Full Paper: Can a First Day Activity Help Raise Customer Awareness, an Important Attribute of an Entrepreneurially Minded Engineer?

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Dr. Haolin Zhu earned her BEng in Engineering Mechanics from Shanghai Jiao Tong University and her Ph.D. in Theoretical and Applied Mechanics from Cornell University, with a focus on computational solid mechanics. After receiving her Ph.D., Dr. Zhu joined Arizona State University as a full time Lecturer and became part of the freshman engineering education team in the Ira A. Fulton Schools of Engineering. She currently holds the title of Senior Lecturer and is the recipient of the Fulton Outstanding Lecturer Award. She focuses on designing the curriculum and teaching in the freshman engineering program. She is also involved in the NAE Grand Challenge Scholars Program, the ASU ProMod project, the Engineering Projects in Community Service program, the Engineering Futures program, the Global Freshman Academy, and the ASU Kern Project. Dr. Zhu also designs and teaches courses in mechanical engineering at ASU, including Mechanics of Materials, Mechanical Design, Mechanism Analysis and Design, Finite Element Analysis, etc. She was part of a team that designed a largely team and activity based online Introduction to Engineering course, as well as a team that developed a unique MOOC introduction to engineering course for the Global Freshman Academy. Her Ph.D. research focuses on multi-scale multiphase modeling and numerical analysis of coupled large viscoelastic deformation and fluid transport in swelling porous materials, but she is currently interested in various topics in the field of engineering education, such as innovative teaching pedagogies for increased retention and student motivation; innovations in non-traditional delivery methods, incorporation of the Entrepreneurial Mindset in the engineering curriculum and its impact.

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Introduction

During the recent years, many institutions across the nation have joined the Kern Entrepreneurial Education Network (KEEN) that aims to promote entrepreneurial mindset in engineering education [1]. Promoting the entrepreneurial mindset is not the same as producing entrepreneurs. The goal is to instill a mindset that complements the technical skillset so that engineering students are able to think like entrepreneurs, i.e., be able to explore the world with Curiosity, make Connections, and identify opportunities to Create value (defined by KEEN as the three C framework) [1]. The attributes of an entrepreneurially minded engineer depicted by KEEN involve technical skillset, customer awareness, business acumen, and societal value [2]. Therefore, customer awareness is an important aspect that needs to be included in the curriculum. Engineering students should no longer be trained to only be able to follow technical specifications provided when it comes to design. Quite a few authors have also emphasized the importance of incorporating customers in course activities especially in design projects in order to instill the entrepreneurial mindset in the curriculum [3-5]. For example, Gerhart and Melton argued that "*EML [Entrepreneurially Minded Learning] assignments differ from PBLs [Project Based Learning] in that they often include a stakeholder or customer. Because stakeholder feedback is essential to re-evaluate opportunities and/or understand what is deemed as valuable (i.e., value is subjective), it is important for the assignments to include a realistic customer (who can be a fictional role-player).*" [3]. In quite a few efforts to incorporate the entrepreneurial mindset in the first year curriculum, customers were incorporated into the assignments or projects. For example, Gerhart et al., implemented a project that requires students to speak to relevant stakeholders of the University when redesigning their first year course to foster the entrepreneurial mindset [6]. Zhu and Mertz have incorporated customers into their introduction to engineering course in three different ways and compared how the differences affected the way and extent to which students exercised the three C's in their project work [5]. Jensen and Schlegel required students to interview potential mini-gold customers when they implemented the entrepreneurial mindset into their first year mini-golf hole design project [7].

In an effort to incorporate the entrepreneurial mindset into the introduction to engineering course at Arizona State University, a first day team based hands-on design activity was developed, among many other activities and projects. And it was implemented during the fall 2018 semester in a section of the course with 37 students during the first lab before students were introduced to any topics or concepts. This activity was designed to help raise customer awareness in first year students from day one. Can this first day activity help raise customer awareness, an important attribute of an entrepreneurially minded engineer in first year students? To answer this question, a survey was conducted prior to the activity to gauge students' understanding of how to approach design problems. After the first lab, students individually submitted reflections about their first lab experience and these reflections were analyzed qualitatively. Themes that emerged during the qualitative analysis of the reflections were noted and the frequencies at which they appeared were counted and tabulated.

