Board 107: Work in Progress: Development of an Innovation Corps-Modeled Bioengineering Course to Promote Entrepreneurial Engagement among Undergraduate Students.

Amanda Walls
Ishita Tandon
Timothy J. Muldoon

Dr. Timothy Muldoon is an Associate Professor in the Department of Biomedical Engineering at the University of Arkansas. Dr. Muldoon teaches the Clinical Observations and Needs Finding, the Biomedical Instrumentation, and the Biomedical Microscopy courses within the Department, and also serves as the Undergraduate Coordinator. Dr. Muldoon's research interests include engineering education, miniaturized optical imaging and spectroscopy approaches for endoscopy applications, and metabolic imaging of the tumor microenvironment.

Prof. Jeff Wolchok, University of Arkansas

BS/MS in Mech Eng from UC Davis PhD in Biomed Eng from University of Utah

Worked in the medical device industry - 8 years

Capstone Design instructor - medical device design

There are other authors for this abstract

Dr. Mostafa Elsaadany, University of Arkansas

Dr. Mostafa Elsaadany is a Teaching Assistant Professor in the Department of Biomedical Engineering at the University of Arkansas. Dr. Elsaadany teaches Introduction to Biomedical Engineering, Biomechanical Engineering, Biomolecular Engineering, Senior Design, and Entrepreneurial Bioengineering. He is active in Engineering Education Research where he studies different mentoring strategies to ensure the academic and professional success of historically marginalized minorities. Further, he studies strategies for instilling the entrepreneurial mindset in engineering students as well as innovative approaches to teaching such as using virtual reality.

Work in Progress: Development of an Innovation Corps-Modeled Bioengineering Course to Promote Entrepreneurial Engagement Among Undergraduate Students

Ms. Amanda Walls, University of Arkansas

Amanda Walls is a doctoral student, funded by an NSF Graduate Research Fellowship, in the Department of Biomedical Engineering at the University of Arkansas. She received her B.S. in Biomedical Engineering from Harding University, where she was first introduced to engineering education research examining students' perceived identities in a first-year engineering course. While her current dissertation work is focused on developing organ-on-chip technology to study the human airways, Amanda also has a strong interest in teaching and education research. She has devoted a semester to teaching as an adjunct instructor for Fundamentals of Chemistry at John Brown University, completed a micro-certificate in the professoriate, and led several educational experiences for underrepresented high school students. Amanda plans to pursue a higher education teaching career and research strategies to promote active learning and improve self-efficacy amongst engineering students.

Dr. Ishita Tandon, University of Arkansas

Ishita Tandon is an SEC Emerging Scholars Postdoctoral Fellow in the Department of Biomedical Engineering. Her research involves developing multiscale *in vitro* and *in vivo* models of heart valves aimed at studying the early detection and monitoring of calcific aortic valve disease. She has received the American Heart Association Predoctoral Fellowship and the University of Arkansas Doctoral Academy Fellowship along with multiple other honors and travel grants. She has also published 13 peer-reviewed articles, a book chapter, and given over 20 conference presentations including an invited talk. Ishita served as the finance chair of the Graduate Society of Women Engineers (SWE) and was the co-founder and president of the Biomedical Engineering Department Graduate Students' Organization. Her career objective is to pursue translational biomedical research in academia. Her leadership goal is to inspire and uplift women who lack opportunities for education, self-development, growth, and leadership.

Dr. Timothy J. Muldoon, University of Arkansas

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Dr. Jeffrey Wolchok, University of Arkansas

Dr. Jeff Wolchok is an Associate Professor and Department Head in the Department of Biomedical Engineering at the University of Arkansas. Dr. Wolchok directs an interdisciplinary research program focused on the design, development, and evaluation of extracellular matrix biomaterials. His lab uses diverse themes in material science, mechanobiology, muscle biology, and regenerative medicine to develop biomaterial-based strategies capable of repairing damaged skeletal muscle. As an independent investigator, he has successfully placed graduate and undergraduate students in

government, academic, and industry scientist positions. He teaches Biomaterials and Design of Experiments.

