Engineering Students Perceived Value of Makerspaces in Relation to Future Career Preparation

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Kate Youmans[1], Idalis Villanueva[2] Louis Nadelson[3], Janna Bouwma-Gearhart[4], Adam Lenz[5], Sarah Lanci[6]

[1]Kate Youmans; Engineering Education Department, Utah State University; e-mail: kate.youmans@usu.edu

[2] Idalis Villanueva, Engineering Education Department, University State University; e-mail: idalis.villanueva@usu.edu

[3]Louis Nadelson, Leadership Studies, College of Education, University of Central Arkansas; e-mail: lnadelson1@uca.edu

[4]Janna Bouma-Gearhart, College of Education, Oregon State University; e-mail: Jana.Bouwma-Gearhart@oregonstate.edu

[5] Adam Lenz, College of Education, Oregon State University; e-mail:lenza@oregonstate.edu

[6] Sarah Lanci, Mechanical Engineering, Colorado Mesa University; e-mail: slanci@coloradomesa.edu

INTRODUCTION

As the popularity of makerspaces in higher education continues to grow, we seek to understand how students perceive the utility of these spaces to prepare them for future careers in engineering. These spaces are often promoted for their capacity to teach 21st century skills such as innovation and collaboration, while at the same time exposing students to current prototyping and manufacturing methods [1], [2]. In this early stage qualitative study, the authors used an open-ended questionnaire to gather student perceptions of how two on campus spaces for "making" could prepare them for future careers in production or development. A qualitative thematic analysis of thirty-two student responses suggest that engineering students recognize the value in being able to translate an idea from conceptual design to functional product within these spaces. Further, they appreciate the opportunity engage in active and collaborative learning in the spaces, the utility in learning the manufacturing process relevant to their future careers in industry. These preliminary findings suggest that students recognize the value of incorporating makerspaces into an engineering curriculum, as these spaces can help prepare them for future careers in engineering.

BACKGROUND

Incorporating spaces for making into engineering curriculum can be a powerful tool in educating the next generation of scientist and engineers. Initially incorporated into engineering curriculum in the early 2000's makerspaces have grown in popularity and can now be found in at least 35 of the top 100 engineering schools [1]. The establishment of makerspaces in K-12 schools, libraries and universities continues to grow as they engage the students in hands-on exploration [3].

Though makerspaces fall under a variety of names and physical representations, they provide an opportunity for students to engage in learning through the construction of physical objects. Supported by Papert's learning theory of constructionism, the development of physical objects can bridge the gap between formal and informal learning, helping students to connect classroom learning to real world problem solving [4], [5]. Further, the construction of physical prototypes has been shown to increase the quality and effectiveness of final designs [1]. To create these physical prototypes, students must also develop technical skills such as 3D modeling, computer programming and technical drawings needed to effectively use prototyping and manufacturing equipment [6]. With their growing popularity, makerspaces have helped to draw attention to the benifits of learning through construction of physical objects at all levels of education.

Beyond the identifiable advantages of learning digital fabrication processes and rapid prototyping skills, the integration of makerspaces into engineering education provides an opportunity to develop engineering students' 21st century skills through active learning and collaboration [7], [8]. By participating in makerspace activities, students are exposed to the maker mindset which supports growth through failure, self-determined exploration and collaborative learning [5], [9]. The mindset encourages learning through self-determined exploration, allowing the individual to explore projects of their own interest with low risk. The growth oriented and failure positive environment suggest that mistakes and failures are a positive part of the learning process. The collaborative nature of the spaces encourages students to engage in developing teamwork and communication skills to be able to work effectively with their peers. The purpose of this work is to explore how engineering students perceive spaces for making can help them prepare for future engineering careers.

METHODOLOGY

The researchers sought to understand the following research question: *How do engineering students perceive campus makerspaces can help prepare them for future engineering careers?*

To answer this research question, an open-ended questionnaire was integrated into a homework assignment, as part of an Institutional Review Board (IRB) approved project and protocol, for an introductory engineering course at a western rural university in the United States during the fall 2017 semester. This course was design to introduce students to the different functions and disciplines within engineering through active learning projects, and career exploration. The course included 41 students, out of which 37 were male and 4 were female. The majority of students (32 out of 37) were freshman or sophomores in the College of Engineering.

