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Examining engineering students' participation in entrepreneurship education programs: implications for practice

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Abstract

Background: Recent research has demonstrated the importance of entrepreneurship education programs (EEPs) in the professional development of engineering students. Numerous universities have adopted various forms of EEPs which are typically offered as elective programs. To create suitable programs that will encourage students to seek out EEPs, it is critical to understand the factors that influence student participation in EEPs. Using qualitative research methods, we examined the question "What influences engineering students' participation in entrepreneurship education programs?" The purpose of our work is to identify and understand the factors impacting engineering student participation in EEPs.

Results: Analysis of 20 semi-structured interviews of undergraduate engineering students was conducted using the first and second cycle coding methods to determine key factors that inform students' participation in EEPs. We found that student decisions to participate in EEPs are influenced by several factors: entrepreneurial self-efficacy, entrepreneurial intent, attitude, subjective norm, goals, academic transitions, information and resources, social capital, opportunities and challenges, and past participation in EEPs.

Conclusions: Findings demonstrate that students' non-compulsory participation is not a result of a single act, but is regulated by multiple factors. Explication of these factors using our qualitative results provides actionable guidance for EEPs to encourage engineering students' participation and offers directions for future research.

Keywords: Entrepreneurship education, Engineering education, Qualitative

Introduction

The economic impact of entrepreneurship and innovation is becoming more widely recognized. In recent years, STEM (Science, Technology, Engineering, and Mathematics) educational institutions have begun to leverage entrepreneurship programming to create a more entrepreneurially minded technological workforce. This growth has broadened entrepreneurship education beyond the business school model of business fundamentals and firm-creation. Recent innovations in entrepreneurship education stem from engineering entrepreneurship programs that have recognized the need to move beyond the classroom for effective entrepreneurship education, leveraging newly developed entrepreneurship content, evidence-based experiential pedagogies, and more informal co-curricular opportunities (Gilmartin et al., 2016; Zappe et al., 2013).

These initiatives have resulted in the growth of a new subfield of engineering education, engineering entrepreneurship. Initially focused on program descriptions (Creed et al., 2002; Standish-Kuon & Rice, 2002) and conceptual papers calling for transforming engineering education with the introduction of entrepreneurship (Byers et al., 2013), engineering education has met these needs with rapid program development (Gilmartin et al., 2014; Gilmartin et al., 2016; Shartrand et al., 2010),

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exploration of an engineering entrepreneurial mindset (Bilen et al., 2005; Kriewall & Mekemson, 2010; Rae & Melton, 2016; Shekhar & Huang-Saad, 2019), review of program models (Duval-Couetil et al., 2016), research in assessment (Purzer et al., 2016; Shekhar et al., 2017; Shekhar & Bodnar, 2020; Woodcock et al., 2019), research on faculty beliefs (Zappe et al., 2013), research on engineering student career choices and intentions (Jin et al., 2016), and development of numerous classroom interventions (Boulanger & Tranquillo, 2015; Gerhart & Melton, 2016). Results from these scholarly works and others have contributed to the growth in engineering entrepreneurship programming, both curricular and co-curricular. While the resulting rapid, wide-scale adoption of entrepreneurship programming signals the growing acceptance of entrepreneurship education as a means of cultivating entrepreneurial engineering students, EEPs are typically non-compulsory, elective courses, or activities. In addition, the significant dependence of entrepreneurship education on co-curricular programming in engineering has demonstrated that students can seek different paths to entrepreneurship education (Huang-Saad & Celis, 2017). As the engineering community seeks to grow the number of entrepreneurially minded graduates, how these initiatives engage engineering students fosters a new area of exploration, students' self-directed participation in entrepreneurship education programs (EEPs).

To date, the majority of engineering entrepreneurship education literature has been forward-facing, in which researchers have assessed the impact of entrepreneurship education on students' entrepreneurial skills, knowledge, and mindset. Instead, our work explores engineering entrepreneurship education from a "pathways to entry" perspective. Rather than examining the effectiveness of engineering EEPs, we examine engineering students' participation in EEPs. Numerous studies report that participation in EEPs leads to positive outcomes for engineering students (Dabbagh & Menascé, 2006; Ohland et al., 2004; Wang & Kleppe, 2001). Thus, given the demonstrated importance of exposure to entrepreneurship education, how do we encourage engineering students to participate in non-compulsory EEPs warrants research attention. We explore this space using qualitative methods grounded in adult participation in learning and entrepreneurship theories (Shekhar et al., 2018). We ask the question "What influences engineering students' participation in entrepreneurship education programs at a large research-focused university?" The motivation behind our work is to identify and understand factors impacting engineering student participation in EEPs. Identifying these factors can inform the development of new and existing EEPs that will encourage engineering students to participate in these programs.

