’It was a Failure, But a Good Failure’: A Qualitative Study Exploring Engineering Students’ Critical Entrepreneurship Experiences and Their Impacts

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Abstract
Integrating entrepreneurship into engineering education has gained momentum in recent years. Engineering students at many institutions now have access to a variety of mediums to get involved in entrepreneurship including classes, pitch competitions, and accelerator programs. Participating in these classes or programs can lead to engineering students getting very involved in entrepreneurship and having important, memorable experiences. This study sought to investigate these ‘critical’ entrepreneurship experiences among engineering students including the impacts they have. The study applied the critical incident technique in a narrative format to elicit and thoroughly investigate three senior engineering student’s entrepreneurship experiences who were very involved in advancing multiple entrepreneurial projects during their undergraduate education. The study reports these critical experiences and their impacts in a narrative format with rich detail. The findings suggest that entrepreneurship funding programs and classes are primarily involved in catalyzing powerful student experiences that have profound effects including changes in attitudes, behavior, and altered career goals. This study overall provides evidence of the value programs and classes have in facilitating the development of an entrepreneurial mindset.

Introduction
Formal entrepreneurship programs (e.g., majors, minors, and certificates) targeting undergraduate students have quadrupled from 1975 to 2006, making it one of the fastest growing subjects overall (Brooks et al., 2007). There has specifically been a movement to integrate entrepreneurship into engineering education. The NSF and other funding agencies including the Kern Family Foundation, the Kauffman Foundation, VentureWell and the Lemelson Foundation have invested significantly in promoting entrepreneurship and innovation in engineering education (Duval-Couetil, Shartrand, & Reed, 2016a). This movement has also been supported by professional organizations such as the National Academy of Engineering (NAE) and the American Society for Engineering Education (ASEE) (Duval-Couetil, Reed-Rhoads, & Haghighi, 2012). The setting of this study, Arizona State University (ASU), is an excellent example of an institution that has invested heavily into developing an entrepreneurship ecosystem. There are many funding programs that award students anywhere from $1,000 to $100,000 to advance their entrepreneurial endeavor. Many of these funding programs and classes are specifically for engineering. The intent behind these programs is often times not just for students to start successful businesses, but to develop more well-rounded engineers with a variety of knowledge and skills that possess an ‘entrepreneurial mindset’.

Considering the significant financial and time investments involved in the creation of entrepreneurship programs, institutional funding competitions, and accelerator programs, it is
notable that there are no in-depth, qualitative studies that explore the entrepreneurship experiences students have because of these programs. In general, there is very little research on the personal impacts of these experiences including how they can affect an engineering student’s attitudes, behaviors, career goals, or personal competence (Duval-Coetil, Reed-Rhoads, & Haghighi, 2011). There is also no consensus on what developing an ‘entrepreneurial mindset’ means. This study builds off current literature in addressing these gaps by exploring the ‘critical’ entrepreneurship experiences of engineering students at ASU with a well-developed entrepreneurship ecosystem. The purpose of this study is to paint a picture of the types of important student experiences that are catalyzed from the creation of institutional entrepreneurship programs and the impacts these experiences have on a student including on their attitudes, behaviors, and career goals. In doing so, it also seeks to provide rich data on what it means to develop an entrepreneurial mindset and the implications of it. The research questions are thus twofold:

Research Question 1: What are the types of critical entrepreneurship experiences engineering students have?
Research Question 2: What was the impact of these critical entrepreneurship experiences?

The findings discuss, in a narrative format, the most important entrepreneurship experiences three senior engineering students had while attempting to advance their respective entrepreneurial projects. The findings suggest that these experiences had profound effects on each student including changes in attitudes and altered career goals. Patterns within the narratives suggest these changes in attitude are within the categories of communication, pitching, working on a team, networking, and the design process. Other attitudes that were developed or were more innately possessed and tested through the experiences include risk-taking, the desire to make an impact, passion, curiosity, and confidence. These attitudes appear to make an impact on behavior including the ability to identify opportunities, make connections, and create value. These specific changes in attitudes and behavior point to the development of an entrepreneurial mindset. This experiences overall had a major influence on all three students’ career aspirations. None of these students had entrepreneurial-related intentions prior to college, which makes the findings all the more interesting.

**Literature Review**

The reason for the strong interest to integrate entrepreneurship into engineering education is it is widely believed entrepreneurship education can lead to the development of knowledge, skills, and attitudes that are in alignment with the ABET E2000 standards (Shuman, Besterfield-Sacre, & McGourty, 2005). According to ABET’s EC2000 standards, the new generation of engineers is expected to possess deep technical knowledge in their field of study as well as professional skills, such as communicating effectively, working in teams, solving unstructured problems, and an awareness of ethical and contextual considerations in engineering (Lattuca, Terenzini, & Volkwein, 2006). The NAE believes engineers need to be flexible, resilient,
creative, empathetic, and have the ability to recognize and seize opportunities (NAE, 2002; Sheppard, Pellegrino, & Olds, 2008)

How can entrepreneurship education lead to these learning outcomes? Most entrepreneurship-related activities students participate in are experiential in nature and include activities such as prototyping a physical product or application, developing a business plan, interviewing potential customers, delivering pitches, applying to grants, and getting feedback from mentors or other entrepreneurs (Duval-Couetil, Shartrand, & Reed, 2016b). Entrepreneurship classes and programs are therefore generally structured in a project-based learning format in which students form team and work on developing solutions for real problems (Duval-Couetil et al., 2016b). In order for students who are participating in entrepreneurship activities to be successful, they must communicate effectively and think critically to design solutions that solve open-ended problems (Byers, Seelig, Sheppard, & Weilerstein, 2013). Successful entrepreneurs are also known for their ability to act on opportunities, learn from their failures, and design for the end-user through empathy (Byers et al., 2013). They also typically have drive, creativity, passion, resourcefulness, and belief in their ability to be successful (Byers et al., 2013). Engineering students who participate in entrepreneurship activities are unlikely to become successful entrepreneurs right away (or even have the intention to do so), but through the learning experience they can practice and develop these attitudes and skills while acquiring new knowledge. These developed attitudes are commonly known as an ‘entrepreneurial mindset’. More formally an entrepreneurial mindset can be defined as “the way entrepreneurs think differently about given tasks (Haynie, Shepherd, Mosakowski, & Earley, 2010), and the cognitive strategies which provide them with the ability to rapidly sense, act, and mobilize, even under uncertain conditions” (Ireland, Hitt, & Sirmon, 2003) (Wheadon & Duval-Couetil, 2016). Integrating entrepreneurship education into engineering education is therefore not solely focused on the outcome of students’ entrepreneurial endeavors and development of specific business skills and knowledge, but also on developing entrepreneurially minded engineers that are prepared to identify and solve problems in innovative ways. These students can then utilize their entrepreneurial mindset to eventually become an entrepreneur or in other ways such as becoming an ‘intrapreneur’ within a company, organization or institution.

