Engineering Deans' Perspectives on the Value of Entrepreneurial Thinking in Engineering Education

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Abstract

The proliferation of entrepreneurship degree programs, centers, and on-campus programs implicitly signal that a variety of stakeholders are involved in advancing these efforts. Among these stakeholders are the deans of engineering colleges since they are primary agents for leading change efforts throughout an institutional context. To date, little literature has explored their perspectives on the value of entrepreneurship and entrepreneurial thinking within engineering. In this study, we present the results of conducting interviews with 23 deans of engineering colleges representing three types of institutions: R1 Public (8), R1/R2 Private (5), and primarily undergraduate-focused (10). During the 30-minute interviews, deans discussed how they onboard and support junior faculty, and the role of entrepreneurship and entrepreneurial thinking in engineering colleges. A thematic analysis of their responses revealed that, overall, engineering deans believe an entrepreneurial mindset can support both students and faculty and expressed their desire to continue scaling their institutions' entrepreneurship initiatives. The findings indicate that deans value entrepreneurial mindset because of its potential to enhance many of the activities that occur within an institutional context. The findings of this study add to the body of literature on this topic by documenting the perspectives of critical change agents connected to this topic.

Introduction

Various stakeholders in the engineering education ecosystem have expressed commitments to advancing entrepreneurship-related topics. For example, it is now commonplace for engineering students to be exposed to entrepreneurship during their undergraduate education. Formal entrepreneurship programs (e.g., majors, minors, and certificates) have quadrupled from 1975 to 2006 [1]. Moreover, the National Science Foundation (NSF) and other funding agencies --including the Kern Family Foundation, the Kauffman Foundation, VentureWell and the Lemelson Foundation-- have invested in promoting entrepreneurship and innovation in engineering education [2]. Similarly, the Entrepreneurship and Engineering Innovation (ENT) Division of the American Society of Engineering Education (ASEE) is also supporting the movement through its mission to "foster and disseminate approaches to educate and stimulate faculty and students at all levels on entrepreneurship, including partnerships with business schools as well as the business and technology enterprise communities" [3].

The efforts to support entrepreneurship in engineering programs often come in the form of entrepreneurship experiential learning activities such as creating a business plan, consulting with practicing entrepreneurs, interviewing potential customers, delivering pitches, applying to grants, and prototyping a minimal viable product (MVP). Entrepreneurship programs and centers

also assist students in taking their projects and ideas beyond the scope of the classroom through accelerator programs that help students start businesses or with commercialization. To many change agents associated with these efforts, the success of these entrepreneurship activities and programs is not contingent on students starting successful ventures, but rather in their ability to cultivate an 'entrepreneurial mindset' (EM) among students.

The Kern Family Foundation in particular has invested significantly in initiatives that promote EM. The foundation has partnered with 33 institutions to create the Kern Entrepreneurial Engineering Network (KEEN) to promote EM specifically for undergraduate engineering students. KEEN defines mindset as "a combination of attitudes, motivations, and dispositions [4]." They specifically characterize EM with the 3C's: Curiosity, Connections, and Creating Value. KEEN believes EM equips students to be more curious about the changing world, make connections from disparate information, and create extraordinary value for themselves and their communities [4]. KEEN partner institutions have integrated EM in a variety of different courses (especially design courses) and in extracurricular opportunities at universities across the United States [5]. This of course involves engaging engineering faculty in these initiatives. Examples of institutions that have formally done this include Baylor University and the University of Dayton. These institutions created the KEEN Innovators program and KEEN Fellows program to expose faculty to EM and assist them in integrating EM into their teaching practice [4], [6].

The perceptions of engineering faculty on entrepreneurship and EM has been documented in a few studies (e.g., [7], [8], [9], [10]). These studies have explored the perception of faculty on integrating entrepreneurship into capstone courses [11], the extent to which engineering faculty value and practice entrepreneurship education [9], and the beliefs of faculty who teach entrepreneurship to engineering students on various dimensions related to EM and the content of entrepreneurship courses [7], [8], [10]. However, there is very little documentation in the engineering education literature on engineering deans' perspectives on this topic.