Background and conceptual framework

In this study, we use an adaptation of Cross's Chain-of-Response (COR) model of participation in adult learning (Cross, 1981), specific to entrepreneurship education, as our conceptual framework (Shekhar et al., 2018). Exploration of participation in EEPs in the context of adult learning theory is critical, as adult participation theory acknowledges a developmental difference in adult learning (Abdullah et al., 2008; Neck & Corbett, 2018). As individuals mature, they become more self-directed in seeking learning opportunities (Knowles, 1980). This self-direction becomes fundamental when looking at elective, non-compulsory learning opportunities such as EEPs. Unless students specifically enroll in an entrepreneurship degree program, EEP participation is reliant on students self-selecting into entrepreneurial training and seeking out elective entrepreneurship programming. Thus, to broaden participation, we focus on understanding what influences student participation in EEPs (self-direction) in the context of adult learning theory.

Cross's Chain-of-Response (COR) model is a comprehensive approach to studying adult participation in non-compulsory, education programs (Cross, 1981). Based on motivational theories, the COR model conceptualizes adult participation as a complex process influenced by the individual's perceptions of self and social transitions (Wikelund et al., 1992). According to the COR Model, adult participation in education programs is generally influenced by six interacting factors, three internal and three external (Cross, 1981). The three variables internal to the student are self-evaluation, attitudes about education, and goals and expectations. The three external variables are a result of environmental conditions: life transitions, opportunities and barriers, and information. The non-prescriptive nature of these six factors offers the opportunity for adaptation to entrepreneurship education program participation.

Seeking to develop an entrepreneurship program-specific model, the Participation in Entrepreneurship Education Programs (PEEP) model draws upon entrepreneurship education assessment literature to identify entrepreneurship education-specific factors and maps them to the COR factors (Fig. 1). The three most commonly used overarching theories used in entrepreneurship education research identified through a systematic literature review of 359 empirical studies (Shekhar et al., 2018) are the Theory of Planned Behavior (TPB, Azjen & Ajzen, 1991), Shapero's Entrepreneurial Event Theory (SEE, Shapero & Sokol, 1982), and Social Cognitive Career Theory (SCCT, Bandura, 1986). These three theories primarily address individual behavior in different contexts and identify antecedents to behavior which are similar to those noted in the COR model. In a generic context of individuals' behavior, TPB posits that

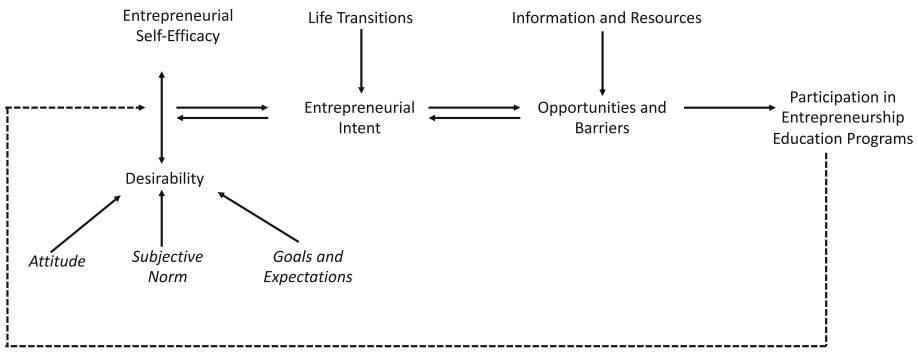

Fig. 1 Participation in Entrepreneurship Education Programs Model (Shekhar et al., 2018). [Note: Participation is both an outcome and influencing factor; thus, the closed loop nature of the figure represents the influence of participation in EEPs on future participation. The connecting arrows and their directionality serve as examples of plausible relationships between factors. However, our exploratory work focusses on unpacking the factors rather than imposing pre-conceived relationships.]

individuals' intent to engage in a particular behavior is the most fundamental predicter of whether the individuals will demonstrate that behavior (Azjen & Ajzen, 1991). This intent is informed by their attitude towards performing the behavior, social approval for performing the behavior, and their perceived ease/difficulty in performing the behavior. In the context of entrepreneurial behavior, SEE posits that individuals' behavior is informed by their perceived sense of desirability and feasibility for performing the behavior and life transitions they are going through (Shapero & Sokol, 1982). In the context of students' career choices, SCCT posits that individuals' behaviors are informed by their perceived ability to succeed in performing the behavior, expectations that performing the behavior will lead to desired outcomes, and its alignment with their goals (Bandura, 1986).

By mapping entrepreneurship education theories to the COR adult participation model, six factors were determined to influence EEP participation as presented in Fig. 1 (Shekhar et al., 2018). A seventh factor is EEP participation itself. Thus, EEP participation is both an outcome and an influencing factor. Based on the COR model, it is conceptualized that past participation may also inform students' continued participation in future EEPs. For example, students who want to pursue entrepreneurial careers will participate in educational opportunities that will teach them to be entrepreneurial (outcome factor). Their experience in the EEPs may encourage or discourage their participation in such programs in the future (influencing factor). While some researchers have interpreted the COR model as a linear decision-making process (Boeren et al., 2010; McGivney, 1993), the PEEP model does not imply any order within the factors. The links between factors underscore that student participation in EEP is not influenced by a single act, but rather regulated by multiple factors. In our presented work, the PEEP model is used to identify different factors informing student participation in EEPs, which are examined separately in the analysis. By unpacking why engineering students participate in EEPs with respect to these factors, we work to not only identify what factors influence students' decisions to participate, but also what these factors mean for engineering students. This information can be used to create elective EEPs that encourage engineering student participation.

