Challenges Integrating Entrepreneurial Training into Summer Research Experiences for Undergraduate Engineering Students

Todd J. Freeborn[a], Susan Burkett[a], Debra McCallum[b], Erika Steele[b], and Ying Qin[c]

The University of Alabama / [a]Department of Electrical and Computer Engineering, [b]Institute for Social Science Research, [c]EDGE Labs

Abstract

In a 10-week Research Experience for Undergraduates (REU) program, training was embedded to provide firsthand experience with entrepreneurship for participating students. The aim was to broaden the learning outcomes beyond research and introduce concepts such as developing business models and turning a research or technology idea into something marketable. The entrepreneurship training was adapted from the NSF Innovation Corps (I-Corps) program to accommodate the REU students. Over the course of 3 summer iterations, 30 students participated in the research and entrepreneurial training. Overall satisfaction with the REU was quite high; however, participants consistently reported lower levels of satisfaction with the entrepreneurial aspects of the REU program, even with revisions made in each iteration to address previous feedback and elements. In this work, an overview of the elements of the entrepreneurial program will be detailed along with summaries of the student feedback, challenges, revisions, lessons learned throughout the program, and recommendations for integrating entrepreneurial training into an REU program.

Keywords

Research Experience for Undergraduates (REU), Engineering, Entrepreneurship

Introduction

Undergraduate involvement in research is considered to be one of several high-impact practices for enhancing student success[1,2]. Participants tend to gain a greater understanding of their major discipline, obtain critical thinking skills, improve their communication skills, gain networking opportunities, and have an increased probability of pursuing graduate education[3,4,5,6]. Undergraduate research has been useful in promoting collaborative interdisciplinary research efforts[7] and engaging female[8] and underrepresented students[9].

In service to the mission to increase the number of undergraduate students involved in research, the University of Alabama (UA) hosted an NSF-funded Research Experience for Undergraduates (REU) site from 2016-2018 centered on innovative engineering using renewable resources. A total of 30 engineering students participated in this site with projects involving the structural, electrical, and mechanical properties of bamboo and other topics related to renewable resources (e.g. solar cells, energy scavenging). Nearly 63% of participating students were from under-represented groups in engineering (56% female, 7% African American, 7% Hispanic, 3% Pacific

Islander and 3% from groups identifying with two-or more under-represented groups) and nearly 37% were from schools with limited research opportunities.

Overall Satisfaction with REU

REU students were invited to participate in an online survey assessing their opinions about participating in the REU. Overall, students reported high levels of satisfaction with the program in terms of their research experiences, topics of research, and ability to do research. The specific questions and average scores for each question for each year of the program are detailed in Table 1. These high scores support that the REU site administrators and research mentors provided an engaging and rewarding research experience for the REU participants.

Table 1: Summary of post-program survey questions on REU student research experiences

Question (scale labels differed, all were 1 = most positive response, 5 = most negative response)	2016 (n=10)	2017 (n=6)	2018 (n=9)
What is your satisfaction with the program overall?	2.0	1.0	1.9
What is your satisfaction with the research experience overall?	2.6	1.2	2.0
What is your satisfaction with the research project topic?	1.8	1.3	1.8
How interesting was your research project?	2.7	2.0	2.1
How much has the REU experience helped increase your ability to do engineering research?	2.7	1.3	2.3
How much has the REU experience helped your ability to have a successful career involving research?	2.9	1.7	2.8
The REU experience gave me insight into emerging areas of research in engineering and computer science	2.1	1.7	1.8

Entrepreneurial Professional Development - Crimson Startup

In parallel with their research projects, the REU students participated in a 6-week entrepreneurship professional development program, Crimson Startup. Crimson Startup is a part of the NSF Innovation Corps (I-Corps) Site at UA, led by instructors from the Alabama Innovation and Mentoring of Entrepreneurs Center (AIME), STEM path to the MBA, the UA College of Commerce and Business Administration, the Alabama Entrepreneurship Institute (a partnership between UA and the West Alabama Chamber of Commerce) and UA's Office for Technology Transfer. The expected student-learning outcomes of this program were to demonstrate an understanding of: key principles for a lean startup, the method for finding how a technology creates value for customers, and the importance of agile development (i.e. pivoting based on customer feedback), and the process of customer discovery or evidence-based entrepreneurship. Opening the program to REU students broadens the reach of the innovation ecosystem. This knowledge is useful when guiding the output of early stage scientific discoveries to the development of technologies, products, and processes with societal impact, which was a strong fit with the aim articulated in Accelerate Alabama, the economic development strategic plan for the state, to have bamboo production become a part of Alabama's economic future.