Dr. Mostafa Elsaadany*, University of Arkansas

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* Corresponding author: mselsaad@uark.edu

Introduction

In recent years, the retention of undergraduate engineering majors and the subsequent career pathways of students after graduation has gained concern as studies reveal that many engineering students do not continue into engineering careers, despite a global need for them. Decreased engineering self-efficacy, lack of engineering identity, and low perceived levels of career preparedness have all been shown to play a major role in the loss of potential engineers[1]–[3]. One factor that may be contributing to this dilemma is that many engineering programs focus on teaching only technical knowledge rather than a combination of technical and professional skills and empathetic design. Students in such programs are often left feeling unprepared to work in a professional business environment where they are tasked with creating effective solutions for real customers [4], [5]. To promote more confidence in engineering students and improve students' success in engineering careers, many degree programs have explored the incorporation of entrepreneurial engagement and the development of students' "entrepreneurial mindsets". Entrepreneurship in the engineering curriculum promotes the development of soft skills, business knowledge, and the ability to create innovative solutions for "real-world" applications and customers – many of the skills that students feel they lack as they work towards their degrees. In turn, students who participate in entrepreneurial activities in their engineering programs have been found more likely to pursue an engineering career post-graduation compared to students who have no entrepreneurial experience [6].

To stimulate more entrepreneurial involvement within the range of STEM disciplines, the National Science Foundation (NSF) and the National Institutes of Health (NIH) recently introduced similar programs called Innovation Corps (I-Corps), which are designed to lead small teams through customer discovery and business model validation during a seven- to eight-week bootcamp. Both programs are widely recognized as effective training camps that "prepare scientists and engineers to extend their focus beyond the university laboratory" and commercialize new technology faster [7]. These programs are primarily intended for graduate students and start-up business leaders, yet there is a need to engage students in entrepreneurial activities sooner in their education [8]. One study by Pellicane and Blaho [8] adapted the I-Corps model to an undergraduate course and found that students who participated had significantly increased collaboration, communication, and networking skills after the course. Another study by Lagouda, et al [9] looked at the impact of an I-Corps program on undergraduate and graduate engineering students at a large university and found the program had an overall positive effect on students' perceptions, and students who participated maintained a high interest in entrepreneurship. The results from these studies suggest the I-Corps model has several potential benefits within undergraduate education, but more research is needed to elucidate the features of I-Corps that are most valuable at the undergraduate level. Thus, we have created a new Entrepreneurial Bioengineering course intended to promote students' entrepreneurial engagement and development of an entrepreneurial mindset through a series of I-Corps modeled tasks. The goal of this study is to understand the extent to which the entrepreneurial experience, gained through customer discovery and business model validations, might affect students' career goals. The study also investigates the attributes of the course which affect students' perceptions of their own self-efficacy, identity, and overall confidence to succeed as an engineer in creating value for customers.

Methods

Entrepreneurial Bioengineering Course

The Entrepreneurial Bioengineering course is adapted from both the NSF and NIH I-Corps programs and follows the same general structure of customer discovery. The course is offered to junior and senior undergraduate engineering students once a year and enrolls 20-30 students each year, introducing entrepreneurship, business model canvas, and lean start-up principles to the students with a focus on medical device customer discovery and technology commercialization. Throughout the semester, students work in teams to perform customer discovery and product-market fit experiments through customer interviews to test their business model hypotheses. Students submit weekly updates on their progress through the Launchpad Central software, a widely used tool to maximize innovation management. Students also complete assignments to analyze teamwork effectiveness, create business model reports, design a minimal viable product prototype, and present their discoveries via oral presentations to community members. Class time is spent discussing many of the learning objectives (Table 1 - appendix) and preparing students for interviews, reports, and presentations. Each learning objective has 3-8 associated specific student outcomes.

Evidence of Student Learning

To assess student learning outcomes and gain a deeper understanding of the value of the I-Corps modeled course, we devised both a pre- and post-course survey which was administered using the Qualtrics online survey system. The surveys consisted of open-ended and 5-point Likert scale questions focused on perceived entrepreneurial knowledge and soft-skill development. The questions in both the pre- and post-course surveys were the same, with the addition of some open-ended response questions in the post-course survey to assess students' overall feelings about the course. The pre-survey was given to all students during the first week of the semester and the post-survey was given during the last week of the class. Thus far, survey responses have been compared for pre- and post-course analyses for one class offering. This study was approved by the University of Arkansas Institutional Review Board (IRB protocol #2209420237).