Entrepreneurial self-efficacy

In the COR model, self-evaluation refers to an individual's perception that they can be successful in the learning experience. This concept of self-evaluation is consistent with Bandura's concept of self-efficacy, an individual's belief that they can successfully complete a task. According to Bandura, "beliefs of personal efficacy can shape the course lives take by influencing the types of activities and environments people choose" (Bandura, 1994, p. 7). In the academic context, SCCT identifies self-efficacy as one of three variables that influences a student's career interest and choice (Lent et al., 1984). From these seminal works, the PEEP model identifies entrepreneurial self-efficacy as an individual's belief that they can successfully complete different entrepreneurship-related tasks.

Desirability

The two remaining internal COR factors that influence participation are attitudes about education and goals and expectations. In the PEEP model, these two factors are collectively represented by desirability (as noted in SEE), an individual's perception regarding the value of participation in EEPs. Desirability is mediated by three sub factors: attitude (is participation in the EEPs valuable), goals and expectations (does EEPs assist in meeting an

individual's goals), and subjective norm (is there social approval of the value of participation in EEPs).

Life transitions

Life transitions, an external factor, capture any life events that make it difficult for an individual to participate in or recognize the need to participate in an experience. In the context of entrepreneurship, SEE postulates that one of the factors that influences individuals to take entrepreneurial action is a "change in an individual's life path" (Shapero & Sokol, 1982, p. 79). According to SEE, life path changes can take the form of negative displacements (e.g., being fired), being between states (e.g., graduating), or positive pulls from an individual's social network (e.g., the offer of financial support). In the PEEP model, life transitions include negative displacements, and transition between states and positive pulls happening in students' personal as well as academic life.

Entrepreneurial intent

While the COR model does not include a factor for intention to participate in a learning experience, entrepreneurship literature draws heavily from intention theory, specifically Ajzen's Theory of Planned Behavior (TPB). Research informed by TPB has shown that entrepreneurial behavior can be predicted by observing intention (Maes et al., 2014; Miralles & Riverola, 2012). For student participation, this implies that students are likely to participate in EEPs if they have an intention to engage in entrepreneurial activities. Thus, the PEEP model includes entrepreneurial intent, the intent to engage in an entrepreneurial activity, as another factor that influences participation in EEPs.

Information and resources

Like the COR model, the last factor that influences EEP participation is information and resources, having access to necessary information. Specifically, this refers to the access to information about EEPs and resources that connect students with EEPs.

Opportunities and barriers

The three overarching entrepreneurship theories predominantly focus on individual behavioral rather than external factors and do not specifically address aspects of educational activities that may influence student participation. Thus, the conceptualization of opportunities and barriers is derived from Cross's COR model and accounts for programmatic aspects of EEPs that may influence students' decision to participate. It is to note that opportunities and barriers exclude life or academic events and factors related to information and resources.

Methods

The PEEP model suggests that student participation in EEPs may be influenced by several factors. Examination of the influence of these factors on participation requires gathering student perspectives to build an understanding of student decisions to participate in EEPs. Interviews are useful in gathering unobservable data such as participants' thoughts and perspectives (Leydens et al., 2004). Therefore, semi-structured interviews exploring student self-reported perspectives are suitable data sources for our study when coupled with steps taken to address concerns associated with qualitative, interpretive line of inquiry (Walther et al., 2013). For our study, 20-h-long interviews were conducted in person during Fall 2017 and Spring/Winter 2018. To maintain consistency, all interviews were conducted by the first author, with the second author supervising two interviews to provide an external check on the interviewing process. All interviews were audio-recorded and professionally transcribed for accuracy and future analysis. A subset of four transcripts was checked against the audio-recording for accuracy in transcription.

Significant measures were taken with regard to research design, sampling, data collection, and analysis to assure research quality and establish "trustworthiness" (Harrison et al., 2001). Detailed in the sections below, these steps address quality parameters recommended in the literature for strengthening trustworthiness in qualitative research: (1) credibility, transferability, dependability, and confirmability (Schwandt et al., 2007); (2) process reliability, theoretical, pragmatic, procedural, and communicative validity (Walther et al., 2013); and (3) triangulation (Decrop, 1999; Patton, 2002).

Interview protocol

A semi-structured interview protocol with both planned questions and iterative probes eliciting details was used (Patton, 2002; Shenton, 2004). Our team consisting of the two authors and another researcher co-developed the set of planned questions. The interview questions were open-ended which allowed students to not limit their responses to the model factors, as listed in sample questions below:

1. How and when did you learn about the entrepreneurship programs/courses?
2. Why did you enroll in these entrepreneurship programs?
3. How did you decide to take this course rather than other entrepreneurship programs?
4. What connections did you see between entrepreneurship programs and other classes?

We sought feedback on the protocol from four undergraduate engineering students in a 30-min focus group session. During this session, the students reviewed the protocol and were asked to reflect on what the questions were trying capture, comment on the clarity of the questions, and suggest additional questions for inclusion. At the end of each semi-structured interview, the participant was informed about the purpose of the study and asked to report any relevant details that the interview was not able to capture. Any recurring details were noted by the interviewer, and questions probing the new details were included in subsequent interviews.