As a part of Crimson Startup, the students formed teams to develop a product idea and business model that was presented at weekly meetings, participating in the same processes that other research groups and faculty at UA were completing towards commercializing the results of their research. Throughout the Crimson Startup program, REU participants were required to engage with potential customers, partners, competitors, and other stakeholders by proposing and testing hypotheses to fine-tune their business model. A significant focus of the entrepreneurship training is the business model canvas, which requires teams to identify customer segments, customer relationships, value propositions, channels, key partners, key activities, key resources, cost structure, and revenue streams. It is important to note that this was not just a theoretical exercise; teams were required to collect information from real potential customers, tasked with making contact with 15 or more people or companies per week. Using this feedback, teams would give weekly update presentations to a panel of coaches detailing their progress and how they were incorporating customer feedback into their project. The panel of coaches would also provide their feedback on the approaches the teams were taking, their interpretation of customer feedback, and how well they were pivoting their idea to address that feedback.

2016 Crimson Startup

In the post-REU surveys collected during the first iteration of the REU Site in 2016, Crimson Startup was one of the most criticized aspects of the program. In spite of this criticism, students made noteworthy progress with respect to learning how to develop a business model and turn research or technology into something marketable. The students came in with a low baseline of knowledge, with the median and mode for both questions indicating that they knew "little," and 30% of the responses listed as knowing "nothing." After the program, fourteen of the twenty responses across the two questions (70%) indicated a higher level of knowledge. While some progress was made, there is room for students to make greater progress going forward.

In spite of their perceived increases in entrepreneurial knowledge, seven of the ten students in 2016 were somewhat or extremely dissatisfied with the Crimson Startup program. The primary criticism of the program was that it was not well coordinated with the REU. The students felt they were at a disadvantage, because non-REU students in Crimson Startup had created their products prior to the start of the program. REU students were asked to do so in a week, at a time when they were busy working to determine the direction of their research. They also mentioned that having more instructional sessions where methods were taught, rather than observational sessions where groups presented and were critiqued, would be helpful. Suggestions for improvement to the Crimson Startup included receiving more assistance in designing their products, being notified to begin thinking of a product before the start of the REU, beginning planning with the mentors before the REU started, or having attendance in the group sessions be mandatory but active participation in the product development process be optional.

Based on feedback regarding the Crimson Startup program, administration of the entrepreneurship training was revised for the 2017 iteration. Changes included adding Crimson Startup details to the recruiting materials (flyers & website), detailing requirements (6-week course with 3-5 hours of participation per week) in the REU offer letters, incorporating Crimson Startup into the orientation activities so it was highlighted as a core and important component of the program, and having REU student teams attend office hours with a I-Corps™ instructor/coach for at least 15 minutes per week.

2017 Crimson Startup

Again in 2017, the area of greatest discontent in the REU was the entrepreneurial component. Although students knew this was a feature of the REU before they arrived, they were not prepared the time commitment they were required to devote to it. As with the group from 2016, the students expressed frustration related to the time it took away from their research projects. They also felt there was a lack of understanding on the part of those conducting the program concerning the differences in priorities between the REU students and the other students whose primary interest was Crimson Startup. They made several suggestions for reducing the burden of the program while maintaining the essence of it. It seems they understood and valued learning about entrepreneurial concepts and skills, but they would like an experience that was less intense and less focused on customer discovery. Interestingly, some of them also said it would be more rewarding if they could work on any product of interest to them and not be required to develop a product that used bamboo. Having more information about the program prior to their arrival on campus was also seen as something that would help them prepare for the program and its activities.

