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Unpacking Why Engineering Faculty Members Believe Entrepreneurship Is Valuable for Engineering Education

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ABSTRACT

Despite an increase in entrepreneurial activity at many universities, faculty perspectives on entrepreneurship and entrepreneurial mindsets are limited. To address this gap, we conducted a qualitative study exploring eighteen engineering faculty members' experiences with entrepreneurship, including why entrepreneurship is valuable to engineering education practice. We used a systems framework, Activity Theory, to guide data collection and analysis in order to capture faculty perspectives in the context of the broader university system. Our analysis identified three reasons why faculty members believe entrepreneurial knowledge, skills, and attitudes add value to engineering education: 1) they support faculty members' goals (societal impact, resource attainment, and interest), 2) they support students' professional preparation, and 3) they contribute to student success and satisfy students' interest in entrepreneurship. We then discuss faculty members' need for entrepreneurial experience, an important consideration that is closely related to our findings.

Key words: Entrepreneurship, Faculty Attitudes, Engineering Curriculum

INTRODUCTION

The desire to be innovative and entrepreneurial is growing at universities across the country. Data from the Association of University Technology Managers (AUTM) reveals increases in academic entrepreneurship through university technology transfer and commercialization activities (AUTM,

2014). Engineering education researchers have also called for increasing entrepreneurship education within engineering education (Creed, Suuberg, & Crawford, 2002; Committee on the Engineer of 2020, 2005; Byers, et al., 2013; Duval-Couetil, et al., 2015; Duderstadt, 2007). This entrepreneurial emphasis has encouraged increases in formal and informal education programs (e.g., entrepreneurship majors, minors, certificates, and clubs) and the emergence of entrepreneurship centers nationally (Gilmartin, et al., 2014; Besterfield-Sacre, et al., 2011; Shartrand, et al., 2010).

Prior research has demonstrated that academic entrepreneurship benefits not only university research and reputation, but also scholarship and student success (Sanberg, 2014). Research has also revealed that faculty have an important role in driving not only the entrepreneurial activities of a university (Perkmann et al., 2013; Siegel, et al., 2004), but also the educational activities leading to students' professional success (Winters, Matusovich, & Carrico, 2012). There have been some studies exploring faculty members' beliefs regarding the intersection of entrepreneurship and university learning environments, including defining entrepreneurial mindset (Hochstedt, et al., 2010), considering how faculty members teach entrepreneurship (Zappe, et al., 2013; Besterfield-Sacre, et al., 2016), and more general analyses of the intersection between entrepreneurship and engineering education (Sheppard, et al., 2015). Despite studies like these, there exists a need to better understand faculty members' perspectives on the value of entrepreneurship in engineering education. This work addresses this gap by reporting why faculty members believe entrepreneurship adds value to engineering education.

METHODS

To explore faculty members' perspectives regarding the value of entrepreneurship in engineering education, we conducted semi-structured interviews with eighteen engineering faculty members from four land-grant universities. The study included participants from all major engineering disciplines and all but one participant was male. All had formal experience with academic entrepreneurship; some also had entrepreneurial experience outside of their formal academic role (e.g., consulting, startup company, university-industry partnership). Although not a criterion for participation in this study, all but one participant also had prior experience working in industry.

The interviews were analyzed using a systems-level framework, Activity Theory (Engeström, 1987), because it enhanced our ability to capture and understand participants' perspectives on the intersection between entrepreneurship and engineering education practice. Briefly, Activity Theory utilizes the *activity system* (Figure 1) to better understand the essence of human activity. While the full description of all seven activity system elements is beyond the scope of this paper (see

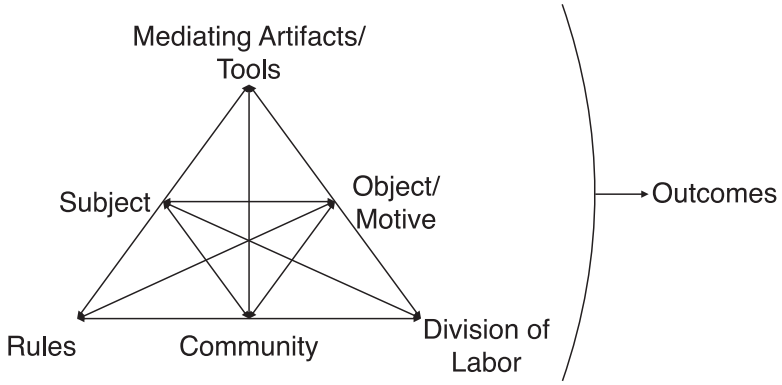

Figure 1. Engeström's (1987) structure of human activity.

