purposes. Åpen Sone do arrange IT camp for girls and arrange visits for high schools, and Makeriet has been involved in the *Girls and Technology (*Jenter og Teknologi) program and STEM training for high school students (ENT3R). Most of the makerspaces are somewhat open to events and programs, but few are arranging or hosting such. The biggest challenges reported are very different from space to space, but a few considers having enough physical space as one, while others have trouble recruiting users.

6 CONCLUSION

There is no doubt after this study how much the maker culture has impacted both education, innovation and society. We believe that our paper has contributed in highlighting the state of university makerspaces in Norway. By examining the different approaches universities have, features and components of makerspaces can be further analyzed to see what the best practices are.

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