Based on the feedback from the 2017 iteration, further revisions were made for 2018. During the orientation the Crimson Startup administrative staff further explained the objectives of the training course and introduced the business model canvas that would be utilized. For the 2018 iteration, the requirement to have the team product incorporate bamboo was dropped in an attempt to increase engagement by allowing students to pursue ideas they were passionate about that they may have had from previous experiences.

2018 Crimson Startup

In the 2018 iteration of Crimson Startup, even with further revisions to address previous criticism, Crimson Startup contributed to the most negative feelings about the REU program. Six out of nine participants gave the program a "fair" rating. The other participants gave the activity a "poor" (n=2) or "very good" (n=1) rating. Open-ended responses indicated that the students felt the activity was irrelevant, not interesting, and a lot of work. Some students could see how the program could be useful but still felt the workload was too much and interfered with their research. Specific criticisms provided to the open-ended questions are detailed below:

> *"Crimson Canvas did not motivate me to do work, it felt like burden"*
> *"I learned many things that I think will help me in the future, like the manner in which the presentations where held, and some business methods, especially when starting. But the workload was way too much, not everyone was interested to begin with and I believe it interfered with our research work."*
> *"If expectations going into it were adjusted it would be better. We also discussed the fact that it was a lot of extra work and this should probably be modified for the REU students."*
> *"It may be a decent program for those who are currently trying to start a company, but for research students it was a waste of our time and the coaches' time. We could have learned just as much from just observing a session or two and spend a fraction of the time on it."*
> *"It was a hassle to deal with it for 6 weeks. I would've been more okay if we just sat in on*

presentations but actually doing the program was not fun"
"Not relevant to our majors"
"While great for someone who is truly interested in it, I was not, and did not enjoy the process. I dreaded making the presentations, presenting each week, and doing customer discovery each weekend. I do still feel I gained skills that will in fact help me in the future. Mentors of this program were a great help and seemed to truly want to help the students."

Students were also asked to rate how much they learned from Crimson Startup on a scale from 1 ("nothing") to 10 ("a lot"). About 45% of respondents rated the amount they learned a 6 (n=3) or 7 (n=1). The other students rated the amount they learned from Crimson Startup at 5 or less. Regardless of how students rated how much they learned from Crimson Startup, responses to open-ended questions suggested that the students could see how the program is applicable to those wishing to start a business.

Finally, the students were split on how applicable Crimson Startup was to their career. Five out of nine respondents felt the program was "applicable" (n=3) or "somewhat applicable" (n=2). Of the remaining students, one was neutral about the program and the other three rated the program as "not applicable" to their careers. Responses to open-ended questions indicated that students felt the program was not relevant to a career in research and/or that the activity should be adjusted for research students.

Mentor Challenges

An additional challenge for the Crimson Startup program was the lack of buy-in from some of the participating faculty serving as research mentors. That is, to get faculty support to stress the importance of entrepreneurship training across the summer, to discuss the Crimson Startup experiences with their students, and explore how those lessons complemented their research experiences. To increase buy-in, each year mentors completed a training workshop during which Crimson Startup, motivations for the program, and elements that students would complete were discussed. Additionally, mentors were encouraged to attend Crimson Startup to observe at least a single session of the process and what their students were completing. While a few faculty mentors had completed the Crimson Startup program to commercialize their research, those who had participated did not use products that were related to their REU projects.

When the faculty mentors were surveyed for their feedback on the REU in 2018, one reported that they strongly agreed that Crimson Startup was a beneficial experience, two agreed it was beneficial, and one strongly disagreed that it was beneficial. Additional written feedback regarding Crimson Startup was also collected which included:

"Crimson startup took up way too much time and was difficult for students since the class they were joining already was in progress."
"Crimson startup, while extremely useful, remains a difficult topic to continually sell the REU students on. I do spend time working with them on it and discussing how it will support their careers, but the time that is required to do a good job on it really pulls them away from research."

From this feedback faculty felt that Crimson Startup took too much time away from their research limiting the progress students would make in an already short timeframe for summer research. Without strong faculty support for these elements, students were likely to have received mixed messages during their experiences; with the REU coordinators and Crimson Startup instructors stressing the importance of the entrepreneurial training based on their specific education goals for the site, and the REU mentors stressing focus on their research projects. This may have contributed to feelings of confusion and frustration on the part of the REU students in terms of what they should prioritize during their experiences.