Initial Findings

Entrepreneurial Knowledge

Survey responses indicated an increase in students' perceptions of their entrepreneurial skills and level of comfort with the entrepreneurial language after taking the course (Figure 1A-B). Students felt more confident about their skills as entrepreneurs and engineers as a whole. There was evidence in the open-ended responses showing that students feel more prepared for the workforce, with one student stating, "I think this class has helped me further develop my perspective on the business side of the industry."

Soft Skills and Empathetic Design

Empathetic design can be defined as designing solutions with an understanding of or sensitivity to the customer's perspective. This type of engineering design, along with soft-skills such as communication and teamwork, is an important part of developing an entrepreneurial mindset. Survey responses showed that the course had a notable impact on students' interview skills and their ability to understand and create value for those customers they interviewed (Figure 1C-D). One student noted that the "most beneficial aspects [of the course] were definitely from the

insights and connections gained through the customer interviews." Several other students mentioned that they will utilize customers' perspectives when working in the future.

Perceptions of Future Career

Interestingly, the course did not have a major effect on students' desires to pursue entrepreneurial careers in the future (Figure 1E). However, open-ended responses indicated that students planned to think more critically about applications of the course in their chosen careers, with one student stating, "I plan to use this information in every aspect of my future in order to think critically about the engineering process."