In the paper, the course and the activity will be described. Findings from the qualitative analysis will be presented and discussed. Possible improvements to the activity and ways to adapt it for shorter class times will also be shared.

Activity Description

The introduction to engineering course at Arizona State University is a two credit 15 week course with a weekly 50-minute lecture and a 3-hour lab that is conducted in a makerspace. It is taught in sections of approximately 40 students and focused on the engineering design process, engineering problem solving, and skills that are essential for engineers. Students usually work in teams of 3 or 4 on two hands on design projects throughout the semester. During the first lab period, a small hands-on design activity is done to engage students from day one and to provide opportunities for them to work with their team that is just formed. During recent years, the course has been revamped to incorporate the entrepreneurial mindset. The first day activity that is described below is among the many other efforts made to achieve this goal in this course.

The group based activity was designed to be implemented during the first lab of the course prior to the introduction of the engineering design process. The customers involved in the activity are the professor and her son with a fictional scenario: the professor needs to focus on work while her three-year old son stays in her office occasionally during the week days. The first phase of the activity involves a physical prototype while the second results in a conceptual design. At the beginning of the activity, the only instruction given to the teams is to design and build a chair out of cardboard and duct tape for the professor's office. No further information is provided unless students ask questions during the activity. After all the chairs are created, there is a brief discussion about how to determine the effectiveness of their designs. Based on students' suggestions from the discussion, all designs are tested to determine if they are able to successfully hold the professor's weight. At the end of this first round, further discussions are made about whether the criterion used for testing is appropriate and where the criteria should come from. During the discussions, the customers including the professor as the payer and her three-year old son as the user are introduced and the intended purpose of the chair was revealed – the professor wants a chair for her son so that he can stay in the corner of the office quietly while she focuses on work. For the second phase, students are tasked with redesigning a solution to address the customer's needs and these conceptual designs are presented at the end of the activity. A suggested timeline for this activity for a class of 10 groups can be found in Table 1. If not enough class time can be used for this activity, alternative formats can be used for students to share their final conceptual designs. The conceptual design phase can also be moved outside of class, though it is suggested that students be provided with opportunities to interact with the customer during this phase. This may be done virtually through a Google doc or in an online discussion forum.

Table 1. Suggested timeline for the activity

Activity	Allotted time (10 groups)
Introduction and hands-on design	35min
Testing	15min
Discussions	10min
Conceptual design	30min
Presentation & Summary	30min
Total Time	120min

This activity was implemented during the fall 2018 semester in a section of the introduction to engineering course with 37 students during the first lab period. During the first phase, no questions were asked about who the customer is, what their needs are, what the chair will be used for, or even what the professor's office is like. All teams focused on creating a chair that would be durable for an adult person. During the discussions, some students mentioned that they thought or assumed the chair was to be used by the professor herself or her students. During the second phase, all groups asked the professor (customer) many questions about the problem and her concerns, the office, the surrounding environment, and about her son. Through customer discovery, many teams discovered that the chair that the customer requested may not necessarily be the most effective solution to address the needs. Many of the solutions created during this phase did not involve a chair.

Assessment and Results

In order to assess whether this activity achieves the objective of raising customer awareness, a pre-survey was conducted at the start of the course and a post reflection assignment was implemented after the first lab period. In the pre-survey, students reported whether they had been introduced to the concept of engineering design prior to the course and created a visual representation of the process they would utilize when approaching a design problem. In the post reflection, students were asked to provide a general summary of what they had done or learned during the first lab and then respond to four questions. Two out of these four questions are related to the activity:

- How did you come up with the design for the lab activity? What would you do differently in the future when approaching a design problem?
- Did you learn anything new about working in a team, and/or designing a solution after the first lab?