Lessons Learned

While the REU site was a success in terms of engaging the students in rich research experiences related to innovative engineering using renewable resources, there were significant challenges in integrating the entrepreneurial training. Even though students reported skill gains from their participation in Crimson Startup, over each iteration it was the component of the REU with which students were most dissatisfied with. These feelings appeared to stem from the required time and training activities, which students felt limited progress they could make in their individual research projects.

While students expressed interest in learning about entrepreneurship there was not a strong interest to do the tasks related to increasing entrepreneurial skills; students expressed desires to be passive observers rather than active actors. The training activities likely pushed the students outside of their comfort zone, requiring communication and relationship building with customers. These tasks were not structured for them and required their active engagement, with critique from the panel coaches when not completed. The failure to connect this active outreach with customers to research activities is a missed opportunity; customer discovery is important not only for commercialization but also researchers working to connect their research aims with program priorities of both public and private funding sources. Further iterations could take this approach to link the similarities in process to both commercialization and research.

It is also important to stress faculty buy-in with the entrepreneurial training. With mentors and their graduate students having the greatest contact with the REU participants, it is absolutely necessary for them to actively participate in the entrepreneurial aspects for it to be a core focus. For future iterations, including research projects from faculty mentors that have an existing entrepreneurial focus or intention to pursue commercialization for their inventions may improve student experiences by aligning the entrepreneurial and research tasks so students do not feel a disconnection between them. This would also accelerate the rate at which students can engage in the entrepreneurial training by removing the need to develop their own project from scratch. This is not without its own challenge, as the number of faculty with research projects at this stage may be limited.

Integrating entrepreneurial training into a summer REU is challenging, requiring a significant effort from program coordinators, research mentors, and instructors to deliver an engaging and rewarding experience that links both research and entrepreneurship.

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Todd Freeborn

Todd Freeborn is an Assistant Professor in Electrical and Computer Engineering (ECE). He regularly teaches courses in circuit analysis, circuit networks, and microcomputers. Through NSF funding, he has coordinated REU Sites for engineering students to explore renewable resources and speech pathology. He is also the coordinator for an NSF S-STEM program to prepare students for gateway courses across different disciplines of engineering to support and retain students in these disciplines.

Susan Burkett

Susan Burkett is Professor Emeritus in Electrical and Computer Engineering (ECE). She taught courses in ECE Fundamentals, Circuit Analysis and Integrated Circuit Fabrication. Through NSF funding, she developed courses to prepare STEM undergraduates for research experiences and also coordinated a REU Site on renewable resources. She was also the Campus Director of a NSF Louis Stokes Alliance for Minority Participation grant. She served on the Executive Leadership Team of the ASEE Women in Engineering Division in the past. From 2005-2007, she was a program director at NSF in the Division of Undergraduate Education promoting exemplary undergraduate research and educational programs.

Debra McCallum

Debra McCallum is a Senior Research Social Scientist and Director of the Institute for Social Science Research. She is a social psychologist interested in evaluations of education and community intervention programs and research on social issues, such as career choices related to STEM fields, social-psychological aspects of health behavior and outcomes, and safety and well-being of children and youth. She has led program evaluation activities for a variety of NSF-funded projects.

Erika Steele

Erika Steele is a Research Associate at the Institute for Social Science Research. She received her M.S. in Cellular and Molecular Biology and PhD in Education from the University of Alabama. She is an education evaluator interested in measurement and assessment of learning, faculty professional development models, and social issues related to health and STEM fields. Erika has co-led program evaluation activities for a variety of NSF-funded projects.

Ying Qin

Ying Qin is a Research Engineer in EDGE Labs, UA's technology incubator. She is a certified NSF I-Corps instructor, she has also served as the program organizer of I-Corps Site at UA and part of I-Corps South Node trainings. She co-teaches two customer discovery courses in the senior level (Lean Product Development in Mechanical Engineering Senior Design class and Ventures in Entrepreneurship) in UA college of Engineering and Honor's College.