Murphy & Rodrigues-Manzanares, 2008), the *Subject* and *Object/Motive* elements of the activity system supported our understanding of participants' perspectives. The *Subject* element captured detailed characteristics about the participants themselves and the *Object/Motive* element captured participants' reasons for engaging with entrepreneurship and incorporating it into their engineering education practice (Engeström, 1987; Murphy & Rodrigues-Manzanares, 2008). Activity Theory has been used successfully in prior studies of work systems (Artemeva & Freedman, 2001; Engeström, 1993) and learning environments (Murphy & Rodrigues-Manzanares, 2008; Blanton, Simmons & Warner, 2001; Paretti, 2013; Hixson & Paretti, 2014), and affords researchers the ability to explore specific elements of an activity while retaining important contextual factors and connections to other system elements, making it particularly useful for this study.

The semi-structured interviews were transcribed verbatim and analyzed utilizing qualitative research best practices such as multiple peer reviews, inter-coder consensus, thorough audit trails, and continuous review of analytic memos (Creswell, 2009; Miles, Huberman & Saldaña, 2014; Seidman, 2006). Analysis included multiple rounds of coding, recoding, and clustering to elucidate themes. The data was first deductively coded using the activity system elements as broad categories and then inductively coded to explore participants' deeper meaning within and across these categories. The codes were then analyzed to identify emergent themes among all participants. To this end, Activity Theory robustly facilitated our exploration of entrepreneurship's value in engineering education practice (an *activity system*) by helping us elucidate insights about the *Subjects* (the faculty participants) as well as their *Object/Motive* for integrating entrepreneurship into engineering education practice. These insights, and their supporting quotes obtain through our analysis, are the focus of the remainder of this work.

CONNECTING ENTREPRENEURSHIP WITH ENGINEERING EDUCATION PRACTICE

The link between entrepreneurial experiences and engineering education practice revealed three specific *Object/Motive* sub-themes regarding why faculty members believe entrepreneurship is valuable within engineering education. They described entrepreneurial activity and developing an entrepreneurial mindset as supportive to: 1) their goals as faculty members (societal impact, resource attainment, and interest), 2) students' professional preparation, and 3) students' success and interest in entrepreneurship.

Why #1: Entrepreneurship's Ability to Support Faculty Members' Goals

Overwhelmingly, participants described that engaging in entrepreneurial activities and developing an entrepreneurial mindset supported their ability to have greater societal impact with their university work, specifically the opportunity to "help people." As one participant stated,

> *I think **my goal is to get my research out there to help people** and to mentor students along the way to teach them how to get their work out there to help people.*

Later in the interview, this faculty member elaborated by first quoting a recent entrepreneurial training and then describing one of his own experiences.

> *… this one guy [at the training] was like, 'You know, if you can have a paper, a lot of you professors are excited that it's been read by 30 people and cited 30 times … versus being able to help some people.' I will say this. It was, I think in [year removed], our technology [significantly and positively impacted the lives of multiple people]. And I got the phone call that it all worked out. This was done in [another country]. He was absolutely right. I was crying. It's the most powerful feeling. That's why people should be doing this stuff. **It's almost our responsibility to get our stuff out there.** … That's what I feel like we're being paid to do. **Or at least educate someone else to be able to do it.***

As this comment suggests, prior entrepreneurial experiences influenced his mindset to one that sought to move beyond publishing papers and toward developing discoveries that impact the world more broadly. At a minimum, as this and other participants stated, even if faculty members don't feel the "responsibility to get stuff out there [outside of academia]," the goal should still be to enable others who can use university-based discoveries, knowledge, and skills to make an impact beyond the walls of the academy.