A few insights have emerged from the few studies that have focused on this critical group of stakeholders. In an ASEE paper describing Baylor's KEEN Innovators Fellow program, Fry and Jordan [6] mention that the Dean of Engineering and Computer Science had publicly supported the program. Another initiative that captured the perspectives of engineering deans (although not explicitly focused on EM), was led by [9]. As part of a broader ASEE initiative, a survey was completed by 110 engineering programs. This survey captured open-ended responses from engineering deans on what they perceived to be principal opportunities and challenges in creating a culture of scholarly and systematic innovation in engineering education. The deans highlighted several practices including offering teaching rewards and teaching release time, the creation of faculty positions in the area of educational innovation, providing financial incentives for innovative education practices, and even changing the promotion and tenure (P&T) expectations to support faculty engagement in educational innovations.

Engineering deans have a crucial role in providing vision and leadership on engineering education, research, and engagement. As a result, they have a major influence on what happens at their respective institutions. Given the important role deans play in making systemic changes, more research is needed to offer insights on their perspective about the role of entrepreneurship and EM in engineering education. This study seeks to begin addressing this gap in the literature. Twenty-three interviews with engineering deans across the U.S. were completed and analyzed as part of a broader study. In these interviews, engineering deans were asked to express their thoughts on the role of entrepreneurship and entrepreneurial thinking. A thematic analysis of their responses revealed that, overall, engineering deans believe that promoting EM has a positive impact on students and faculty, and that they intend to continue growing their EM initiatives and entrepreneurship programs. The remainder of this paper outlines details about the methods that led to the research findings, and a discussion about the significance of the results.

Methods

As part of a larger study that aims to investigate the current problems and needs associated with onboarding, mentoring, and supporting junior engineering faculty, the authors of this study conducted 23 interviews with engineering deans from three different types of institutions: R1 Public (8), R1/R2 Private (5), and primarily undergraduate-focused (10). Six of these undergraduate-focused institutions are part of the Kern Entrepreneurial Engineering Network (KEEN). The schools were sampled in this manner to ensure a wide-diversity of perspectives from different institutions.

The interviews ranged from 26 to 49 minutes, but the majority of the interviews were completed in 30-35 minutes. The interviews were completed over the phone one-on-one with at least one of the authors. The interviews were semi-structured: all of the authors followed the same interview protocol but had flexibility to ask follow-up questions based on the participants' response to various questions. The interview protocol addressed targets for hiring, process for onboarding, mentoring models, areas of guidance/strength, programs/workshops, resources available, retention strategies, top priorities, and supporting mid-career/senior faculty. The interview protocol can be seen in Appendix A. One of the questions in the interview protocol asked about the role of entrepreneurship and entrepreneurial thinking within engineering colleges. The authors felt this question in particular elicited compelling responses and it was thus decided to analyze these responses further through a separate thematic analysis.

All of the interviews were audio recorded and later transcribed using REV's transcription services. These transcriptions were then uploaded to a qualitative analysis software called Dedoose [12]. A rigorous process was followed to analyze all of the data. First, one of the authors listened to all of the audio recordings. Second, the same author read through all of the transcripts once and generated initial codes. An initial codebook was created and revised based on feedback from the other authors. This codebook was then used to code all of the transcripts. One of the codes was labeled 'entrepreneurial thinking and entrepreneurship'. Any excerpts in

which the deans explicitly referred to these terms or related to this topic were coded under this label. These excerpts were compiled, and then the author made several passes through just these excerpts and generated sub-themes. These themes were reviewed by the other authors, and then the final three themes were agreed upon.

Results

Three major themes emerged from the deans' responses to a question asking about their perspective on the role of entrepreneurship and entrepreneurial thinking within engineering: (1) the impact of EM on students, (2) the impact of EM on faculty, and (3) the growth of EM and entrepreneurship.