Context

Participants of this study were undergraduate students enrolled in the college of engineering (CoE) at a large midwest research institution in the USA. The CoE enrolls over 6500 undergraduates. In 2015, there were over 25% women in the CoE. The institution consists of 19 schools and colleges that enroll approximately 30,000 undergraduates. There are over 15 entrepreneurship programs and centers on campus; one of which is part of the college of engineering. University students can participate in numerous forms of entrepreneurship education: a university-wide minor, individual courses, or co-curricular programing. A range of entrepreneurship courses are available at the university covering topics such as product design, economics of entrepreneurship, and leadership. Co-curricular programming allows students to participate in entrepreneurship community throughout the year. The co-curricular programming addresses all levels of entrepreneurship and interest. Students can participate in trips to different start-up communities, business plan competitions, innovation competitions, entrepreneurial mentorship, entrepreneurship workshops, and accelerators and incubators.

Participants

Twenty participants were recruited through an email advertisement sent to undergraduate engineering students who participated in EEPs during the 2015–2016 academic year. The email advertisement asked students to report their participation in EEPs and demographic information (gender and ethnicity). Participants were offered a financial incentive of $20. Maximum variation sampling (Cohen et al., 2013) was used to cover a wide range of characteristics in connection with the examined issue. Students selected for the study reported participating in different types of EEPs—individual courses, co-curricular EEPs, and the entrepreneurship minor. The sample also included a student who did not participate in EEPs to gather counter perspectives. An equal number of men and women was selected. There were 5 White/Caucasian, 3 Asian/Asian-American, 1 Latino(a)/Hispanic, and 2 mixed (1 White/Caucasian and Latino(a)/hispanic and White/Caucasian and Asian/Asian-American). Nine participants did not report their ethnicity. Lastly, students from varied academic standings and engineering majors were included to enhance the diversity of our sample (Table 1).

Data analysis

The first cycle and second cycle coding methods described by Saldaña (2010) were used to inductively code interview transcripts. While the first cycle coding method involves initial coding of the data to build a general list of codes, the second cycle coding is more analytical, where categories are identified to develop a coherent synthesis and interpretation of the data (Saldaña, 2010). Cumulatively, these steps focus on inductively generating a comprehensive list of codes (first cycle) and then aggregating the codes into categories (second cycle). During the first cycle coding, the two authors independently coded one interview transcript using descriptive coding (Saldaña, 2010), by assigning basic labels relevant to student participation. The conceptual model was not used in the first cycle coding to avoid limiting coding to the PEEP model factors. Following a detailed discussion, an initial inventory of codes was developed from the two authors' coding. In addition, another researcher, who was not involved in the study, co-coded an interview transcript and discussed the code with one of the authors. This additional discussion was an external check for any biases the primary researchers may have had.

The two authors independently coded two additional interview transcripts to further develop the initial coding inventory. Followed by lengthy discussions, codes were refined and new codes were created. The final coding inventory consisted of 44 codes. This inventory was used by the two authors to code four additional transcripts. An intraclass correlation of 0.88 at this stage of coding demonstrated inter-rater reliability. The coded transcripts were further discussed to resolve remaining discrepancies and to reach agreement. The remaining transcripts, including the three coded in the first and second stages, were coded by the two authors. Coding was performed so that each phrase was coded for all potential codes. This assured that our coding captured the different factors individually and mitigated the chances of missing some aspect due to similarity. For example, this student quote was coded for (a) student events, (b) subjective norm, and (c) scheduling:

> **I learned about it over orientation (a)** when I was signing up for courses. Many **older students recommended it (b)** because they said that you get to meet very interesting CEOs and that it wasn't too

Table 1 Participant details

Participant	Gender	Major	Academic standing	Curricular EEP	Co-curricular EEP	Entrepreneurship minor
1	Male	CS	Sophomore		X	
2	Male	ME	Senior		X	
3	Male	CE	Senior	X	X	X
4	Male	CS	Junior	X		
5	Male	IOE	Senior	X	X	
6	Male	ME	Senior	X	X	
7	Male	IOE	Sophomore		X	
8	Male	Undeclared	Freshman	X		
9	Male	Undeclared	Freshman	X		
10	Male	ME	Sophomore	X		
11	Female	NE	Junior	X		X
12	Female	ME	Senior	X		X
13	Female	ME	Senior	X		
14	Female	IOE	Junior		X	
15	Female	CE	Junior	X		
16	Female	BME	Sophomore			
17	Female	CS	Freshman	X		
18	Female	Undeclared	Freshman	X		
19	Female	Undeclared	Freshman	X		
20	Female	Undeclared	Freshman	X		

CE computer engineering, *ME* mechanical engineering, *IOE* industrial and operations engineering, *BME* biomedical engineering, *CS* computer science, *NE* nuclear engineering

heavy of a workload, so it was **easy to fit into any schedule (c)**

During the second cycle coding, the coded data was categorized based on conceptual similarity (Saldaña, 2010) using focused coding. This involved combining inventory codes into overarching operationalized codes and categorizing the operationalized codes (Kajfez & Matusovich, 2017; Patton, 2002) with respect to the PEEP model factors, as applicable (Table 2). The categorization was discussed with a researcher who did not code the data, providing an external check to the approach.

