Developing a Conceptual Framework to Understand Student Participation in Entrepreneurship Education Programs

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Developing a conceptual framework to understand student participation in entrepreneurship education programs

Abstract: The importance of fostering innovativeness and creativity in graduates has been widely noted in national calls and accreditation reforms to enhance graduates’ competitiveness in the global economy. As a result, universities and other higher education institutions have initiated curricular and pedagogical reforms to create learning environments that are conducive for the attainment of 21st century skills such as innovativeness, teamwork, communication, problem-solving and creativity. In engineering, among other initiatives, colleges and schools have leveraged entrepreneurship education programs (EEPs) to instill some of these needed skills in graduates. Although these EEPs differ in size, structure, pedagogical approaches, and curriculum, they generally focus on fostering entrepreneurial mindsets and behaviors, as well as teaching fundamental business content.

The development of EEPs in engineering colleges and universities has led to the creation of engineering entrepreneurship as a new area of inquiry in engineering education research. Researchers have examined several aspects of EEPs such as student learning, student career choices, attitudes, and retention. However, two critical gaps remain in the literature. First, there is an overall lack of research which leverages theory in their examinations. Second, there is almost no work examining the factors that influence engineering students’ decision to enroll in EEPs. As EEPs continue to grow and evolve, it becomes imperative to assure that EEPs cater to a diverse student population and that research revolving around EEPs is grounded in strong theoretical underpinnings.

This paper presents an overview of our work that focuses on examining engineering students’ participation in EEPs using entrepreneurship assessment and adult participation theories. The purpose of our paper is to provide a methodological resource for researchers interested in conducting theory-driven engineering entrepreneurship research. We present the three phases of our work on the development of a conceptual framework for understanding student participation in EEPs. Our conceptual framework is guided by the Cross Chain-Of-Response Model of Adult Learning. We explicate our approach involving the identification of key theories in entrepreneurship assessment through a systematic review of the literature (Phase 1), synthesis of the theories into a conceptual model (Phase 2), and validation and revision of factor definitions based on student interview data. Our work identified six factors that inform student participation in EEPs – entrepreneurial self-efficacy, desirability, entrepreneurial intent, life transitions, information and resources, opportunities and barriers. Recommendations for engineering education researchers and implications for entrepreneurship education research are offered.

Introduction

With the advent of a technology-driven global economy, institutions of higher educations are increasingly investing in providing undergraduate engineering students with learning environments that assist in their professional formation. In addition to technical skills, academia has recognized the importance of developing domain-general skills needed to solve future problems [1]. Engineering entrepreneurship education has been noted as a platform for developing 21st century professional skills such as innovativeness, teamwork, communication,
problem-solving and creativity [2]. Increasingly, universities and higher education institutions are leveraging entrepreneurship education programs (EEPs) to expose undergraduate engineering students to entrepreneurial environments in curricular and co-curricular settings [3]. Expanding from a business school focus of venture creation [4], EEPs in engineering also place emphasis on the development of entrepreneurial mindsets and behaviors in graduates. Many EEPs seek to promote innovation and creativity in students pursuing both entrepreneurial and non-entrepreneurial career paths [5]. To develop entrepreneurially-minded engineers, EEPs often leverage student-centered teaching practices (e.g., project-based learning, group discussion, pitch competitions, mentorship, and experiential learning) to instill entrepreneurship practices such as opportunity identification, customer discovery, validation and pivoting [6], [7].