Participants also expressed other goals for incorporating entrepreneurship into engineering education. One was the opportunity to utilize entrepreneurial activities as an additional funding mechanism for their professional activities. In this sense, by extending their research into entrepreneurial activities or by utilizing an entrepreneurial mindset, faculty were able to apply to additional or supplementary funding programs such as the National Science Foundation's Innovation Corps (I-Corps) program, Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) programs, internal university grant programs, and university-industry partnership programs. These funding mechanisms provided resources for entrepreneurial activities, fundamental research, graduate students, and laboratory equipment all of which supported faculty members' professional goals. Lastly, participants discussed personal interest as a goal for incorporating entrepreneurship. Faculty noted that they "enjoy" entrepreneurship and found it "interesting" and "fun."

Why #2: Entrepreneurship's Impact on Students' Professional Preparation

With respect to entrepreneurship's impact on students' professional preparation, most participants described students' entrepreneurial engagement and mindset development as an important part of their overall education. Typically, this involvement targeted graduate students or post-doctoral scholars working on faculty research or in faculty labs; however, some participants also mentioned incorporating entrepreneurial experiences/thinking into undergraduate courses and programs.

An approach described by multiple participants involved having conversations with graduate students early in the student's graduate training to determine whether the student was interested in an industry or academic career upon graduation. The participant would then attempt to provide that student with experiences that would best prepare them for their desired professional trajectory; often with an eye toward entrepreneurship. For example, if students were interested in an industry career, participants intentionally utilized entrepreneurial experiences to exposed them to aspects of the research and development process not generally addressed in traditional graduate education. As one participant explained,

> *"a person with a PhD in Engineering should be a – well, if they go to academia that's a different story but if they go to industry – they should probably be some type of leader in the R&D [research and development] process at some company. And if they have a leadership position, then they should have the skills,* ***not just the skills to let's say write software or something like that****. They should have the* ***skills to make presentations to other people at the company****. They should have the* ***skills to explain things to people in other groups****. They maybe worked on a prototype and now the other group needs to implement something related to that prototype. They* ***need to be able to understand the***

> ***IP [intellectual property] process*** *as part of being in a leadership position in the design process. So, I think that I'm trying to train them to be –* ***I want them to be successful. I don't want them to be mediocre. So, I'm trying to train them with a variety of skills***.

This participant viewed entrepreneurial experiences as an essential mechanism to teach students "a variety of skills" needed in industry (e.g., communicating across disciplines, prototyping a design, and managing intellectual property).

Another preparation-focused practice faculty members described included incorporating entrepreneurial knowledge, skills, and attitudes (KSAs) into undergraduate education. Some noted that they had successfully leveraged their entrepreneurial experiences to supplement technical engineering content with "stories" describing how engineering concepts were used to innovate and enhance impact in the "real world." Others added entrepreneurial content to foundational courses through entrepreneurship-focused modules or guest speakers. Unsurprisingly, participants cited senior capstone courses, which often have ties to industry, as the course where entrepreneurial KSAs were and could be integrated most directly.

Why #3: Entrepreneurship's Impact on Students' Success and Interest

Lastly, as the previous quote suggests, incorporating entrepreneurial KSAs into engineering education had value beyond student learning. That is, faculty members described entrepreneurial experiences and mindsets as valuable because they increase students' chances of becoming leaders and being professionally *successful*, or as the quotation suggest, to advance from being "mediocre" to being a "leader in the R&D [research and development] process at some company." Others describe technology transfer as the type of entrepreneurial activity that enhances the competitiveness of the university and prepares students to "be some of the best," as illustrated in the following comment:

> *"We have to make sure our students are* ***prepared in the most competitive environment and be some of the best****. So, having them aware of technology transfer and what that means, that's definitely important."*

This participant elaborated by describing how entrepreneurial KSAs have opened doors for corporate partnerships in all aspects of his career (research, teaching, and serving society), as well as how entrepreneurial thinking has opened doors for his students, including competitive internships and jobs upon graduation. Unlike the previous *why,* this data moves beyond essential preparation and toward future professional success.