The KERN Family Foundation (“The Kern Family Foundation,” 2016) is focused on promoting entrepreneurial mindset learning (EML) among engineering students and faculty across the country as part of the Kern Entrepreneurship Engineering Network (“KEEN Engineering Unleashed,” 2017). This mission appears to be supported by instructors who teach entrepreneurship to engineering students. According to a study completed by (Besterfield-Sacre, Zappe, Shartrand, & Hochstedt, 2016), instructors who teach entrepreneurship to engineering students believe programs and courses should focus equally on teaching skills and developing values and attitudes. This study had 25 instructors complete the Faculty Entrepreneurship Knowledge Inventory (EKI). The results indicate instructors believe they can impact a students’ self-efficacy, their ability to act on opportunities, adapt to new situations, be resourceful, learn
from failure, and tolerate ambiguity, but that they may not be able to influence other characteristics as much as passion, drive, and being outgoing. Although this study involves a limited sample size, it does indicate entrepreneurship instructors believe they can teach entrepreneurship and facilitate the cultivation of an entrepreneurial mindset to a certain extent.

There appears to be a growing belief among foundations, engineering departments, and engineering faculty that entrepreneurship education can be a gateway to developing an entrepreneurial mindset. In other words, the creation of entrepreneurship programs and classes can lead to students having entrepreneurship experiences that may have impacts on the student including changes in attitudes, behaviors, career goals, or personal competence. There is, however, very little research that assesses these impacts (Duval-Coetil et al., 2011). This partly stems from only a few valid and reliable instruments being used widely in the field especially for engineering students. One study that does address the lack of quality assessment on the attitudes and outcomes of entrepreneurship education of engineering students was completed by Duval-Couetil, Reed-Roads, & Haghighi (2012) when they developed and distributed an instrument to 501 senior engineering students. The results indicate students who had taken one or more entrepreneurship courses were more likely to have the desire to start their own business or work for a small business or startup. They were also significantly more confident in specific entrepreneurial self-efficacy measures including their ability to ‘write a clear and complete business plan’ and ‘recognize when an idea is good enough to support a major business venture’. These students also possessed statistically significant higher levels of risk tolerance.

Another recent quantitative study called the Entrepreneurship Education Project investigates the motivational processes of three groups of undergraduate students participating in entrepreneurship (entrepreneurship students, non-entrepreneurship business students, and non-business students) (Vanevenhoven & Liguori, 2013). Initial results, from over 18,000 students spanning over 400 universities within 70 countries, indicate the number of entrepreneurship courses offered within a university positively correlate with Social Cognitive Career Theory’s (SCCT) motivational constructs. This large-scale quantitative study indicates this uptick in motivation from entrepreneurship education is driven by self-efficacy, outcome expectations, and goal-directed activity. Entrepreneurship education thus may lead to students that are empowered to self-drive their own projects, which they view with optimism.

Lack of Qualitative Entrepreneurship Research

Although there are only a few reliable instruments, quantitative studies within entrepreneurship are still heavily favored over qualitative studies (Smith, McElwee, McDonald, & Drakopoulos Dodd, 2013). According to Smith et al. (2013) there has been a call for more qualitative entrepreneurship studies. In their study they sent out a survey to scholars who had published qualitative papers in the top ranked entrepreneurship journals over the past 20 years to better understand the antecedents, processes, and consequences of authoring qualitative research. The value of qualitative research, according to these authors, is it provides more rich data that
improves “understanding of multi-faceted complexities” or the “phenomenon”, which leads to “insightful inferences”. Despite these benefits, the findings of the study suggest there still appears to be a perception issue for qualitative studies within entrepreneurship research as participants highlighted the most significant problem as “getting published”.

Another study, by Suddaby, Bruton, & Si (2015), conducted a thematic review of nine qualitative studies “to better understand the emergence of entrepreneurial opportunity”. They argue that entrepreneurship is “a highly individualized journey” and that quantitative analyses cannot fully capture the messy experiences with trustworthiness. They advocate that listening to entrepreneurs tell their stories are “a powerful way to investigate entrepreneurship” and that quantitative, positivist approaches should be balanced with interpretivist, qualitative studies. They also highlight that entrepreneurship research has failed to develop original theories and that qualitative methods could support the generation of theories that can enhance future entrepreneurial studies. In their findings, they identify patterns among the qualitative articles that relate to the concepts of “imprinting” and “reflexivity”. In “imprinting”, the environment interacts with an individual, and changes the individual in a way that enhances their ability to discover opportunities. This typically requires the individual to have a long-term interaction with the entrepreneurship community and as a result they have critical experiences, which “sensitize” their ability to identify potential opportunities. In “reflexivity”, individuals observe social and economic arrangements in the environment, and through reflection, they are able see possibilities of new and creative social realities. They thus create opportunities rather than discover them.

Despite calls for more qualitative research and specifically exploring the stories of entrepreneurs to generate theories, there have been virtually no studies within engineering entrepreneurship education that focus on analyzing the narratives of engineering student entrepreneurs. There is one qualitative study that looks at engineering students perceptions of studying entrepreneurship during a specific course or program (Taks, Tynjala, Toding, Kukemelk, & Venesaar, 2014). This study adopted a phenomenographic research approach and identified four different categories of experiencing entrepreneurship with multiple dimensions of variation. This study captures the variations of how a student can experience entrepreneurship, but is limited to the scope of just one class experience. The proposed study aims to build off this study as there still lacks a comprehensive, in-depth qualitative study that captures an engineering student’s journey navigating through multiple entrepreneurship experiences at an institution with a robust entrepreneurship ecosystem consisting of multiple courses and programs. This long-term interaction with the entrepreneurship community is likely to lead to more critical experiences that have strong impacts. As discussed, most of the attention in evaluating engineering entrepreneurship has been directed toward developing quantitative instruments to assess entrepreneurship programs or entrepreneurial mindset. This study therefore addresses multiple gaps in areas with sparse to no research. The narratives elicit detailed information on students’ critical entrepreneurship experiences and the impacts of these experiences. The rich, contextual information elicited from the students’ critical experiences can inform future studies and the
design of entrepreneurship programs so that they are better equipped to facilitate and support these types of experiences.

Methods

This study investigated three engineering students’ most critical entrepreneurship experiences and the impact of these experiences. In this context, the term ‘critical’ experiences was defined as the most memorable or important entrepreneurship-related experiences engineering students identified within the constraints of a one hour interview. These ‘critical’ experiences, also synonymous with critical events or critical incidents, are likely to have had a profound impact on the storyteller (Bohl, 1995; Webster & Mertova, 2007) and often contribute to personal development, accelerated learning, (Woods, 1993) or radical changes within a person (Webster & Mertova, 2007). The overall research study methods were thus centered on extracting these entrepreneurship-related critical experiences and their impacts from the participants. These critical experiences were then reported out in a narrative that is divided up into sub-sections per critical experience. An inductive thematic analysis was then completed to report the patterns across these narratives.