The growth of EEPs has also fueled research in the area. Researchers have explored a variety of EEP aspects such as their impact on student career choices, attitudes, and retention [8]–[10]; assessed learning outcomes [11]; and have presented different models for EEPs [12]. Cumulatively, these studies have provided empirical support for the benefits of entrepreneurship education in the professional development of undergraduate engineering students. However, two critical gaps remain in the EEP literature. First, in spite of the significant amount of research disseminated through different publication avenues, there is a paucity of research that has leveraged theory in their work [13]. Second, apart from a few recent studies [14], [15], there is almost no work examining factors that inform engineering students’ decisions to enroll in EEPs. Given the continued investment in entrepreneurship education by universities, it is critical to ensure that EEPs attract diverse students by examining influencers behind engineering students’ engagement/disengagement in EEPs. Furthermore, it is imperative to ground this examination in relevant theories. With the wider aim of broadening participation in EEPs, this paper presents our multi-year work involving the development of a conceptual framework to understand student participant in EEPs. We explicate our multi-step approach involving systematic review of the literature, synthesis of theories, and validation using student interview data. The purpose of this paper is to serve as a resource for engineering education researchers who are interested in entrepreneurship education and may need assistance leveraging extant theories in the field to conduct their research. Implications for engineering entrepreneurship education and lessons learned through our work are also presented.

**Background and Prior Work**

Entrepreneurship education has witnessed significant growth in the last two decades in postsecondary settings. In engineering, more than half of ASEE affiliated schools offer entrepreneurship training to undergraduate students [16]. In addition, several nation-wide programs such as the National Science Foundation’s I-Corps [17], the Epicenter Program: National Center for Engineering Pathways to Innovation [18], and the Kern Engineering Education Network [19] have been initiated to provide entrepreneurial training to scientists, engineers and students; contributing to the growth of entrepreneurship education. For example, the Epicenter program provided entrepreneurial training to more than 450 students at approximately 130 post-secondary institutions over the course of five years following its initiation in 2011 [20]. Similarly, the national I-Corps program has been providing training to NSF funded scientists to examine the venture potential of their scientific innovations. To date, NSF supported 9 I-Corps Nodes and over 100 I-Corps sites located at different higher education
institutions are engaged in providing entrepreneurial training [17], [18]. Focused on engineering, The Kern Engineering Education Network partners with several engineering institutions to develop best practices in developing entrepreneurial mindset in engineering students [19].

With the increased dissemination of entrepreneurial training among science and engineering faculty through these programs, it is highly likely that the number of engineering schools offering EEPs will increase. Furthermore, this growth is anticipated due to continued calls for fostering innovation [21] and recognition of entrepreneurship as an important element of engineering education [22], [23]. Depending on the availability of resources and targeted goals, EEPs for engineering students follow a variety of existing models, such as specialized academic degrees, including minors [18], standalone entrepreneurship courses [24], and entrepreneurial training integrated into existing engineering design programs [25]. In addition to varied programmatic structures, EEPs also differ in their pedagogical approaches which range from student-centered teaching practices, formalized mentorship with practicing entrepreneurs, informal field trips, to guest speaker-centered seminars [26].

This multitude of varying approaches to engineering entrepreneurship education has brought with it research opportunities to 1) examine the impact of EEPs on students, and 2) explore what factors drive individuals to entrepreneurial training and practice. As noted in the sections above, there have been several studies focusing on the former aspect; research on the latter aspect is just beginning to emerge. For instance, (Blinded for review) studied EEPs from a pathway to entry perspective by examining differences and similarities between students participating in a curricular and co-curricular EEPs [27]. Using regression analysis on undergraduate student enrollment data, the researchers found that student characteristics such as gender, nationality and GPA are influential in determining the type of EEPs (curricular and co-curricular) students select to participate in. Furthermore, the researchers found that curricular EEPs act as a gateway to involvement in entrepreneurial activities outside of the classroom and women are more likely to participate in curricular EEPs than co-curricular programs. In another recent work, Yi & Duval-Couetil (2018) developed an entrepreneurial motivation scale to study motivation behind engineering students’ decision to select entrepreneurial careers [14]. The researchers identified three sub-factors contributing to entrepreneurial motivation: motivation for creating and finding a solution; motivation for personal gains, such as earning more money; and motivation for managerial pursuits, such as heading an organization.