Overall, there was agreement between the authors on the categorization with a few issues that were resolved through discussion. First, since the students only referenced academic transitions during their interviews, the factor "life transitions" is presented as "academic transitions." However, we do acknowledge that our sample participants may have not fully captured student populations for whom other life transitions may have an influencing role. Second, since we found no direct evidence to support desirability as a second-order factor, the three sub-factors of desirability (Attitude, Subjective Norm, and Goals and Expectations) were examined and presented as distinct factors. In addition, due to the lack of direct support for expectations, only goals were used to define the factor. Third, we purposefully made a distinction between entrepreneurial intent and goals, delineating the difference between entrepreneurial intention and personal interest. Entrepreneurial intent represented a student's behavioral intent to engage in entrepreneurial activities such as "solving problems" and "starting a company" (Yi & Duval-Couetil, 2018). Goals were specific to personal interest (e.g., making money and personal development). Fourth, certain codes were categorized as "social capital," an emerging research area in engineering education (Brown et al., 2009; Martin et al., 2013), thus resulting in the identification of a new factor.

After the categorization, the researchers recognized that the majority of emergent codes were relatively consistent with the seven theory-derived factors, less the newly defined category of social capital. After detailed discussion and review, researchers concluded that one plausible explanation is that some theory-derived factors were inherently broad which resulted in codes being categorized within the ten factors. For example, the factor "opportunities and barriers" by definition included all programmatic aspects of EEPs that may promote/hinder participation and thus included instruction, scheduling, and curriculum codes. We acknowledge that these codes

Table 2 Description of codes

Factor	Operationalized code	Description
Entrepreneurial self-efficacy	Confidence in entrepreneurship	Confidence in ability to perform different entrepreneurship-related tasks
Entrepreneurial intent	Start a company	Initiating a new venture or seeking self-employment
	Solve a problem	Devise solutions to different problems in the world
Attitude	Value of EEPs	Perception of the value of participation in EEPs
Subjective norm	Subjective norm	Approval of the value of participation in EEPs from peers, friends and family
Goals	Make money	Personal goal of earning a lot of money
	Personal development	Skills and experiences deemed helpful in one's personal and professional growth
Opportunities and challenges	Instruction	Teaching approaches and instructional staff including teachers, speakers, and mentors
	Scheduling	Scheduling conflicts with required courses
	Curriculum	Material and content covered/focused in the course
Information and resources	Student events	Events held by and/or for students including student orientations, student organization events, and in-class visits
	Online/print media	Information accessed through online/print media including both targeted advertisements and cataloged resources
	Academic advising	Information from EEP representatives and academic advisors
	Purpose of EEPs	Information on the purpose and benefits of different EEP offerings
Social capital	Social capital	Gaining social capital by being part of entrepreneurship community
Academic transitions	Academic year	Students preferences for when they would undertake EEPs
Participation in EEPs	Change in perception	Past experiences leading to change in perception of EEPs
	Learning and exposure	Past experiences helping in learning more about EEPs and gain exposure to entrepreneurship

may be a unique factor in themselves. However, because our exploratory work focused on twenty participants, we refrained from presenting them as individual factors. Implications of this research design are also noted in discussion. Nonetheless, to maintain consistency between the emergent results and factors, "opportunities and barriers" were operationalized as "opportunities and challenges." This is because our sample mostly included students who participated in EEPs, and thus, our emergent findings were associated with "challenges" these students perceived rather than "barriers" that may hinder students from participating at all.

Lastly, consistent with recommended qualitative research approaches (Saldaña, 2010), recurrent themes that emerged within the factors were identified (Table 3). A theme is described as an abstract entity that brings meaning to a recurrent experience by unifying the basis of the experience into a meaningful whole (DeSantis & Ugarriza, 2000). Identification of themes involves analytic reflection that weaves together the coding and categorization outcomes for "meaning interpretation" (Saldaña, 2010). Recurrent themes representing the PEEP model factors were synthesized after multiple iterations with respect to student participation in EEPs.

Feedback on the emergent themes was sought from four study participants who agreed to participate in follow-up member checking. Member checking involves presenting themes to the participants and gathering their comments through a reflective dialogue such that participants are able to "recognize their own experiences within the synthesized themes" (Birt et al., 2016, p. 1084). Our approach loosely followed Harvey (2015)'s suggestions for member checking which included presenting the identified themes, gathering comments and concerns, and asking how members interpreted sample participant statements. This information enhanced the credibility of our results which are presented in the following section.

Results

Analysis of the qualitative interviews indicated that students' participation in EEPs is influenced by ten factors. While our the first and second coding methods underscored the role of theory-derived factors, emergent themes further unpacked the factors as summarized in Table 3 and explicated in sections below.