Impact of EM on Engineering Students

Since 6 out of the 23 deans interviewed were part of the KEEN network, the term 'entrepreneurial mindset' (EM) naturally emerged in the interviews along with the 3C's KEEN used to define EM. Several deans spoke about the value of EM in promoting the 3C's (curiosity, making connections, and creating value) among students. Other deans expanded on the value of entrepreneurial thinking by discussing how it aligns well with their desire to have their students thinking about customer needs, making an impact, and reflecting on the consequences of their work. Dean A at a primarily undergraduate-focused institution remarked:

> *I think as our engineering students think about how they're going to solve world problems and how they're going to make a difference in the world, how do they do that with an entrepreneurial mindset, and how to think about what does it really mean to create value, how do we do that and what are the things that you think about. It's not about just for the technology but really understanding customer needs, and what is the real need. It's not just about developing a really cool hammer and then not looking for an application.*

Additionally, several other deans felt that entrepreneurial thinking enables students to be become more innovative and forward-thinking. Dean A also remarked, "The people with that entrepreneurial mindset will be out in the lead and will be steering the needle where we're headed, versus just always catching up and playing catch up". Several deans described that exposure to entrepreneurial thinking enables students to more readily adapt to changes and can support their problem-solving abilities. Dean B chose to expand on how entrepreneurial thinking can reframe the idea of failure from being a bad thing to a necessary part of the design process. Dean B (from a primarily undergraduate-focused institution) comments:

> *I think it [entrepreneurial thinking] offers the engineers an opportunity to get more comfortable with failure. I think our educational system, particularly in K-12 really makes failure a burden and there's a lot of negative connotations go to it and working engineers, their building designs ... they don't get it right all the time. Failure's not only an option, failure's almost a necessity.*

A few deans also discussed the changing workplace and that the students they are graduating now likely won't have the same long-term stability in their future jobs as the previous generation did. They argue that those that have EM will be able to adapt and respond more effectively to these changes. Dean C (from a primarily undergraduate-focused institution) remarked:

> *What does the world look like in another 20 or 50 years? We contract everything. We all become individual contractors. Therefore, entrepreneurial skills ... I would argue that entrepreneurial skills are absolutely as essential as Calculus I.*

Dean D (from an R1/R2 private institution) discussed the importance of mindset development in training "21st century engineers" and that their institution is taking steps toward revamping their curriculum to focus more on mindset development than just knowledge-based education. This dean discussions entrepreneurial mindset as a component of this mindset training.

Although deans' perspective on entrepreneurial thinking and EM was unanimously positive, several deans did highlight some of the limitations they felt the term had. Dean E discussed how EM only covers part of the mindset that engineering students need to develop. Dean F elaborated on this point by saying that their curriculum also focuses on leadership and communication skills in addition to EM but does acknowledge that there is some overlap. Deans G & H presented interesting perspectives by sharing that there isn't necessarily value in using the buzz word 'entrepreneurial mindset'. They argue that although the mindset implied form these terms is important, there isn't necessarily any universally understood definition supporting these terms versus commonly used business terminology. Dean G commented "I would love to get to the point where we just assume that students can recognize opportunities and can talk about their technical decisions in ways that other people can understand - in business terms". Dean H elaborates on this sentiment by describing how the term entrepreneurial thinking must be supported by educating students on the fundamentals of business and having them practice entrepreneurial activities to really have any real meaning.

Impact of EM on Faculty

The deans also spoke highly about how EM could support faculty in several key areas. Dean I explicitly discussed how faculty are generally very entrepreneurial in that they have considerable autonomy in their roles and must become good at investigating problems, identifying opportunities, and creating solutions to these problems. They must also be able to develop their own brand and sell themselves as teachers and researchers. According to the deans interviewed, the most common ways EM could help faculty is through enhancing the impact of their research and having them place more value in educational innovation. This is exemplified perfectly by the following quote from a dean J at an R1/R2 private institution:

I am really speaking about using research funding to develop technologies that have, generally, commercial application, but that could be put to broader use beyond an individual laboratory. One of the descriptors I've used is, "science that doesn't stop at the laboratory door." Meaning, publishing the paper is wonderful, but that's what society expects of scientists. For engineers, they are looking for us to take the next step to be the implementers, to refine it, develop it, and put it to use to improve the human condition. That's what engineering was about 75 years ago, and then I will argue that we fell in love with this notion of engineering science, where engineers published papers in Science and Nature in a university environment, the same as scientists did, and that was the mark of prestige. That's great, and we want our faculty to publish in those places, but what we really value is putting it to use. We talk about lives touched, and the way to touch the greatest number of lives, which is what society asks of us as engineers, is to have your development, your creation, your invention, be commercialized and put to broad use. I see it, as fundamental to what engineering is asked by society to do, fundamental to why we became engineers.