These two studies suggest that students’ drive to engage in different EEPs may differ across demographics and are mediated by individual characteristics such as entrepreneurial motivation and interest. As engineering education reforms seek to develop a skilled, diverse workforce, it is imperative to examine the influencers behind engineering students’ participation in EEPs to foster skill-development in a diverse student population through exposure to entrepreneurial training and practice. Findings from these examinations could provide critical insights into factors that EEP developers should be cognizant of when promoting diversity in EEPs, particularly among groups that have been historically underrepresented in the field. Also, the nascent and emergent state of entrepreneurship education in engineering education research warrants that such examinations are grounded in strong theoretical foundations and serve as a resource for guiding future work in engineering entrepreneurship education. This paper focuses on unpacking participation in EEPs from a theoretical perspective and presents implications for
future research. We present our project steps to highlight the ways by which we navigated the process of developing a conceptual model utilizing systematic review of literature and validation of the model through qualitative student interviews.

Our Research Approach

Our research project consisted of three phases: 1) a systematic literature review [13], 2) development of a conceptual model [28], and 3) model validation [29]. Given the interdisciplinary nature of entrepreneurship education, we first started with a systematic literature review of the most commonly used theories in entrepreneurship education assessment in business, engineering and education literature (Phase 1). Based on our findings in Phase 1, we synthesized the identified theories and mapped them to an adult participation in learning model to create an entrepreneurship-specific model of student participation (Phase 2). Finally, in Phase 3, we used qualitative student interviews to validate the model. A description of the three phases explicating background, methods and key results is presented in the following three sections.

Phase 1: Identification of Key Theories

Background. The use of theory in education research provides a process for systematically developing and organizing ideas to explain the phenomenon under study. Typically, theories explicate plausible relationships between different concepts and serve as a basis for “considering how what is unknown can be organized” [30]. For researchers, theories play a vital role in developing a comprehensive conceptual understanding of the problem under study by leveraging relevant ideas and concepts that have been explored in the literature. They provide researchers with a framework for designing a study and also serve as a lens for conducting the analysis [31]. Thus, to understand student participation in EEPs (the phenomenon under study in the current work), we first needed to identify key theories that have been used in entrepreneurship literature. To accomplish this, we conducted a systematic review of the literature with an overall intent to develop an understanding of entrepreneurship education and leveraged the review to identify key theories used in entrepreneurship assessment.

Methods. Results of the systematic review are detailed elsewhere [13] and only briefly discussed here. The review involved a comprehensive search of entrepreneurship education assessment journal articles and conference papers published in two major databases: Elsevier’s Scopus and ProQuest. These two databases were selected to examine a literature from the fields of engineering, education and business. The string used for searching was [entrepreneurship education OR entrepreneurial education] AND [measurement OR instrument OR assessment]. After removing duplicates and only including empirical studies, a total of 359 articles were included in the final dataset for our presented work. Two researchers coded the articles for theories used in entrepreneurship education assessment. A liberal approach for identifying theories as used, if a theory was discussed before the methods section of the article, it was coded. This approach allowed us to capture a wide range of theories that have informed entrepreneurship education research studies. An intra-class correlation of 0.97 between the researchers assured inter-rater reliability in the coding process.
Results. The coding results found that only 53% of the papers referenced theory in their work. This result further strengthened the rationale behind our work to develop a theory-driven model to assist future entrepreneurship education research. Nonetheless, a total of 153 unique theories were documented in the 359 articles. It is important to note that the theories were documented irrespective of the disciplinary background of the articles in which they were cited in to generate a wide list instead of focusing specifically on engineering fields. This emphasized that researchers may utilize a wide spectrum of lenses to study different aspects of EEPs due to the interdisciplinary nature of entrepreneurship education and the nascent state of research in the field. Furthermore, this reiterates the need to consider the key theories when researching EEPs, specifically student participation for our case. To identify the key theories, the documented theories were assessed for their level of use based on the number of times they were cited in the 359 articles. Theories that were cited in at least 10 articles were shortlisted, yielding a total of seven key theories – 1) Theory of Planned Behavior [32], 2) Theory of Reasoned Action [33], 3) Social Cognitive Career Theory [34], 4) Social Cognitive Theory [35], 5) Social Learning Theory [36], 6) Self-Efficacy Theory [37], 7) Shapero’s Entrepreneurial Event Theory [38].