Entrepreneurial self-efficacy

Overall, several students reported high entrepreneurial self-efficacy (ESE) in performing tasks they thought were part of the entrepreneurial process. Particularly, students were confident in their communication and public speaking skills which informed their decision to enroll in EEPs. While students were confident about their

Table 3 Summary of themes

Factor	Key themes
Entrepreneurial self-efficacy	Confidence in communication and public speaking skills
	Lack of confidence in regard to business-related skills and perceiving entrepreneurship to be intimidating
Entrepreneurial intent	The intent to start a company or be self-employed
	The intent to solve problems in the world
Goal	Perceived value of EEPs in meeting one's *goal* of personal development and making a lot of money
Attitude	Perceived EEPs as valuable (*attitude)* for gaining professional skills and business knowledge
Subjective norm	*Subjective norm* or approval of the value of participation in EEPs came from peers/friends and family
Opportunities and challenges	Course scheduling conflicts to meeting degree requirements
	Lack of technology-oriented entrepreneurship curriculum
	Mostly positive feedback for active learning instruction with few negatives for pitch competitions
Information and resources	Learned about EEPs from participation in student organizations and student events
	Lack of academic advising on different entrepreneurship courses
	Lack of information about the purpose and benefits of different entrepreneurship programs
Social capital	Exposure to entrepreneurship community and access to social capital
Academic transitions	Introducing EEPs early allows students to tailor their curriculum accordingly and meet entrepreneurial goals without postponing graduation
	Later years better suited because students are making post-graduation career decisions and have acquired sufficient engineering knowledge. In early years, students are still adjusting to college and engaged in completion of required engineering courses
Participation in entrepreneurship programs	Past experiences exposed students to entrepreneurship and helped them learn more about it
	Past experiences positively shaped students' perception of EEPs

communication skills, there was a lack of confidence noted among the students in regard to business-related aspects of entrepreneurship such as dealing with uncertainty and selling things. Students reported that "a lot of people are scared to go into an environment where they think you have to be a certain way at the certain thinking process." Another student expressed, "I feel like I'm not good at selling things, which is something I see in my brother. He's one of the most confident people I've ever met, which is part of the reason I think he's successful in business." As a result, students found entrepreneurship in the context of business specific skills to be intimidating and underscored it as a barrier to students' participation in EEPs.

Entrepreneurial intent

As would be expected, the intention to start a company emerged as a key reason for engaging in EEPs. A majority of the student responses highlighted that the desire to start their own venture pushes students towards participating in EEPs. Students reported that they preferred self-employment instead of working for a company and that is why they participated in EEPs. For instance, one student commented, "I feel like those guys also only did that class because they were just interested in doing this themselves and coming up with ideas, and starting their own company someday or something like that." In addition, in several instances, students expressed their intention to solve problems with their inventions and ideas by participating in EEPs, as noted in this comment, "I could definitely see where someone sees entrepreneurship and they're like, 'Oh, that means I have to start my own company'. No, it doesn't, it just means you're innovating and problem solving, which can be applicable to any career." Students were interested in the "innovation aspect" of EEPs, which in contrast with other courses, allowed them to engage in open-ended problems. For example, a student expressed, "there are many, many problems in the world that exist, and I think entrepreneurship is the fast track to solving those."

Goals

In regard to the value of EEPs in meeting one's *goals*, students reported that EEPs were valuable for meeting two overarching goals—personal development and making a lot of money. Realizing the need to develop professional skills that will be helpful in their future careers, students perceived EEPs as valuable for their personal development, as evident in this comment, "Even if you don't go on to start a company, it's so helpful to just be self-accountable and have more problem solving and all those soft skills." Also, responses noted that EEPs provided a platform for students to pursue their goal of making a lot of money. For example, a student said,

"Seeing a bunch of people going through it [app development] and reading about them, and learning about them. You're like, "Oh, yeah. I can just build an app and put it on the App Store and I'll make millions."

Attitude

Guided by the abovementioned goals, students reported positive *attitude* or perceived EEPs as valuable for gaining professional skills such as problem-solving, creativity, communication, and networking (valuable for personal development goal) and business knowledge and exposure to entrepreneurship in a low-stakes environment (valuable for making money goal).

Subjective norm

Subjective norm or approval of the value of participation in EEPs came from peers/friends and family. Students' responses underscored the importance of approval from peers/friends, thereby serving as an important factor in their decision to participate in EEPs. Students used peer feedback to evaluate the importance of the course. Seeing peers enrolled in EEPs also motivated and inspired them to participate themselves. For instance, a student expressed as follows:

> So actually, that first class I took, it wasn't the best experience … But after talking to a bunch of other kids in the class who were doing the minor, and they told me how much fun they were having and how much real-world experience they were gaining, that's what helped me decide that I wanted to stick with it and do the minor.

Opportunities and challenges

Three key programmatic aspects were reported as opportunities and challenges for student participation in EEPs: scheduling, curriculum, and instruction. Challenges associated with course scheduling and meeting degree requirements emerged as a major barrier to students' participation in EEPs. While some students mentioned that EEPs were attractive due to less course load with respect to engineering courses, the majority of the students reported that fulfilling their engineering degree requirements was a major challenge for participating in EEPs. Students had to prioritize their core engineering classes over EEPs when there was a conflict in course scheduling and found it challenging to fit EEPs in their "schedule without postponing graduation" and expressed that their required engineering coursework did not leave "room to take electives."