This quote epitomizes a growing cultural shift happening across engineering colleges in that faculty are being encouraged to participate in entrepreneurial and impact-focused work that creates value. Dean K of one institution even revealed that one of their goals is to have had over half their faculty members to have started a technology-based company, and that they are currently are at one in three. These types of non-traditional academic work seem to come more naturally to younger faculty. Several deans described the younger faculty as being more collaborative, data-driven, and entrepreneurial than older faculty. Consequently, they are doing more non-traditional things in their roles such as commercializing their research, building new programs, and disseminating their research in creative ways. The following excerpt from a dean K (from an R1 public institution) highlights an example of how a young faculty member did just this:

The younger generation of faculty are far more collaborative, and often more data-driven. More entrepreneurial. Are interested in being nontraditional in what they do. Let's say you're starting the Hackathon, which a young assistant professor did, here. How do we incorporate that into his success? Is it teaching? Yes, it is. Is it research? Well, a lot of research goes on, there. Student research. Is it outreach? Absolutely. There's companies involved. There's companies looking to hire students. There's companies supporting it. So there is a young, at the time, untenured professor, non-tenured, doing things that nobody else had done before. How do we factor that into his success?

Dean K appears to be supportive of the effort that goes into creating a Hackathon and the impact it can have, however the dean raises an interesting question on how this type of activity should be evaluated in the tenure and promotion decision compared to other activities. Other examples of non-traditional activities faculty are more involved in now that were mentioned by

the deans include faculty commercializing their research, helping a graduate student start a company, creating a makerspace, giving a Ted Talk, and creating educational innovations. Dean L explicitly discussed some of the changes they have made in their tenure and promotion guidelines that grant merit in engaging in these types of activities. According to dean L, these types of institutional changes further validate and encourage faculty to participate in non-traditional activities as long as they can demonstrate they make an impact. Dean D (from an R1/R2 private institution) that mentioned the importance of EM in supporting educational innovations stated:

> *I think the broad academic community values certain things very much. As we should, we value scholarship, research excellence very highly in top research universities and that's what we should do. But we also could value ... We value experiential learning or educational and pedagogical innovation or however you want to look at it or entrepreneurial mindset learning. If we value that as a part of our culture, then I think that really matters.*

Despite being supportive of EM in their colleges, several of the Deans reported experiencing some resistance from older faculty. The terms entrepreneurial thinking and EM seem to be rebuked by some faculty because it is rooted in the word entrepreneurship. They acknowledge that it should not be forced upon faculty to engage in non-traditional activities. With that being said, several deans report that the culture is shifting regardless, and that older faculty are becoming more open to it.

Growth of Entrepreneurship and EM

Many of the deans discussed the expansion of their entrepreneurship programs including certificate programs, minors, majors, centers of entrepreneurship, funding competitions, and events. They also discussed their desire to continue getting more of their engineering students involved in these programs so that they can develop EM and have the opportunity to create an impact in college. There are also several professional development programs that deans encourage their faculty to participate in such as the NSF I-Corps™ program or local events in which faculty can connect with venture capitalists, executives of companies, and/or entrepreneurs. All of this points to a growing cultural shift in which entrepreneurship and EM are growing within engineering colleges and have the support of engineering deans.