Phase 2: Development of Conceptual Model

Background. Research on student participation is well-established in higher education. However, existing literature offers limited theoretical work that is specific to student participation in entrepreneurship programs. To develop a conceptual model, we leveraged what we know from entrepreneurship literature and applied it to student participation. By critically reviewing the entrepreneurship theory literature, we were able to refine the student participation model to develop a new conceptual model for EEP. This development of a conceptual model for understanding student participation in EEPs required analyzing the key theories found in Phase 1 to identify relevant factors and mapping the factors to existing models offered in adult participation literature. In particular, we identified Cross’s Chain-of-Response (COR) model for understanding influences behind one’s participation in learning activities and programs [39]. The COR is a seminal work that is widely used in higher education research [40]–[42]. The model integrates three prior models that conceptualized motivational aspects behind student participation [43]–[45]. The basis of the COR model is that a student’s decision to participate in an educational program or activity is a complex process informed by the student’s perceptions of their self and their interaction with socio-environmental factors. The COR model posits that students’ decisions to participate in an educational program is a result of the interaction between internal (self-evaluation, attitudes, goals and expectations) and external (life transitions, information, and opportunities and barriers) influencers.

While the COR model consolidates multiple motivational and environmental aspects into a holistic framework, the model is not specific to entrepreneurship education programs. This generality of the model provides the rationale for Phase 2 which involved refining the model in the context of EEPs. Thus, we performed a critical review [46], analyzing and synthesizing competing entrepreneurship theories, to specifically address student participation in entrepreneurship education programs. The aim our critical review was to synthesize commonly used theories in entrepreneurship assessment literature and consolidate them with the COR
model to create a new model for understanding influencers informing students’ participation in EEPs.

**Methods.** The Search, Appraisal, Synthesis and Analysis (SALSA) procedure for critical reviews was used because it provides a systematic method for identifying key theoretical factors used in entrepreneurship assessment literature, which were used to revise the generic COR model of adult learning to make it specific to EEP participation [46]. For our study, we utilized this method by systematically reviewing commonly used theories (searching) and shortlisting them based on their usage (appraisal) in the area of interest (as described in Phase 1). Then we synthesized the theories to identify common factors (synthesis) and used the identified factors to refine the COR model (analysis) in Phase 2.

**Results.** In the synthesis of the seven theories from Phase 1, we identified two overarching theories that incorporated four other theories. Specifically, theory of reasoned action is subordinate to theory of planned behavior; and social cognitive, social learning and self-efficacy theories are included in the comprehensive social cognitive career theory. Thus, at the end of this theory-level synthesis, we found identified the three unique theories (Theory of Planned Behavior (TPB), Social Cognitive Career Theory (SCCT), and Shapero’s Entrepreneurial Event Theory (SEE)) that are most commonly used in entrepreneurship assessment studies. Further factor-level analysis of the three unique theories revealed that some of their constituent factors are similar:

1) An individual’s confidence in their ability to successfully perform a particular task is noted as a common antecedent to engaging in an activity in all three theories. However, differing terminologies are used to identify this confidence – self-efficacy in SCCT, perceived behavioral control in TPB, and perceived feasibility in SEE.

2) In SEE, the factor ‘Perceived desirability’ conceptually incorporates three sub-factors which are also noted in the other two theories: attitude (noted in TPB), subjective norm (noted in TPB), and outcome expectations and goals noted in SCCT).