With regard to curriculum, students preferred to participate in engineering/technology-oriented EEPs, such as those involving devising engineering solutions to solve real-world problems or guest speakers from technology companies whose talks "resonated with a lot of the engineers." While technology-oriented EEPs encouraged participation, the lack of relevancy of the content with some engineering majors was a frequent concern. Students reported that content was often more relevant to computer science and mechanical engineering than other engineering disciplines, such as chemical or nuclear engineering. For example, computer science students were able to apply knowledge gained from their programming and algorithm courses, whereas this was not the case for a nuclear engineering student, as underscored in this comment:

> With my specific major, not so much, because nuclear engineering is … I think I'm the only nuclear engineering student minoring in entrepreneurship at this point in time. But if you were to say eecs [electrical engineering and computer science] or mechanical engineering …You see students our age who are creating these products with the skills they've learned in their other classes, and they're able to successfully create businesses out of them.

With respect to the third programmatic aspect related to instructional approach, overall, students were positive about the active learning elements of the program. Students stated that they enjoyed engaging in hands-on activities, interacting with instructor and peers, and working in teams on projects. They specifically stated that the instructional approach used in EEPs played an important role in encouraging their participation. Students underscored that collaborative hands-on projects were similar to the engineering practice and thus were beneficial for encouraging participation. For example, contrasting the teaching style used in EEPs with lecturing, one student reported:

> I personally am a very hands-on learner, so I thought the discussions where we were able to work on our projects was the most beneficial learning style for me, just because I could … My GSI would sit down with me when I was trying to implement this whole timing thing, and we laid out the logic for it, right? And that was something I wouldn't get if I was just listening to a lecture.

Although students were predominantly positive about the student-centered pedagogy used in EEPs, several students found pitch competitions to be challenging and intimidating. Pitch competitions are often used in EEPs requiring students to put their ideas, solutions, and designs in front of instructors, investors, and peers depending on the type of EEP. Students expressed discomfort in participating in pitch competitions and

indicated that this activity may act as a deterrent to their participation in EEPs, as evident in this student remark, "Honestly, when I was looking at the pitch competitions, I felt threatened … No matter how badly I want to do it, I just don't think, when the application comes up, I can't do anything within that time period so I back away from that."

Information and resources

The most commonly reported way students learned about EEPs was from participation in student organizations and student events. Students recommended that student organizations should advertise EEPs and events could be organized to disseminate EEP information. They suggested approaches such as collaborating with minority organizations, working with design teams, and hosting events at engineering competitions. In contrast, students also reported a lack of academic advising with respect to entrepreneurship courses. Students reported that their academic advisors provided no information on EEPs that could be taken as electives, as expressed in this comment:

> My academic advisor never mentioned entrepreneurship classes, I was the one that heard about [EEP] and put it on my schedule. I mean, maybe they don't know about them or maybe they don't have the authority to be like, 'You should take this entrepreneurship class.' I'm not really sure how that works on their end.

As a result, a widely noted theme in student responses was the lack of information about the purpose and/or benefits of different EEPs. Student responses indicated that they were unaware of the benefits of EEPs and how they can be used in their future careers. Students expressed difficulty in understanding how EEPs were applicable to their specific engineering majors and careers. For example, highlighting the difficulty in understanding the contribution of EEPs, one student expressed:

> I don't know if I could articulate, on my resume, that I took an entrepreneurship class ... I just don't know if you could specifically put that on your resume" and suggested that "they [academic advisors] could at least give you examples on how this relates to your field and what you could do with it.

Acknowledging that this lack of information could be a barrier to students' participation, students suggested increasing access to academic advising that would provide them with specific information about the different EEPs.

Social capital

Students reported EEPs as a means of becoming part of an entrepreneurship community and consequently having access to shared resources and social capital. For example, reflecting on a co-curricular EEP experience, a student highlighted that the main reason behind participation was to become part of "… that network, tapping into the [X] community and those individuals that would be able to help me find others that I can help out." Students highlighted that they benefitted from being part of the entrepreneurship community as it provided them access to an interconnected group of individuals whom they can seek help and assistance in their entrepreneurial pursuits.

Academic transitions

Interestingly, students' responses indicated that their academic transitions were a more notable factor rather than general life transitions. Students reported specific preferences for when it is best to encourage undergraduates to engage in EEPs. While several students advocated for introducing students to EEPs early in their academic careers, others felt that EEPs should be offered later. Students argued that introducing students early will allow a student who wants to start a company to strategically plan their undergraduate career accordingly, thus meeting their entrepreneurial goals without postponing graduation. In contrast, students advocating for EEPs in later years argued that early years will be overwhelming because students are still adjusting to college, being exposed to a lot of information about curricular and co-curricular programs, and engaging in required engineering courses, as noted is this student statement, "I think freshman year, everyone's just very focused on, like, you're finally at college, and taking the basic engineering courses … There's already a lot being thrown at people, so it could just get lost amongst the noise." These students felt that EEPs are better for upper-level students, because that is when students are making decisions about their post-graduation plans and have acquired deeper technical expertise that can be applied to their entrepreneurial pursuits.