Discussion & Conclusion

Overall, the deans were unanimously supportive of promoting entrepreneurship and EM among their students and faculty. The deans highlighted that entrepreneurial activities can support positive attitudes among students such as curiosity, adaptability, desire to understand customer needs, and the ability to be innovative, bounce back from failure, make connections, identify opportunities, and problem-solve in a way that creates value. The deans also expressed a desire to continue expanding engineering students' involvement in these entrepreneurship

programs. Due to the scope of the study, it is not clear to what extent they believe the minimal exposure or involvement in entrepreneurial activities engineering students should have in the curriculum or how EM should be integrated. It has however been highlighted that there is an inherent connection between design and EM (Huerta et al., 2017), which makes EM complementary in supporting the design process in freshman project-based courses and senior capstone projects. The deans expressed the desire to continue trying to scale their entrepreneurship programs for students.

The deans also saw value in how EM can support faculty in creating value and maximizing their impact in their different roles (e.g. researcher, teacher, mentor, service, etc.). It was noted that faculty must already be entrepreneurial in their research since this involves identifying needs in research, investigating these research needs, and in some cases, developing solutions. Similar to entrepreneurs, they must also raise funds to support their research initiatives, which involves clearly articulating the value of their research to funding agencies. Perhaps the most interesting finding is that engineering deans' expectations for their faculty seem to be increasing. Deans want their faculty to go beyond just publishing research. They want their faculty to translate their research or other endeavors into real-world solutions that create value. Thus, non-traditional activities (e.g. faculty commercializing their research, helping a graduate student start a company, creating a makerspace, and creating educational innovations) appear to be valued by the deans, broadening the scope of what it means to be a good scholar. These types of non-traditional activities seem to connect well with younger faculty and have implications for how engineering schools might on-board and mentor new faculty. It does however raise the question of how these evolving expectations should translate in tenure and promotion guidelines. As one dean discussed, if schools want their faculty to support non-traditional activities, they must reward and recognize faculty as long as they are making an impact or creating value through their participation.

One of the concerns brought up by two deans related to the ambiguity of what EM means and argue that since the term is not grounded in a concrete meaning, it may not have utility. They seem to advocate for faculty to focus more on using concrete business terms. This is an interesting perspective that has merit as there is still no gold-standard definition for EM. A few deans also describe some faculty being resistant to EM because the term is rooted in the term 'entrepreneurship'. This should not be surprising as it has been shown that engineering faculty generally do not value engaging engineering students in entrepreneurship programs nearly as much as in laboratories, research, and internships, and not more than international programs or engineering competitions (Besterfield-Sacre et al., 2014). The deans acknowledge that entrepreneurship is not for all engineering faculty and that it should not be forced.

It would seem that if entrepreneurship or EM helps faculty reflect more about creating value or even taking actions like commercializing their research, then it has utility among faculty. Our future work includes studying how to create institutional structures that maximize the effectiveness of all faculty. We have piloted a new faculty mentorship model that integrates

the findings from this customer discovery. We will build on lessons learned from the pilot to explore how to fully institutionalize a mentorship model that enables faculty to achieve success through a career of meaningful impact.

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Appendix A - Interview Protocol

1. On average, how many faculty does your college hire per year? (ask about TT and contract)
2. Do you have a process for onboarding new faculty and if so, can you describe it?
3. As faculty get started, have you noticed any areas where they tend to need more guidance, or alternatively, areas where they seem to do well?
4. Have you noticed any requests or trends from faculty in terms of what they need to be successful?
5. What would you suggest as critical components of a faculty mentorship model/program?
6. Are there programs (such as faculty development workshops) that you are aware of, and that you recommend to your faculty? (could be internal, external) And why those, if any mentioned?
7. Do you provide any resources to your faculty in terms of mentorship/faculty development? Please describe. Probe for where funding for resources come from and how much.
8. Does your college have specific targets for recruitment and retention? If so, probe for any strategies that college is implementing to achieve targets.
9. What are some of the top priorities for your college? (e.g. the overall strategic direction, mission, etc.)
10. In recent years entrepreneurship (or entrepreneurial thinking/education) has become more present in engineering colleges. What is your perspective on the role of entrepreneurial thinking in engineering?
11. What opportunities (or needs) are you aware of that relate to mentorship of faculty after promotion/tenure?
12. Are there any questions I should have asked or anything else I should know?