Lastly, the final analysis involved mapping the factors with the COR model. It should be noted, that the COR model has three internal (self-evaluation, attitudes about education, goals and expectations) and three external factors (life transitions, opportunities and barriers, and information and resources). With the exception of life transitions (noted in SEE), the factors identified in entrepreneurship theories are largely consistent with the COR’s internal factors. In particular, self-efficacy (SCCT), perceived behavioral control (TPB), and perceived feasibility (SEE) are similar to the COR model’s ‘self-evaluation’. TPB’s ‘attitude’ and SCCT’s ‘outcome expectations and goals’ are similar to the COR model’s ‘attitudes about education’ and ‘goals and expectations,’ respectively. To develop the Participation in Entrepreneurship Education Programs (PEEP) model (Figure 1), similar factors among the three theories and the COR model were combined and rephrased to make the COR model EEP-specific [28]. This was performed through multiple iterations and detailed discussions by the project team. The project team consisted of researchers with entrepreneurship, engineering education, and discipline-based education research backgrounds, which assisted in controlling for potential biases. The description of the factors is presented in Table 1.
Table 1: Model Factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>Definition</th>
<th>Adapted from</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrepreneurial Self-Efficacy</td>
<td>Confidence in one’s ability to perform entrepreneurial tasks</td>
<td>COR, TPB, SEE, SCCT</td>
</tr>
<tr>
<td>Desirability</td>
<td>Perception of EEP participation to be valuable (attitude), helpful in meeting one’s goals (goals and expectations), and social approval for the value of participation (subjective norm)</td>
<td>COR, TPB, SEE, SCCT</td>
</tr>
<tr>
<td>Entrepreneurial Intent</td>
<td>Intent to engage in entrepreneurial activities</td>
<td>COR, TPB, SEE</td>
</tr>
<tr>
<td>Life Transitions</td>
<td>Personal circumstances that may impact engagement/disengagement in EEPs</td>
<td>COR, SEE</td>
</tr>
<tr>
<td>Information and Resources</td>
<td>Formal and informal resources that provide information about EEPs</td>
<td>COR</td>
</tr>
<tr>
<td>Opportunities and Barriers</td>
<td>Programmatic aspects that hinder/promote participation</td>
<td>COR</td>
</tr>
</tbody>
</table>

Figure 1. Participation in Entrepreneurship Education Programs Model
(Reproduced with permission from International Journal of Engineering Education [28])

Phase 3: Validation of the Conceptual Model

**Background.** As noted in the previous sections, the PEEP Model was developed through careful synthesis of well-established theories for which significant empirical support exists. Further validation of the PEEP is warranted, particularly in the context of engineering students. Validation of a conceptual model is a process that starts with the researcher (Phase 1 and Phase 2), who then seeks validation among ‘outsiders’ [47]. In particular, it is important to determine: 1) if each of the factors in the PEEP model are emergent within the study population relative to
the outcome of participation; and 2) the way in which those factors are manifesting. This initial qualitative work sets the stage for subsequent identification of appropriate quantitative measures for further empirical validation of the developed conceptual model.

**Methods.** A qualitative interview-based approach was used to gather students’ perspectives to unpack factors informing engineering students’ decisions to engage/disengage in EEPs. The interview participants were undergraduate engineering students enrolled in a large, research university. Maximum variation sampling allowed us to capture varied perspectives by including students representing a wide range of characteristics [48]. Our sample of 20 participants included undergraduate engineering students with different EEP experiences (e.g. individual courses, minors, co-curricular, and no participation) from varied academic standing, engineering majors, and gender (Table 2).

**Table 2: Participant Background**

<table>
<thead>
<tr>
<th>Participant Characteristic</th>
<th>Distribution*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male (10) and Female (10)</td>
</tr>
<tr>
<td>Major</td>
<td>Computer Science (3), Mechanical Engineering (5), Industrial and Operations Engineering (3), Biomedical Engineering (1), Nuclear Engineering (1), Computer Engineering (2), and Undeclared (5)</td>
</tr>
<tr>
<td>Academic Standing</td>
<td>Freshman (6), Sophomore (4), Junior (4), and Senior (6)</td>
</tr>
</tbody>
</table>

* (N) = Number of Participants

A semi-structured interview protocol was co-developed by three researchers and was revised based on feedback from students [49], [50]. All in-person interviews were audio recorded and professionally transcribed for analysis. The interviews were analyzed using the First Cycle and Second Cycle coding approach [51]. In the first cycle, an initial inventory of codes was generated. Basic labels (descriptive coding) were assigned to participant responses identifying influencers that informed students’ decision to engage in EEPs, negative or positive. The coding process was performed by two researchers. In the second cycle, the emergent codes from the first cycle were categorized by aggregating similar codes based on their conceptual similarity. This categorization involved using the PEEP model as a guiding framework. The two cycles of coding involved two researchers independently coding the transcripts, follow-up discussions to resolve discrepancies and performing checks by consulting an external researcher. This process yielded high inter-rater reliability (intra-class correlation of 0.88) and strengthened the research quality of our qualitative, interpretative approach [52], [53]. Lastly, member checks were conducted with 4 participants to validate the findings of the interview analysis.