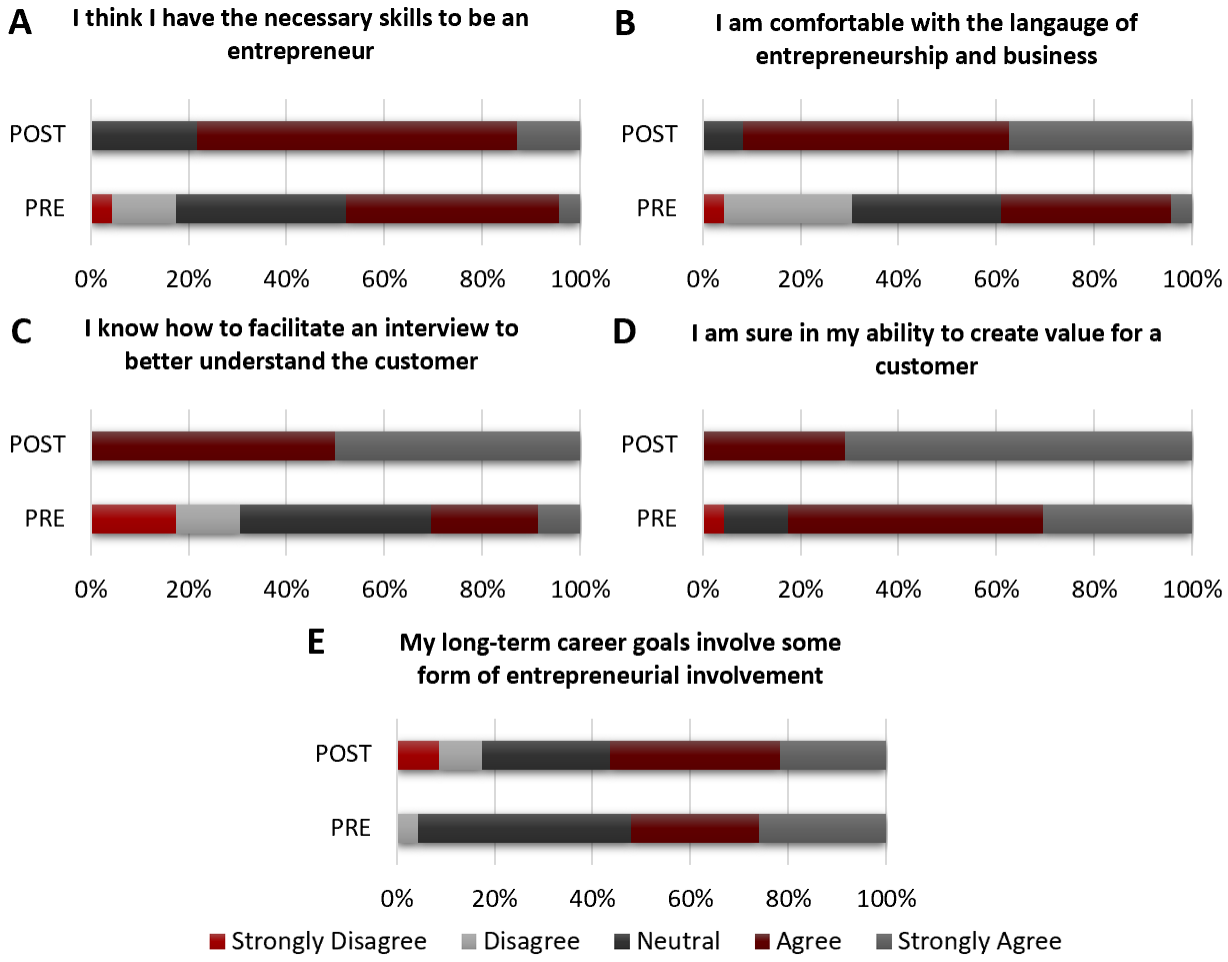

Figure 1. Comparison of five of the pre- and post-course survey responses (n = 23).

Discussion and Future Work

The initial findings comparing the pre- and post-course survey responses indicate that the Entrepreneurial Bioengineering course provided an effective means of engaging students in entrepreneurship and helped to develop their entrepreneurial mindsets. After taking the course, students felt more confident in their engineering skills and their ability to create valuable

solutions for customers. As evidenced by the survey and open-ended responses, there is likely a correlation between the students' soft skills and their perceptions of their engineering abilities as a whole. Though the course may not have impacted students' future career goals, it is promising that it will influence the way students approach engineering problems in the workplace.

This study has been limited thus far by a small sample size of students, which will likely increase as the course is offered each year. Additionally, future work will aim to identify how the course impacts students' entrepreneurial mindsets and career goals long-term in their senior capstone projects. As the course gains interest among engineering students, this study will also aim to understand how different engineering majors are influenced by the course activities.

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Appendix

Table 1. Course goals and outcomes.

Course Goals	Learning Outcomes
1. The students will learn the principles of entrepreneurship	1.1 Students will be able to recall the history of entrepreneurship and the success stories of current entrepreneurs
	1.2 Students will be able to define entrepreneurship
	1.3 Students will be able to state the principles of entrepreneurship with a focus on bioengineering applications
2. The students will appreciate the importance of regulatory affairs	2.1 The students will be able to articulate bioethics practices
	2.2 The students will be able to define the responsible conduct of research
	2.3 The students will be able to describe the FDA regulations
	2.4 The students will be able to identify intellectual property
	2.5 The students will be able to compare patents and trade secrets
3. The students will understand the principles of the business model canvas	3.1 The students will be able to formulate value prepositions
	3.2 The students will be able to identify different customer archetypes in an ecosystem and the customer workflow
	3.3 The students will be able to create a petal diagram of the ecosystem and obtain a market size estimate
	3.4 The students will be able to identify channel economics and distribution complexities
	3.5 The students will be able to recognize customer relationships and how to get, keep and grow customers

	3.6 The students will be able to calculate the customer acquisition cost and the customer lifetime value
	3.7 The students will be able to understand the different models of revenue creation
	3.8 The students will be able to create the payment workflow diagram and calculate the breakeven point
4. The students will learn the interviewing skills	4.1 The students will be able to apply the good interviewing practices
	4.2 The students will be able to acquire efficient notetaking skills
	4.3 The students will be able to demonstrate how to become good listeners
	4.4 The students will be able to analyze interviews narratives and identify key takeaways
5. The student will understand the structure of a minimum viable product	5.1 The students will be able to state the definition of minimum viable products
	5.2 The students will be able to identify a minimum viable product that conforms with the regulatory affairs
	5.3 The students will be able to design a 3D model of a minimum-viable product prototype
6. The students will know different methods of effective communication	6.1 The students will be able to create effective PowerPoint presentations
	6.2 The students will be able to compile and edit a video to summarize the project takeaways
	6.3 The students will be able to write technical reports and publications to disseminate their ideas
7. The students will value the importance of teamwork	7.1 The students will be able to define good teamwork practices
	7.2 The students will be able to use team creation and evaluation software
	7.3 The students will be able to identify effective and responsible methods to leave feedback

	7.4 The students will be able to assess their peers' effectiveness
8. The students will value the applications of Biomedical Engineering to solving real-life problems	8.1 The students will be able to identify, formulate, and solve bioengineering problems
	8.2 The students will be able to reflect on the roles and responsibilities of an engineer in the workplace
	8.3 The students will be able to identify examples of course concepts in the real world
	8.4 The students will be able to ask questions about examples and role models of entrepreneurs they see in their own lives