Data Collection

The study used a combination of the critical incident technique (Flanagan, 1954) and narrative in an interview format to elicit students’ critical entrepreneurship experiences. The overarching theoretical perspective is interpretivism, which seeks to increase understanding of student’s particular subjective experiences (Case & Light, 2011). Each interview began with the researcher describing the scope of the study and allocating a few minutes for the student to reflect and write down their most impactful or important experiences they want to discuss. When the student informed the researcher that he or she was ready, the researcher prompted the student to describe their earliest impactful or important entrepreneurial experience that occurred in college. The critical incident technique was then utilized by the researcher to further investigate the experience and the impacts of it. Once the researcher was satisfied the critical experience had been investigated sufficiently, the researcher prompted the student to identify the subsequent critical entrepreneurship experience that occurred. This process naturally facilitated a flow progressing from critical experience to critical experience in a mostly sequential fashion until all of the critical experiences were identified and thoroughly discussed. This aligns closely with how Hinchman and Hinchman (1997) defines a narrative. According to these authors, narratives are “discourses with a clear sequential order that connect events in a meaningful way for a definite audience, and thus offer insights about the world and/or people’s experiences of it.” Once all of the critical experiences were discussed, the interview concluded with one or two additional questions that asked the student to summarize whether their entrepreneurship experiences have changed them in any way and affected their future plans. The interview protocol is included in Appendix A. The protocol includes the researcher’s introduction to the study, the reflection activity designed to initially trigger critical experiences, questions aimed at further investigate critical experiences, and the concluding questions. This protocol can be viewed more as the
general framework that guided the researcher in applying the critical incident technique and narrative research method.

**Participants**

This study took place at Arizona State University, which has a robust entrepreneurship ecosystem consisting of many funding programs and classes that support students in advancing their entrepreneurship projects. Many of these funding programs and classes are specifically for engineering students including an accelerator program called the eSeed Challenge. Within the engineering school there is the Fulton Schools Startup Center, which manages this accelerator program and other venture competitions. The Fulton Schools Startup Center also offers workshops, mentoring, and curricular and extra-curricular events. There are also numerous entrepreneurship classes engineering students can take as an elective, as part of a degree requirement, or to obtain an entrepreneurship minor. Examples include the FSE 301 course called Entrepreneurship Value Creation or the EGR 535 course called Engineering Innovation & Entrepreneurship.

The three students that participated in the study were selected because they had experiences developing multiple entrepreneurial projects and had even been successful obtaining funding from funding competitions. All of these students were seniors enrolled in their final semester of engineering at the time of the interview. All of the interviews were completed in a private study room at the university’s engineering library. The interviews were audio-recorded and transcribed by the researcher. The initial draft of the study was planned around conducting focus groups with entrepreneurship teams composed of at least one engineering student. Focus groups are typically effective in group discussions or situation in which one member can inspire or elicit certain thoughts from another member of the group. Although this format may have had these specific benefits for this study, it could also create bias and would inhibit the ability to further investigate and discuss the entirety of each individual student’s critical experiences and the progression of what they may have learned from project to project. Therefore, interviews were selected because they can more seamlessly combine the critical incident technique with narrative research. A narrative approach has several benefits. Telling stories is also considered to be a fundamental human activity in which people represent themselves to others and make sense of their lives (Case & Light, 2011). This helps organize their experiences and share them in a natural way that may contribute to creating a comfortable environment to share raw, lived entrepreneurship experiences.

**Data Analysis**

A thematic analysis was selected as the initial method of analysis to identify the major patterns within the narratives. The thematic analysis processes recommended by (Braun, V. and Clarke, 2006) and Creswell’s (2016) were used as references during the thematic analysis process. Initially, the researcher read through all three transcribed interviews twice to familiarize himself with the narratives. On the third pass, the researcher segmented the data according to
critical experiences and wrote memos for potential codes. On the fourth pass, the researcher wrote these potential codes on post-its. These post-its were placed on a wall and organized in a way where similar codes were grouped together. The researcher then consolidated many of the potential codes and drafted the initial codebook, which was composed of 25 codes and 4 themes. An inter-rater reliability test was then completed to provide the researcher with feedback on his initial codebook. It was decided the codebook needed to be further refined as there was some redundancies and overlap between the codes. For the second cycle of coding, strategies from Saldaña’s (2005) *The Coding Manual for Qualitative Researchers* were applied to reduce the redundancies and overlap of the codes. These strategies were identifying the top 10 quotes that are most representation of the study, codeweaving, and applying the touch-test. Codeweaving involves writing up brief narratives that ‘weave’ the codes, categories, or themes in to describe the findings. The touch-test involves brainstorming whether each code can be transformed into a more abstract term or meaning. After multiple iterations, the 25 codes were collapsed into 10 codes and two themes. A theory was also generated from the final codebook that organizes the codes even further, describing the patterns within the narratives.

Although the thematic analysis highlights the patterns within the student narratives, much of the richness of the critical experiences was lost. Thus, the researcher opted to report the findings in a narrative format and discuss the thematic analysis results in in the discussion section. The content of the narratives was primarily influenced by how the researcher segmented the transcriptions into critical experiences. Only the necessary details were included to show what led to the experience happening, the experience itself, why the experience was so important or memorable, and the impacts of the experience.