**Results.** The coding analysis confirmed that factors in the PEEP model inform engineering students’ decisions to engage or disengage in EEPs. Furthermore, the first and second cycle coding contributed to refining the interpretation and context of the PEEP factors. Since the focus of this paper is on the factors informing student participation in EEPs, we present the results of our interview analysis in regard with how the findings contributed to expanding the definitions of
PEEP model factors for engineering students. Table 3 presents the six PEEP model factors and their descriptions which were developed using initial definitions (Table 1) and emergent findings from student interview responses (italicized). Example student quotations for the factors are provided in the Appendix.

### Table 3: Factor descriptions incorporating student responses

<table>
<thead>
<tr>
<th>Factor</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrepreneurial Self-Efficacy</td>
<td>Confidence in one’s ability to perform business-related and communication/public speaking tasks</td>
</tr>
<tr>
<td>Desirability</td>
<td>Perception of EEP participating to be valuable for networking and gaining business knowledge (attitude), in meeting personal development goals and to make a lot of money (goals and expectations), and social approval for the value from peers/friends and family (subjective norm).</td>
</tr>
<tr>
<td>Entrepreneurial Intent</td>
<td>The intent to start a company (venture creation) and devising solutions to problems (problem-solving)</td>
</tr>
<tr>
<td>Life Transitions</td>
<td>Students’ current academic level may impact engagement/disengagement in EEPs as their graduation and post-graduation plans vary depending on academic year</td>
</tr>
<tr>
<td>Information and Resources</td>
<td>Formal (academic advising) and informal (student events and organizations) resources that provide (purpose and/or benefits of EEPs) information about EEPs</td>
</tr>
<tr>
<td>Opportunities and Barriers</td>
<td>Programmatic aspects associated with course scheduling, technology-oriented EEP curriculum, and instruction used in EEPs</td>
</tr>
</tbody>
</table>

### Discussion and Implications

First, the findings of the systematic literature review noted that, in spite of the limited reference to theory, a notable number of theories (153) were cited in the reviewed entrepreneurship assessment literature. This highlights the variety of lenses through which different aspects of entrepreneurship education can be examined. Given the interdisciplinary nature of entrepreneurship education, it seems understandable that there are several theories that can be used for researching the area. However, considering the nascent state of entrepreneurship education in engineering fields, the use of several theories might make their selection and appropriate use challenging, particularly among engineering educators interested in entrepreneurship. This is also indirectly noted in our Phase 1 analysis which showed that out of the 153 identified theories, only seven theories were used in more than ten studies.

Second, our Phase 2 analysis pointed out that among the seven, four theories were subordinate of two overarching theories, thus, yielding three unique theories (SCCT, TPB, and SEE).

Furthermore, our factor-level analysis noted that several constituent factors defined in these unique theories overlapped with each other on a conceptual level. These results highlight how the emergent engineering entrepreneurship education field can benefit from work that brings together concepts and theories from disparate fields; and consequently, address the lack of holistic theoretical perspectives that are specific to engineering entrepreneurship. Recent efforts show that the various stakeholders have begun moving in the direction of coalescing different terminologies to build a unique vision for entrepreneurial training for engineers. For example,
although not derived from theories, the widely used 3C’s (creativity, curiosity and connection) conception of entrepreneurial mindset has provided a common terminology, particularly for educators [19]. Our work presented in this paper is a similar effort (in regard with developing a common taxonomy) which focuses on student participation in EEPs and provides a comprehensive model rooted in the literature. The SALSA procedure presented in this paper provides an example of how systematic review methods can be used by researchers in developing conceptual models to ground their work in relevant theories. We encourage other approaches for synthesizing vast literature from different fields into more cognitively digestible models and mitigate the risks of ‘reinventing the wheel’ as entrepreneurship education continues to grow as a critical area of inquiry in engineering education research.