For the assignment, students were asked to visit two campus spaces design for making: (a) a newly opened contemporary makerspace and (b) a traditional engineering shop. After visiting both spaces, students were asked to answer a series of open-ended questions. Earlier work by the research team

compared the nature and scope of projects and the safety and equipment in each space [11]. For the scope of this study, the research team focused on students' perceptions of how both campus spaces for making could support future career development. To do so, we focused our review focused on the fourth homework question that asked:

- *Thinking about the function of development or production, how do you think using these spaces would help prepare you?*

Thirty-two responses were collected and evaluated using an thematic coding. The coding was completed in MAXQDA 2018 a mixed methods analysis software. A test of the coding system was conducted and an inter-coder agreement of 93% was achieved.

RESULTS

In responding to open-ended questions, students recognized the value that these two campus spaces for making provide in preparing them for future careers in engineering. In particular, students recognized the value of taking an idea form conceptual design to physical product. Further, students recognized the value of the collaborative and hands-on nature of these spaces. Finally, students recognized that utilizing the equipment in both of the spaces would help prepare them to understand prototyping and manufacturing processes that are used in industry. Frequency of occurrence of the themes along with example quotes are summarized in Table 1.

Table 1: Representative Quotes Describing the Value of Makerspaces for Career Preparation

Creating a Physical Prototype *Frequency of Occurrence (13)*
"Before production can begin, an engineer must have a safe place to construct and test new designs. A design on paper may look great, but it has no purpose until it is actually constructed. This requires a lot of equipment and tools, which can be found in labs such as these. These spaces also allow for group work, which can greatly speed along the develop process." - Participant 27, Line 169
"I think they would help me with development and production a ton because they would allow you to take designs from the drawing board and bring them to life to test them and improve them." – Participant 18, Line 113
Collaborative and Active Learning *Frequency of Occurrence (10)*
"Anything that teaches you hands on how to fix a problem or create something will teach you faster than any lecture in my opinion. These labs are great to advance the learning of those to work on projects from the real world. To me experience is sometimes a greater incentive for someone to hire you over getting straight A's." -Participant 14, Line 92
"As I develop and produce different projects and materials, I think these labs will give me the resources I need to create innovative and reliable products. It is also nice that in both locations, there are people working there who can help me work machines and come up with new ideas." -Participant 30, Line 183
"Both spaces encourage group collaboration, and maintain a safe environment for students to bring designs to life." – Participant 27, line 167

Table 1: Representative Quotes Describing the Value of Makerspaces for Career Preparation

Learning Manufacturing and Production Processes *Frequency of Occurrence (14)*
"This equipment is an engineer's future. Using these labs could help me prepare for my career path. As a mechanical engineer there is a lot of design and production involved in it, so using these cutters, presses, etc. can teach me how to design and produce a product." - Participant 32, Line 204
"They allow you to use tools and fundamentals that are going to prepare me for my future. I think it is very important to get a little bit familiar with all of the different types of machines so that if I am ever in a job situation and they want me to use it I will already have experience. I think that it is really cool that the school provides these resources for students." -Participant 5, Line 43
"Using these spaces has great potential for hands on learning how the manufacturing process works. By understanding how something is made, you can better understand how to design things with the production process in mind." - Participant 29, Line 176
"These spaces can give you an idea of how going through the whole production process works. Seeing something made from simple sketch all the way to the real product would help me get an idea of how the process works and what is required of me to get it done." –Participant 11, Line 77
"They would help you get a feel on how you design the products. If you see how the process works in creating your ideas and designs, then you can better know how to design the products. I think you would also be able to save more time as you understand the process. Less room for mistakes and errors in your designs." – Participant 12, Line 82

DISCUSSION AND IMPLICATIONS

This preliminary study helps illustrate students' perceptions of the utility of makerspaces in preparing them for future careers in engineering. Based on the data collected students recognize that being involved in makerspaces can help prepare them by providing opportunities to learn in an active learning environment with the support of peers and trained staff. This collaborative and the active learning environment can foster many of the competencies that future engineers will need including teamwork, problem-solving, communication and lifelong learning [7], [12]. Additionally, students recognize that these spaces can help them understand the translation of a conceptual design into a physical object. Engaging in this transformation, from a design on paper to a physical model has been show to produce higher quality and more effective designs [1]. Finally, students recognize that working in these spaces can help them develop the technical skills in production and manufacturing that employers are looking for. These student perceptions as well as the growing body of research on makerspaces support the integration of these spaces as a learning tool in engineering education.

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