**Results**

Each student was encouraged to thoroughly describe their most memorable, important experiences and the impacts of those experiences. A thematic analysis was completed on these experiences and impacts. The research design naturally produced two main themes: (1) entrepreneurship experiences and (2) impacts. The main experiences students decided to discuss were related to participating in funding competitions, developing their project, experiencing challenges and failures, taking entrepreneurship classes, and networking. The main impacts that were discussed were related to the development of an entrepreneurial mindset, new knowledge and skills, and modified personal and project goals. These experiences and impacts are discussed in detail in Table 1. Each student’s critical experiences naturally flowed to create a narrative. These narratives were preserved to demonstrate how each experience, and the impacts of it, affected the subsequent experience. The results thus explore three student narratives which are each divided into several pivotal entrepreneurship experiences. Included within each experience is a discussion on the impacts. At the end of each student narrative is a summary of their future goals. It should be noted that the student names are pseudonyms.
<table>
<thead>
<tr>
<th>Code</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Entrepreneurship Event</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funding competition experience</td>
<td>Student describes a funding competition event</td>
<td>An experience that involves competing in a pitch competition including applying, developing a pitch, pitching, and the outcome.</td>
</tr>
<tr>
<td>Project development experience</td>
<td>Student describes an experience in which they made an effort to advance their entrepreneurial project</td>
<td>An experience within the design-process such as performing customer discovery, modifying a business model, prototyping, pivoting, implementing solution, etc.</td>
</tr>
<tr>
<td>Challenging experience</td>
<td>Student describes an experience in which they encountered a challenge or problem while working on their entrepreneurial project</td>
<td>Encountering legal issues, difficulty balancing entrepreneurial project with school, project development stagnates, etc.</td>
</tr>
<tr>
<td>Failure experience</td>
<td>Student describes an experience in which they failed</td>
<td>Failure in the design or solution, unsuccessful attempt to obtain funding, entrepreneurial project discontinues, etc.</td>
</tr>
<tr>
<td>Class-related experience</td>
<td>Student describes the general experience of taking an entrepreneurship class or a specific event that took place as part of a class</td>
<td>Entrepreneurship classes and project-based classes or specific actions performed in class such as pitching an idea in class, forming a team, performing customer discovery, etc.</td>
</tr>
<tr>
<td>Networking experience</td>
<td>Student describes an experience involving making connections through networking</td>
<td>Attending a conference, finding a job, meeting and learning from an expert, etc.</td>
</tr>
<tr>
<td><strong>Impacts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneurial Mindset</td>
<td>Student describes attitudes, affective traits, or behaviors they (1) believe are important to advancing an entrepreneurial project, (2) were personally developed through their entrepreneurship experiences</td>
<td>Attitudes toward communication, pitching, team, networking, design process, and EM attributes, which include the desire to be successful or make an impact, passion toward their work or being intrinsically motivated, confidence, curiosity, and belief in one’s own ability to find opportunities, make connections, and create value</td>
</tr>
<tr>
<td>Developing knowledge &amp; skills</td>
<td>Student describes learning new skills and knowledge in business, entrepreneurship, technical, or communication</td>
<td>Learning how to develop a business model, create and deliver an effective pitch, navigate through the design process, programming skills, etc.</td>
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Claudia’s Entrepreneurship Journey

1st Funding Competition Experience

Claudia was enrolled in the Engineering Projects in Community Service (EPICS) course. She used her EPICS project to apply to a funding competition called Social Venture Partners. Her project was selected as a semi-finalist and she got the opportunity to participate in a three month process consisting of multiple events including practice pitches. At the time Claudia had not considered turning her project into a charity or business, but through the competition process, she was forced to learn how to create an effective pitch, which required her to develop her project into a potential business idea. This was a challenging process for Claudia that included a number of “terrifying” moments. She felt like an imposter at the first required event, a mixer. Claudia recalled,

I got there and everyone was 10 years older than me and knew each other so I was actually terrified. I kind of felt way out of my league and way just like wow I'm not sure I belong here.

Over the course of the three months, Claudia gained confidence and refined her pitching skills while also learning basic business knowledge. Claudia even goes as far as to say that she “developed a love for pitching”. She was ultimately chosen as the student finalist and pitched in front of an audience of around 400 people winning $2,000 in the process. This was a very exciting experience in which Claudia developed an awareness of the power of being able to “sell a story” through a pitch. She also developed a love for networking with other entrepreneurs who she describes as “innovative” and “passionate”.

Challenges of Advancing her Project

After this funding competition experience, Claudia faced the daunting task of advancing her entrepreneurial project. In the fall semester of her junior year, she decided to take an entrepreneurship class called Lean Launch and also applied and was accepted into the eSeed Challenge, a funding competition intended for engineering students. Claudia experienced a number of challenging experiences trying to develop her business idea. She describes this semester as being the “toughest semester of college” and “exhausting” primarily because of these challenges. In particular, Claudia recalled how she did not have a team to support her and learned how difficult it was to build a business without a team. As part of the Lean Launch class, Claudia has to complete a number of customer interviews. She also described the challenges involved in completing these customer interviews at a zoo, but that she did learn the importance of
understanding what customers think about your idea. Claudia attempted to persevere through each challenge to advance her project over the course of five months, but kept running into more challenges.

I just kind of felt like I was running and running and not really moving forward. I kept running into roadblocks and like legal roadblocks and a lot of what I was doing involved children so it was privacy policy issues and all these things that I thought were going to work weren't working.

At the end of the semester, Claudia pitched her idea in the second round of eSeed and did not make it to the next round of funding. This was very disheartening for her and she decided to discontinue her project temporarily to reflect. This was a very difficult time period for Claudia in which she felt “emotionally exhausted”. She broke down into tears several times during this time period. Claudia decided to discontinue her project, but her love of entrepreneurship and the community still remained. “I still love this community and still love these people…. I love their ideas and being a part of their ideas.”

Challenges of Advancing a Class Entrepreneurship Project

After her tough previous semester, Claudia wanted to take a break from entrepreneurship, but opted to take another entrepreneurship course called Value Creation to fulfill a requirement for the Grand Challenges Scholars Program she was a part of. This was a challenging experience, but not in the same way as her previous entrepreneurship project. She comments:

I was with a team that wasn’t really committed. I ended up doing all of the work and it was very exhausting in a lot of ways but I wasn’t as emotionally attached so it wasn’t as emotionally exhausting because it was just this idea that I was doing for class. I never had the intention to move it forward.

This project was not self-driven and Claudia lacked intrinsic motivation to advance beyond the scope of the class. This combined with a lack of a strong, committed team made the project more of a tedious class project for her than anything else.

Rebooting her Entrepreneurship Involvement

The following semester (fall semester of Claudia’s senior year), Claudia started working at the university’s Engineering Startup Center. She was able to get this job by presenting some ideas she had to the Director of the Engineering Startup Center at [institution name]. In other words, through networking, she was able to create a job that did not exist. Claudia’s previous experiences as a student entrepreneur led her to develop a love for the entrepreneurship community and a desire to remain involved. This intention and the network she established from her previous experiences paved the way for her to create this opportunity. Meanwhile, Claudia was completing her senior year capstone. The knowledge she gained from her initial
entrepreneurship experiences with the EPICS project played a major role in the capstone project she selected. Claudia described the process of creating a capstone project when she said:

I knew exactly what I wish I had for [previous project name]. I knew exactly the type of device I wanted. What I wish it could have done. All these different things from having spent all this time fighting against these walls because I couldn't get this one to do this. I couldn't get through this and get this policy and so I knew exactly how to do it. And so I pitched that to then I shifted to pulse oximetry.

In other words, although it seemed Claudia’s EPICS project had failed, she ended up pivoting the project in a new direction based on the mistakes she made and what she knew would be a better direction. Claudia also finally discovered what it’s like to work with a committed team. She remarks:

Everyone’s really passionate and on it and committed and intelligent and motivated and it’s just such a different dynamic. It’s hard, but it’s fun. You’re actually moving the needle forward because you have people to push it forward and you are not just trying to climb over walls by yourself all the time.