Thirty one students provided consent to participate in this research study and their responses were analyzed qualitatively. The pre-survey responses were checked to see if customer was mentioned in their visual representations. For the post reflection, the number of reflections in which customer was mentioned was counted and a few specific themes were identified.

In the pre-survey, only one out of the thirty one participants mentioned customer and this participant indicated that s/he had been exposed to the concept of engineering design through the

Engineering Projects in Community Service (EPICS) High School program. Projects involved in the EPICS programs all involve customers, i.e., the community partners and thus his/her prior experience had led to the mentioning of customers: "*one would have to question and research those who are affected by the problem*". Though the other eleven participants who indicated that they had been introduced to the concept of engineering design before this course through Project Lead the Way, Introduction to Engineering course in high school, or EPICS failed to include customer involvement in their visual representations of the process used to approach design problems.

In the post reflection submissions, 24 out of the 31 participants (77.4%) mentioned customers and 11 of them mentioned it in more than one places in their reflections. When these reflections were analyzed qualitatively, four themes emerged and the frequency at which each of these themes appeared is summarized in Table 2. The total number of mention of a specific theme may not match the number of reflections in which that theme was found because some themes were mentioned in more than one places in some reflections. In some reflections, there is mention of customer, but not a specific theme was identified, for example, one mentioned "*I learned that the customer is the number one priority when creating a solution to the problem*".

Table 2. Themes and frequencies of their appearance (Total number of reflections = 31)

Theme	Total number of mention of the theme	Number of reflections where the theme was found
Customer needs and wants	24	19
Communication with the customer	22	13
Requirements and criteria	7	7
What customer requests may not address their real needs	3	3

For the theme *customer needs and wants*, some participants discussed how failing to identify the needs and wants of the customer has led to unsuccessful designs while others mentioned the importance of considering the needs and how designs should be created to address the needs. For example, one participant noted: "*Unfortunately, we did not consider the customer's wants and needs leading to an unpreferable design.*", another mentioned "*In the future, we would figure out what is needed before we build it*", and one pointed out "*You need to make sure you are fulfilling the clients needs while solving the problem*".

For the theme *communication with the customer*, many mentioned that they have learned to ask the customer questions. And examples of this include: "*What I learned is that communication with the clients is key to a successful design*", "*Next time we must begin by asking many questions about the client's needs, wants, and criteria preferences*", "*My team and I found out how important it is to speak to the customer and figure out their needs/wants*".

The other two themes did not show up as frequently in the reflections as the first two. Besides these four themes that appeared in more than one reflections, one participant mentioned the importance of identifying the cause of the problem. And another said: "*I also learned that engineering should be more about SHOULD we build it rather than CAN we build it*". Thinking

about the “why” before the “how” will likely lead to design solutions that create value for the customer.

Conclusions and Suggestions

This paper describes a first day activity for the introduction to engineering course and its effectiveness at raising customer awareness. The suggested length for this activity is 120 minutes and possible ways to shorten it for less class time are proposed. Prior to this activity, only one participant included customer in their visual representation of engineering design process, indicating that almost all of the participant did not realize the importance of customer involvement in the design process. Based on qualitative analysis of reflections submitted after this activity, it was found that twenty four out of the thirty one students mentioned the importance of asking customer questions and learning about their needs without being prompted to talk about customers. Out of these twenty four students, eleven mentioned this in more than one places in their reflections. The following four themes emerged in these reflections: *customer needs and wants*, *communication with customer*, *requirements and criteria*, and *what customer requests may not address their real needs*. Based on these results, it can be concluded that this first day activity is very effective at raising customer awareness.

Suggested improvements to this activity include providing more materials for prototyping as using cardboard limited the types of designs that students were able to create; and making the first phase conceptual and the second phase hands on so that students will stay more engaged during the second phase of the activity.

References

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