Lastly, our Phase 3 results validated the PEEP factors as influencers of students participating in EEPs, and also established the meanings of the factors from an engineering student perspective. For example, students’ responses indicated that entrepreneurial intent constituted the intent to start a company as well the intent to devise solutions to problems. This finding leads to the fundamental question about the grounding and direction of EEPs in engineering education. Although engineering EEPs have moved beyond venture creation to focus on skill-development, programs place significant emphasis on business aspects. In regard to student participation, our findings show that students are attracted to EEPs because they want to work on solving a problem rather than just create a venture.

For future research, this suggests that while the broader theoretical work conducted in other relevant fields assists in identification of key factors that may influence the area under study, factors may hold nuanced, if not entirely different, connotations for engineering. Thus, more work should be conducted in developing engineering-specific conceptual models that incorporate relevant theories offered in the literature. Such models will assist researchers as well as administrators and practitioners in their development and assessment efforts. Particularly, in the context of engineering entrepreneurship education, gathering engineering stakeholders’ perspectives will be critical for theory-driven work because the majority of the foundational work in entrepreneurship has been performed with business students, faculty and industry employees in mind; failing to include additional factors that may not be important or explicit in traditional business entrepreneurship contexts but critical for engineering entrepreneurship education. While use of key theories and factors derived from different fields allows multiple lenses to be considered, validation and revision of frameworks to incorporate engineering perspectives will assist in enhancing the quality of research in engineering entrepreneurship education.

Conclusion

Recent years have seen a rapid rise in the creation of engineering entrepreneurship curricula, programs and centers. Because of the nascent nature of the field, there are few theory-based measures and constructs that can be used to study and inform practice in this growing field. The work presented here seeks to bridge this gap by systematically exploring theories used in entrepreneurship assessment and using them to inform the development of a model for understanding student participation in entrepreneurship education programs. Our research provides critical guidance for this growing community as new programs are in the process of
being designed and expanded. As the engineering education community works towards cultivating a diverse and innovative engineering workforce for the future, it is critical that we examine how innovative educational programs such as entrepreneurship engage and influence all types of students. This research will guide universities in developing effective, scalable and accessible engineering entrepreneurship education programs with informed reach. Using past literature from business, engineering and education; gives us confidence that the PEEP model presented in this paper constitutes possible factors and the validation from engineering students’ perspective produces a more thorough understanding of how the model factors may manifest when applied in engineering entrepreneurship education.

**Acknowledgements**

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**References**


[31] P. M. Reeves and T. Pennsylvania, “Comparisons of Faculty and Student Definitions of Entrepreneurship Comparisons of Faculty and Student Definitions of Entrepreneurship Abstract A definitive definition of entrepreneurship is elusive and may contribute to the,” 2014.


## Appendix

### Example Student Quotes

<table>
<thead>
<tr>
<th>Factor</th>
<th>Example Student Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrepreneurial Self-Efficacy</td>
<td>I really enjoy public speaking, and I have for almost my whole life, like since I was in elementary school. Pitching to me is just an extension of that.</td>
</tr>
<tr>
<td>Desirability</td>
<td>He also wanted to do the Entrepreneurship Minor because he saw a lot of value in it. Especially for finding a job, coming out with an Entrepreneurship Minor, many startups, businesses will see that and say, ‘Wow, okay. You already have all this experience, we don't have to teach you it’.</td>
</tr>
<tr>
<td>Entrepreneurial Intent</td>
<td>I think it was mostly I was interested in starting the business and seeing what it took to take an idea into an LLC.</td>
</tr>
<tr>
<td>Life Transitions</td>
<td>Teach it as early as you can, show it as early as you can.</td>
</tr>
<tr>
<td>Information and Resources</td>
<td>I'll read a course description and then I'll see if it aligns with what I intend to do.</td>
</tr>
<tr>
<td>Opportunities and Barriers</td>
<td>It's not actively on my mind to say, ‘I'm going to take these courses’. Especially as a double major, I just don't have the schedule space.</td>
</tr>
</tbody>
</table>