Claudia was also able to apply the knowledge obtained from her previous entrepreneurship experiences to lead her engineering capstone team in winning seed money from a student funding competition run by a local accelerator called BioAccel. None of her teammates had any previous entrepreneurship experiences. She taught them basic business knowledge and led them in creating an effective pitch that included financial projections and a competition matrix.

Claudia’s Goals & Future Plans

Claudia’s entrepreneurship experiences have had a major impact on her future goals and gave her a direction. At the very beginning of the interview Claudia said, “I never thought that I would get involved in entrepreneurship”. Claudia now aspires to work for an incubator or accelerator with a role that is focused on growth enterprise development. She plans to continue advancing her new entrepreneurial project in the meantime. Claudia displays the development of many facets of an entrepreneurial mindset in that she welcomes the uncertainty involved in her new career path especially when comparing it to her engineering friends who “already have their jobs figured out”. She attributes this mainly to the network she has created, “By doing all of these experiences I’ve met so many people that work for companies that have these you know organizations that they run. And it's opened these doors to possibilities for networks and communities and people that have your back.”

Munir’s Entrepreneurship Journey

Early Funding Competition Experiences

Munir’s very first entrepreneurship experience can be traced back to when he was a freshman applying to a funding competition called the Edson Student Entrepreneur Initiative
with a personal drone idea. At the time he knew it was an ambitious idea and that the likelihood he would receive funding was low. However, the thought of winning the grand prize of $20,000 was alluring enough to motivate him to apply. Munir did not win funding for Edson, which may have contributed to his drone project never gaining traction. In the same semester though, Munir also got involved in an EPICS project in which the goal was to build sustainable gardens for rural communities in Zimbabwe. He ended up winning a $5,000 scholarship that semester, which he largely attributes to having the EPICS project on his resume “I didn’t have much else on my resume - I was a freshman.”  A semester later, his team won $5,000 for the Social Resolution Venture as part of the Clinton Global Initiative University (CGIU) conference. Munir describes winning funding as being “validating” and that it made the project more real. It also was the spark for him to develop a goal of wanting to be an entrepreneur “It was the first taste of validation for the work we’re doing. Combine that with applying to Edson for the drone company and those two fused together to okay I want to be an entrepreneur.” Through these experiences, Munir learned about how to develop a business model and to pitch. Although this may be an over exaggeration, Munir comments later in the interview, “I spent more time as an electrical engineering student at [institution] creating pitch decks, editing videos, and writing grants than actual engineering”. Munir attributed the development of these skills to him having a relatively high level of success in future funding competitions in which he would continue to hone his pitching skills and gain more confidence.

Challenges of Advancing his Project

Similar to Claudia’s initial experiences, Munir’s team now had the funding to advance their entrepreneurial project. Munir’s teammate traveled to Zimbabwe the summer following their sophomore year to implement the project and discovered their idea did not work. The team decided to pivot the concept and applied to the eSeed Challenge during Munir’s junior year. They made it past the first round, but similar to Claudia, they pitched and did not make it to the second round. Munir describes this as a humbling moment and that the failure was upsetting because the amount of time he invested to compete in the competition. Munir learned from the process though and concluded that they did not make it because they didn’t have a sustainable financial model. The outcome of this funding competition had a strong effect on Munir’s motivation to continue with the project “I wanted to leave the project. I wanted to focus on my studies and my own ventures so I just kind of left the project. There was some time I wasn’t communicating with Solar Water Solutions”.

Challenges of Advancing Another Project

Munir shifted his attention to focusing on electrical engineering and getting hands on experience. He had been working on another drone project through the EPICS program since his sophomore year. In his junior year, Munir’s team decided to turn the class project into more of an entrepreneurial endeavor after they lost contact with their project partner. They had the freedom to identify a problem and develop a drone-related solution. Munir’s team went through a number of pivots, but ultimately settled on designing a drone for campus security. Following
the design process was very frustrating for Munir who just wanted to focus on building a drone. “At the end of the day we just wanted to build a drone and watch it fly, but we had to do a lot of documentation. Here’s the problem, the project statement, and stakeholders.” Munir’s team applied to the eSeed challenge and got accepted. They would however soon drop out, because they knew it was not a profitable idea. Munir’s team did not have the intrinsic drive to advance the drone idea as an entrepreneurial project, but simply viewed it as fun engineering project to develop technical skills.

**Successes Advancing a Class Entrepreneurship Project**

During the same time frame as the EPICS drone project, Munir decided to take the Value Creation entrepreneurship class. He found the course content to be useful “It was a great class…a boot camp. You went through all of the steps of creating a small business including marketing, creating a brand, market research, prototyping, legal entities, and the legal steps you take to create a business”. Munir applied his previous pitching experience to share a note sharing idea he had with classmates. He formed a team, developed the idea as part of the course, and applied to the Edson program. After two failed attempts as a freshman and sophomore, Munir applied as a junior and got accepted into the program with the note sharing idea for his senior year. Edson failed to live up to the high expectations Munir had built up since his freshman year. This was because Munir already had three years of entrepreneurship experiences in which he had made many connections with mentors, acquired business knowledge, and developed pitching skills. He had already learned so much through his journey that the program provided little value to him other than the funding “Through the three years of doing entrepreneurship, I had already gotten everything I was looking to receive from this [Edson]. So now that I had gotten into Edson, it was a letdown”. The process of developing the note sharing website has been satisfying for Munir because he had the intrinsic motivation to advance it. Munir expresses a sense of ownership and pride with the project since it was his idea. Through working on the project, Munir was able to develop his programming skills in a fun, self-driven manner. He credits his current job as project manager for a software company in large part to developing these programming skills from this project and through the network he established from his entrepreneurship experiences.

**Goals/Future Plans**

Munir is uncertain of his future plans. Towards the end of the interview he said:

I don’t know what I want to do. I think what I do know for sure is I don’t want to fizzle out. I have this momentum as an entrepreneur and I don’t want to go to this cubicle and work as a low-level engineering and have the entrepreneurship drive fizzle out. I want to create something.

Although Munir does not have concrete plans, he has developed an intention to one day be an entrepreneur. With such an intention, it appears unlikely that Munir would spend much time following a traditional route of working as an engineer if he does at all. Munir is constantly on
the lookout for potential business opportunities and describes this as one of the main impacts of his entrepreneurship experiences “The biggest way it changed me is having that mindset where now is if you have a problem, is it a profitable problem?”. Many of his conversations with friends, family, and even strangers have a business component. Ultimately, Munir aspires to make the necessary connections to create value and believes he can do it “I think you can create something of value. And it is everywhere.” In many ways, Munir demonstrates an entrepreneurial mindset in that he has an interest in identifying opportunities and making connections with the hope of one day developing a business that creates value.