Similar to faculty motivators, participants described incorporating entrepreneurial experiences and mindset into educational practice as adding value to students by satisfying students' personal entrepreneurial interests. For example, multiple participants described positive responses from their students after being taught about or exposed to entrepreneurship (e.g., "Students love it. They want to see the science or the engineering come to life.") Participants also described students asking to initiate entrepreneurial endeavors based on their work in the faculty member's lab or asking for entrepreneurial advice on a personal project because they knew the faculty member had prior entrepreneurship experience.

Collectively, these three *Object/Motive* themes demonstrate multiple ways in which incorporating entrepreneurship into engineering education adds value to engineering faculty and student development.

IMPORTANT CONSIDERATIONS FOR THE FIELD AND FUTURE WORK

These exploratory findings, drawn from a small and meaningful dataset, demonstrate plausible reasons *why* entrepreneurship adds value to engineering education practice. While this plausibility would benefit from a broader, large-scale investigation, we believe these findings, especially considering the prior entrepreneurial experiences of our participants, affords an opportunity to discuss a closely-related overarching question:

> *If data suggests that entrepreneurship education adds value to engineering education, do engineering faculty members need to have entrepreneurial experience in order to teach, advise, and mentor engineering students about entrepreneurship?*

Other researchers have suggested similar questions (Sheppard et al., 2016), and answers to this question are at best complicated and debatable. The reality is many faculty members, unlike the participants we interviewed, have little experience with non-academic entrepreneurship or as professionals in the non-academic STEM workforce. Instead, many faculty traverse from undergraduate programs through graduate school and into faculty positions without gaining or needing these experiences. At best these faculty experience entrepreneurship through the inherent nature of faculty work (e.g., seeking funding – or revenue – through grants, managing research groups/employees, and creating value through service to students, the field, or the community). But do they utilize these experiences to add value to engineering education practice similar to those who have non-academic entrepreneurial experience? Questions like these require further study.

If we instead consider the question from the student perspective, we must acknowledge that most engineering graduates (both undergraduate and graduate) leave our universities and enter into the technical STEM workforce – an increasingly entrepreneurial workforce largely centered on producing products and services that must be commercialized. These products and services rely on a sound technical foundation, but they, and the companies producing them, also benefit from engineering graduates who can think entrepreneurially. It is logical to hypothesize that there is value to working with and learning from faculty with entrepreneurial experience in the non-academic STEM workforce, but again, future work is needed in this area.

In light of these considerations and our findings, we believe the question of necessary faculty experience is prime for exploration. We also believe this question may skew the conversation away from equally meaningful programmatic discussions within engineering education. Based on our analysis, faculty members with entrepreneurial experience and mindsets have clear opportunities to add value (e.g., by teaching the entrepreneurial KSAs needed in the non-academic STEM workforce). At the same time, entrepreneurship activities also help some faculty and students achieve their goals and satisfy their interests. We therefore encourage the field to consider an equally important question:

> *How might universities (and/or the field of engineering education) best leverage the faculty who do have entrepreneurial experience and entrepreneurial mindsets when preparing the future STEM workforce?*

We plan to continue to explore and discuss these aspects of engineering entrepreneurship education in future work.

CONCLUSION

This work describes the findings from a study exploring the intersection of faculty members' entrepreneurial experiences and mindsets with engineering education practice. We offer three reasons *why* engineering faculty believe entrepreneurship adds value to engineering education. Specifically, entrepreneurship can satisfy faculty members' goals, support students' professional preparation, and enhance students' success and interest. These findings have important implications for entrepreneurially-minded faculty, university administrators, and students. For example, by understanding the value entrepreneurship adds to students' professional preparation, faculty members' can make informed decisions regarding their teaching, advising, and mentoring practices. The findings can also support university leaders as they seek to support student and faculty

entrepreneurship by informing administrative decisions regarding entrepreneurial policies and training opportunities. Equally as important, entrepreneurial experiences and mindset development can directly and indirectly enhance faculty and students' interest, professional success, and societal impact, all of which benefit the broader STEM ecosystem. Lastly, a direct methodological implication of this work is Activity Theory's effectiveness at capturing faculty members' perspectives in the context of engineering education. While the methodology will be detailed further in subsequent publications, we believe this use of Activity Theory is transferrable to other studies of mindset in engineering education research.

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