Sid’s Entrepreneurship Journey

1st Funding Competition

Sid started an organization as a freshman in college that had the goal of providing workshops and college mentorship to underprivileged students who wanted to pursue a college education. The idea formulated when Sid witnessed first-hand how one of his very intelligent friends did not go to college after high school because he could not afford it “Normally the kids who performed at this level would be going to prestigious universities like Harvard or Stanford. He couldn’t even go to [institution name]. He had a scholarship, but he still couldn’t support it.” Sid was passionate about his organization, but his teammates were not “The majority of my team was more interested in getting an experience to put on their resume than actually passionate about the problem we were trying to solve.”

Sid pressed on though and decided to apply to a funding competition at [institution name] called Changemaker Challenge. Sid experienced a challenging moment when preparing a pitch with his teammates. One of his teammates wanted to be part of a pitch, but he was not the best pitcher according to Sid, and therefore, it was not in the best interest of the project to have him pitch. Sid felt compelled to confront with his teammate who also happened to be a friend “I thought if it weren’t for this project, I wouldn’t have to have this awkward encounter with my friend.” Ultimately the confrontation was well-received and the teammate, who had strong technical skills, participated in the question and answer segment of the pitch presentation. This experience taught Sid a lot about leadership and that a difficult conversation is sometimes necessary to have if it overall positively affects the team. He had to make a judgment call on whether to believe in his teammate versus telling him he can’t do it. Fortunately, this difficult conversation was resolved with no conflict, because Sid found a way to put his friend in a position that aligned more closely with skills, and thus in a position where he was more likely to be successful. Through the process of participating in Changemaker Challenge, Sid also learned the importance of creating a sustainable financial model and that he could not “simply win off being a very passionate and well-spoken person”. Sid’s team ultimately obtained a small amount of funding from Changemaker Challenge, which was exciting for his team. However, that excitement quickly wore out once they had to focus on developing the project again.

Using Curiosity and Networking to Advance a Project
When describing how he attempted to develop his organization, Sid emphasized how important it was to continuously learn through research “I thought what was more relevant was this idea that I had the ability to learn anything if I put my mind to it and if I researched it and pursued it with enough motivation”. Sid’s actions indicate he has what appears to be an important component of an entrepreneurial mindset: curiosity. His reflections also show he is aware this characteristic is important:

I think what will make you a great entrepreneur is this driving curiosity, because if there's ever something you don't understand, then you have to be able to figure it out and research it enough to understand exactly how to do it or to solve it or to understand it or whatever it is you need to do.

Sid also discovered the learning process could be expedited through networking and talking to the right people. One conversation with a senior member of an organization was particularly enlightening for Sid “I had a chat with him, and I realized that he had done everything that I had researched in the past couple weeks and more. Just talking to him gave me so much insight on both the problem on the steps I could take to participate in a solution.” This conversation motivated Sid to continue networking and have many more conversations with others after. Ultimately, Sid’s project would stall after a new opportunity emerged.

Challenging Moments Joining a New Project

In Sid’s sophomore year, he shifted his efforts to another student-driven project, which was focused on providing access to clean water in developing countries. This was a difficult transition to make since he was joining a team with members that had several years of experience working with the project and were on the cusp of developing it into a formal entity. Sid was determined to contribute, but had to balance being overzealous, and focus on “getting up to speed” and “acclimating to the team environment” by learning as much as he can and “asking questions about anything [he] didn’t understand.” Sid demonstrates aspects of an entrepreneurial mindset in describing his drive to make an impact on the organization and the curiosity to ask questions and learn more. “I think being an entrepreneurial person, you want to affect a lot of change, and you want to create an impact on anything that you're doing.” This also happened to be a problem he was very passionate about, which likely enabled him to have the intrinsic motivation that fueled this drive. Sid’s previous experiences applying to funding competitions, pitching, and networking allowed him to carve out a role on the team. He took a leadership role as the grant writer and team pitcher, and also made impactful connections with non-profit leaders working in several developing countries that turned into projects for the organization.

Funding Competition

One particular pivotal experience for Sid was through a funding competition called the Pakis Social Challenge. It was a three month process in which Sid’s organization was forced to
carefully refine their business model and communicate it in seven minutes. Sid describes the process of developing a pitch as “very iterative” involving trial and error “You really need to spend time writing something out, getting someone else’s feedback on what the flaws might be, and then working to correct it with future iterations, and really think about everything.” It forced the team to think about every aspect of the project to ensure they had a strong business model. Sid worked very hard on the pitch so that when the competition day arrived, he felt ready. The team placed second in the competition, winning $18,000 to advance their project. From this experience, Sid learned that developing a solid business model requires hard work, time, and is an iterative process, but that it can be a rewarding process that builds real confidence and momentum “I think what Pakis taught me is that once you get the momentum of working hard and achieving success for that hard work, everyone wants to work hard.” This level of understanding of the iterative nature of entrepreneurship is another example of how Sid demonstrates an entrepreneurial mindset.

Project Development Experience

After winning the funding, Sid described the team as “really locked in” and that “everyone did their job to make the final project a reality.” When it came time to do the project the team was well-prepared to implement it successfully “We worked so hard before that the actual project was just a question of how do we check off each box.” Completing a successful clean water project was a very rewarding experience for Sid:

We had, I’d say, 20 or 30 children line up. I felt like it was more because they got back in line after they got their water. They came and they all got glasses of clean water. It was just an amazing experience. They loved it. They were exuberant to drink. The parents were telling us how important our work was and how thankful they were for our work. They celebrated by throwing flower petals on us. It was just a great event. I think it was so rewarding to actually see that we were creating real impact. You can work on something for a long time and not create any impact. I think that was one of the first times that I had, from start to finish, worked on something that made a genuine impact on a lot of people with that work. That was super, super rewarding. Seeing the project through to that point was definitely very impactful to me.

The process of working on 33 Buckets seems to have taught Sid that with hard work and passion, he could make a real impact in a self-driven project. Sid also describes learning the value of having a strong team composed of members that are passionate, positive and supportive of each other, have a willingness to learn, and have a unique role or skill to contribute.

Goals/Future Plans

Sid’s entrepreneurship experiences made him a more daring person willing to put himself in uncomfortable situations and take risks:
Yeah, I think they’ve definitely changed me, because they taught me two major things. One is that it's okay to take risks, and it's okay to put yourself in situations where you're uncomfortable, because I think that's when you grow the most as a person…I think before pursuing these entrepreneurial projects, I always tended to want to put myself in situations where I wanted to be comfortable, and if I ever heard something that was slightly like I don't know if that would be good for me, I would shy away from it. After these, I think if I'm uncomfortable, I'll try it out, and I think it will help me grow as a person. I think that that change in mindset has made me a lot more daring as a person and, I think, has made my experiences a lot more rewarding.

Sid’s entrepreneurship experiences have impacted his career aspirations to wanting to have a leadership role at a company that solves important global problem. He is also considering consulting as a career path. This is a stark contrast from his plan as a freshman in college. Sid recalls that he was “set on being a doctor” because of the stability of the role, but now finds these other professions attractive despite the inherent unpredictability of these roles.

Discussion

The Entrepreneurial Student Experience

There were several main patterns that emerged from the narratives. These patterns were examined and organized via a thematic analysis and the creation of the codebook. The themes and codes, or patterns within the data, were then used to generate a flow chart called the “Entrepreneurial Student Experience” (ESE). This process is highlighted in Figure 1. For each experience to occur, a number of initial conditions needed to be present to catalyze it. These initial conditions include ‘environmental conditions’ and ‘student inputs’. The ‘environmental conditions’ that catalyzed the student entrepreneurship experiences almost always related to the entrepreneurship ecosystem at [institution name] as the funding programs and entrepreneurship classes were usually at the center of each entrepreneurship experience. The ‘student inputs’ includes the student’s attitudes, knowledge, skills, and behavior that led to each experience occurring. For these set of narratives, the critical experiences included experiences related to funding programs, classes, stages in project development, challenges, failures, and networking. They were critical experiences because of their profound impact on the student.

After highlighting each critical experience, the student was asked to discuss these impacts. The students primarily focused on the changes in beliefs or attitudes they had. These changes in attitudes mainly related to valuing the importance of communicating, pitching an idea, working on a strong team, networking and making connections with others. Additionally, students also gained more confidence in their ability to communicate and pitch, lead others, and navigate through the design process to create value. The students also discussed the key attitudes and behaviors they developed. These key attributes include a propensity toward risk-taking, the desire to be successful or make an impact, passion, curiosity, and an enhanced ability to identify opportunities, make connections and create value. It is unclear to what degree these attitudes
were innate or developed through these experiences, but the narratives do suggest that there was some degree of changes with all of the students. The changes in attitudes and behaviors are defined as an entrepreneurial mindset in the codebook. Additionally, the narratives discuss the specific knowledge and skills the students learned from their experiences including acquiring business knowledge (e.g. creating a business model), creating and delivering an effective pitch, and navigating through the design process. Finally, it is evident from the narratives that the student’s career aspirations were largely affected by their entrepreneurship experiences. Claudia now wants to work at an accelerator or incubator where she can support entrepreneurs. Munir has the intention to become an entrepreneur. Sid’s experiences led him away from wanting to be a doctor to now aspiring to work in some leadership capacity at a company that solves global problems. This is a significant finding considering none of these students had exposure to entrepreneurship prior to college.

The main impacts for each entrepreneurship experience are therefore some combination of acquiring new knowledge and skills, the start or continued development of an entrepreneurial mindset, and modified goals. The impacts from each experience influenced the subsequent entrepreneurship experience. This repeating process makes up the ESE process (captured in figure 1). A number of these experiences were powerful enough to alter a student’s personal goals including their drive to advance their project. The cumulative effect of having multiple critical experiences even led to changes in long-term career goals in all of these students.

**Figure 1:** The Entrepreneurial Student Experience (ESE) process

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**Implications**

This study addresses the need for more qualitative, interpretivist research in the field of engineering entrepreneurship. It provides rich data on engineering student entrepreneurship experiences and their impacts. Analyzing patterns among the student narratives led to the
development of the ‘Entrepreneurial Student Experience’ process. The results validate that the creation of an entrepreneurship ecosystem, specifically in the form of funding programs and classes, serves as a mechanism to trigger impactful student entrepreneurship experiences. The ESE process highlights that one critical entrepreneurship experience can lead to a series of these types of experiences. The results also suggest that the concept of “imprinting” (environment interacts with individual leading to discovery of opportunities) is more relevant among this sample group than “reflexivity” (individual creates opportunity through observation and reflection). This result indicates that an entrepreneurial mindset and the intention to be an entrepreneur are not necessarily innate, but can be developed over time with the right environmental support systems.

It is notable that the first critical entrepreneurship experience for each student related to participating in a funding competition. This indicates the thrill of participating in a funding competition can be the spark that leads to the first of perhaps many critical experiences. This also seems to support the notion that these funding programs provide a platform for students to have meaningful experiences that perhaps motivate them to want to advance their projects. Winning money from a funding competition is initially very motivating for a student and elevates their confidence on their ability to carry out their project. It also seems to make the project more real as they actually have the funding to advance their entrepreneurial projects. However, as highlighted by all three students, when they attempt to advance their projects they often encounter difficult challenges that lead to iterations and sometimes failure. On the other side of the spectrum, not winning money from a funding competition can be a very deflating experience for a student that can lead to emotions such as frustration and doubt, and can deflate confidence. It can also lead to self-reflection in which the student questions why they did not advance to the next phase of the competition or obtain funding, and lead to them either pivoting their project or dropping it altogether. Administrators and faculty should be aware of the powerful consequences of funding competitions on students’ emotions and their projects, and design them accordingly in a way to support students on both ends of the spectrum. The findings suggest funding programs that provide continuous support after completion of the competition element may be more successful as the newly acquired funding will ultimately lead to challenges as the student attempts to advance their entrepreneurial endeavor. Incremental distribution of funds might also make sense as there appears to be a high likelihood of failure for many student entrepreneurship projects. If a student team continues advancing their project and demonstrates progress, they can continue to be funded in phases. Finally the findings suggest feedback should be a critical component of any funding program especially for students that do not receive funding. A student should know exactly why they were not successful so that they can either improve their proposal for a future competition or come to a realization that their project may not be worth advancing and either pivot or drop the project.

Also supporting the notion of “imprinting” is that each of these students experienced shifts in attitudes from their entrepreneurship experiences. For example, going through multiple
critical experiences seems to have “sensitized” at least one student’s ability to identify opportunities in their everyday life. Munir spoke extensively about how he now is constantly identifying potential opportunities in his everyday interactions. The cumulative effect of these experiences seems to have made the students more okay with taking risks and being okay with uncertainty. Sid explicitly credits his entrepreneurship experiences with changing him into more of a risk-taker. Claudia discusses how she is okay with the uncertainty of her untraditional career path while her classmates follow more traditional routes like pursuing an engineering job or attending medical school. Other changes in attitudes each student describes related to valuing communication, pitching, working on strong teams, and networking. The students also exhibited more realistic expectations toward the design process including the challenges involved in creating a valuable product or service. All of the students indicated their career goals had changed as a result of their entrepreneurial experiences. Overall, these results are in alignment with previous work by Duval-Couetil, Reed-Rhoads, & Haghighi (2012) in which their instrument revealed that students exposed to entrepreneurship were more likely to have the desire to start their own business or work for a small business or startup, have confidence in their ability to identify opportunities, and have higher levels of risk tolerance. They also expand on these results by highlighting that these entrepreneurship experiences may also help develop more well-rounded engineers that are capable of communicating ideas effectively, that know how to develop and play leadership roles within teams effectively, and value networking, connecting, and collaborating with others. The results also suggest because of the challenges these students encountered while attempting to advance their projects, they may have a better grasp on the iterative nature and difficulty of creating a product or service of value.

Within each student narrative there was also a clear intrinsic motivation that manifested as passion for their projects. Passion was an essential ingredient the students felt was vital to them driving their project forward. Claudia and Sid explicitly named passion as a vital characteristic they look for in teammates. This passion for their work is an important element that should not be disregarded. It suggests that these students are self-regulating their own learning, developing knowledge, skills, and attitudes while they attempt to advance their projects. The passion these students had for their projects seems to have led to them having the curiosity to learn whatever they needed to learn to advance their project. Ultimately, each of these students had at least one failed project, and in one case, multiple failures. Despite all of their previous projects failing at one point, and that they are all seniors in engineering, all three students had at least one entrepreneurship project they were currently working on that they expressed a desire to continue advancing even beyond graduation. Each of these students, through the support of entrepreneurship programs and classes at ASU, has developed an entrepreneurial mindset and the knowledge, skills, and attitudes they have developed along with their actions and goals demonstrate it.

The findings also may provide insight on the different role classes and funding programs may play in getting students involved in entrepreneurship. Entrepreneurship and project-based
learning classes present an opportunity for students to get involved in an entrepreneurship project and create a team. A student can also learn entrepreneurship theory and the steps needed to start a business. They can then apply their learning with a project they develop in the class. Funding competitions on the other hand present an opportunity for students to acquire funds to advance their project. In the student narratives, they seem to have a greater influence in affecting a student’s motivation to advance their entrepreneurship project. However, the narratives suggest classes are vital in getting students involved in potential entrepreneurship projects. They seem to act like a funnel for students to get involved in funding programs. Classes can be hit or miss meaning that sometimes a class can be a great way to get started on an entrepreneurship project or learn theory that can be used to advance a project, and form a team. The class structure and not always getting good teammates can however be an inhibitor to intrinsic motivation though. Nonetheless, having students participate in project-based learning courses, or entrepreneurship classes, early in the engineering curriculum and encouraging them those interested in applying to funding competitions could perhaps spur more critical entrepreneurship experiences for engineering students early in their undergraduate engineering program. This initial critical experience could lead to more critical experiences, as they did in this study’s students, and could lead to more students developing an entrepreneurial mindset and working on projects they are driving because they are passionate about them.

Limitations & Future Work

The study was limited in scope as only three engineering students were interviewed. Many of the patterns within the data are therefore not generalizable, and needs to be explored further to be validated. Future work, including the development of assessments that measure impact, should consider including aspects of the three components of impact in the ESE process: entrepreneurial mindset, knowledge and skills, and personal & project goals. Within entrepreneurial mindset, the attitudes this study revealed should be considered being included for validation on larger sample sizes. Within personal goals, assessments should account for not just whether a student now wants to create a business or not by measuring entrepreneurial intention, but also how their experience(s) may have affected their career goals or the role they want to play within a company. Future work can also focus on exploring the different roles and impacts funding programs and classes have. In particular, experiences involving funding completions were a focal point of many of the student’s narratives. The outcomes of these competitions had powerful effects on student’s motivation and confidence toward their projects. Understanding the consequences of these funding programs and how variations within the structure and design affect these consequences should be investigated more thoroughly.

Conclusion

In summary, entrepreneurship programs and classes being integrated within engineering schools continues to grow. The goal of this qualitative study was to better understand the consequences of the development of these entrepreneurship ecosystems and the experiences and impacts they have on engineering students. Three senior engineering students were interviewed
using the critical incident technique. Narratives were generated from the interviews and a thematic analysis was completed on these narratives, which was then used to create the Entrepreneurial Student Experience process. The findings highlight that these students had a multiple critical entrepreneurship experiences that led to profound impacts including changes in attitudes and altered career goals. These impacts are described in detail and point to the development of an entrepreneurial mindset. The findings from this study are useful for administrators to be aware of when designing their programs and for researchers interested in further investigating the impacts of different types of entrepreneurship experiences.

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References


**Appendix**

**Interview Protocol**

Hi [Team Name] team, my name is [My name]. I am a PhD student in the Engineering Education program at ASU. I did my undergraduate and masters in engineering here and had some entrepreneurship experiences also. I am curious to learn a bit more about your entrepreneurship experiences.

Specifically, the purpose of this interview is for me to learn about some of the most important entrepreneurship experiences that have shaped the development of your respective project and your perspective. First I want to start by asking you to brainstorm on a piece of paper some of the most important experiences you have had while working on this project for about 5 minutes or so. Feel free to do this in any way that seems reasonable to you. It can be a timeline, bullet-points or whatever suits you. The important thing is identifying these important experiences and to start thinking about why they were important to you. They can be rewarding/challenging experiences, a key pivot in your project, an experience important to advancing your idea (an “aha” moment, a major connection that was made, a first sale, or anything else that was important.).

If it is helpful, you can follow (SAID) the framework to stimulate your thinking

- Recount the situation (Situation)
- How you felt about it (Affect)
- Why you think it happened this way and what you learned or realized (Interpretation)
What did you learn from this experience (Decision making)

[Students are given a blank sheet of better with instructions and SAID framework and 5 minutes to brainstorm]

Questions that can be asked to trigger subsequent critical experiences during the brainstorming period include:

- What were some of the critical experiences in starting your project and forming your team?
- Can you tell me about an “aha” moment you had during the project or a major connection you made that advanced your project?
- Can you provide me with an example of a key pivot that occurred in your project? Why was this so important?
- Who or what experiences helped you with the development of your project the most?
- What were some of the challenging (or rewarding) experience during the development of your project?
- What was the most exciting (or disappointing) moment of your project?

Overview of your experiences

Okay let’s now start from the beginning. What is the first memorable, important early entrepreneurship experience you had during college?

For each of the critical experiences identified, these are questions that can be used to dive deeper and learn more about what students learned from their experience:

- What exactly happened in this experience?
- How did this experience happen? What led to it? What happened afterwards?
- What was it like to go through this?
- How did you feel about this experience?
- How would you describe the emotions you felt (i.e., excited, anxious, overwhelmed, curious, confused, satisfied)?
- Why was this experience important to you or the team?
- Who was involved?
- What did you learn from this experience?
- What knowledge, skills, and/or attitudes do you think you have gained or developed from your entrepreneurship experiences?
- Were there any lessons you learned from this experience?
- How have you applied what you learned from this experience since this experience?

Final Thoughts
• Overall, what are some of the major things you will take away from your entrepreneurship experiences?
• Have your entrepreneurship experiences changed you in any way?
• Do you think your experiences in entrepreneurship have affected your future plans?