Participation in entrepreneurship education programs

Past experiences with entrepreneurship programs also positively contributed to students' decisions to participate in more EEPs as students became exposed to and more familiar with entrepreneurship. For some students, participation in informal EEPs, such as incubators, hackathons, and student entrepreneurial organizations, encouraged to participate in formal entrepreneurship courses; for others, formal courses motivated to minor in entrepreneurship. For instance, reflecting on an event, a student mentioned, "I feel like going to hackathon

initially was kind of what got me interested in entrepreneurship because it's just a bunch of people getting together and building products together." Also, past experiences were influential in positively shaping students' attitude towards EEPs by helping them realize the benefits of entrepreneurship education for their future.

Discussion

Guided by key entrepreneurship and adult learning theories, our interview results identify and unpack factors that inform engineering students' decisions to participate in EEPs in a large research-focused university. The emergent themes build an understanding of what the theory-derived and empirically emergent factors mean for engineering students and highlight the judicious choice of our qualitative approach. These results provide insights into how to encourage engineering students to seek out "elective" EEPs and offer implications for practice. Specifically, as explicated below, our findings provide insights on how administrators can develop new or existing EEPs that encourages engineering student self-directed participation by focusing on the curriculum and instructional design of EEPs, how EEPs are advertised in outreach efforts, and through which channels.

First, EEPs that have an engineering-focused curriculum will allow engineering students to work on entrepreneurial projects in a context that is relevant to their academic background. Typically, EEPs have followed the approach of first identifying key entrepreneurial tasks and skills and then creating teaching environments that replicate entrepreneurial practice (Turner & Gianiodis, 2018). Although this approach offers experiential learning and assists in developing an entrepreneurial skillset, the amount of engineering-emphasis is ill-defined. Furthermore, instructors of EEPs are often hired from a wide pool of business faculty, faculty from core STEM disciplines with interest/experience in entrepreneurship, and more frequently, practicing entrepreneurs. As a result, the curriculum followed in EEPs widely varies in the level of integration of entrepreneurial components with core disciplinary content. Engineering EEPs might consider including more engineering relevant content, such as technology product ideation and prototyping (Rideout & Gray, 2013). Researchers have argued that the relevance of the course content is critical for entrepreneurship education to establish the legitimacy of the courses and programs among students (Manolova, 2015). Our results provide empirical support and confirm these researchers' arguments in highlighting that increased engineering emphasis will enhance the relevancy of EEPs among engineering students and lead to increased participation. Integration of entrepreneurship with core engineering courses, such as design courses, is one approach to increasing the engineering emphasis in EEPs (Goldberg, 2005; Matthew & Turrentine, 2015; Oden et al., 2012). Universities can also leverage STEM faculty who undergo entrepreneurship training through programs such as I-Corps (Huang-Saad et al., 2017) to facilitate integration. This integration will also help address scheduling conflicts with required courses which was consistently noted as a constraint to participation.

Second, outreach efforts might consider ensuring alignment of students' perceived value of EEPs with their career intentions. In line with prior work (Wigfield & Eccles, 2000), our findings for goals and attitude suggest that students' participation will depend on what value the courses offer. We found that students participate in EEPs to achieve a wide array of goals such as personal development, problem-solving, gaining business knowledge and making a lot of money. Together, these perceived value propositions catered to students with a wide range of career plans (venture creation, working in a startup, or traditional industry jobs). While we acknowledge that the aims of EEPs vary and often may include aspects beyond venture creation, the perceived notion that EEPs are for students who want to start their own company may deter students who are not interested in venture creation from participating (Duval-Couetil & Wheadon, 2013). Recent research has that found the motivation for creating and solving is a critical factor that drives engineering students to be entrepreneurs (Yi & Duval-Couetil, 2018). We suggest that EEPs place equal emphasis on "inventing solutions" to better align programs with the entrepreneurial intentions of its prospective engineering student population. This can be performed by focusing on the problem-solving, innovativeness, and other skill development aspects of EEPs, rather than just founding new companies.

Third, greater emphasis might be placed on providing academic advising to students about EEPs to ensure alignment between their perceived value of EEPs and their career intentions. Our results show that students were unaware of the purpose and/or benefits of EEPs with respect to their future careers. The lack of academic advising, as noted in our results, exacerbates this information deficit and will hinder student participation. While engineering students typically have access to academic advising with respect to degree requirements from advisors in their home departments, EEP information is provided by entrepreneurship centers/organizations offering the courses. It is likely that these centers might not be able to help students understand the value of EEPs in connection with their core area of study. Quality academic advising establishes connections between students and their education by helping students understand their course choices and the learning associated with them (Hunter & White, 2004) and is noted to positively impact student retention by assisting them in

meeting their future career goals (Drake, 2011; Metzner, 1989). Administrators might consider providing academic advising which goes beyond providing students with a prescriptive list of courses, but assists students in understanding the value of EEPs in meeting their individual needs.

Implications for future research

In a recent systematic review of entrepreneurship assessment literature, Huang-Saad et al. (2018) found that while more than half of overall entrepreneurship education studies referenced theory, engineering entrepreneurship research lagged behind in their use of theory. In addition, they found that 153 unique theories were referenced in a total of 359 examined empirical studies. While the nascence of engineering entrepreneurship explains the lack of theory-driven research, engineering entrepreneurship education's interdisciplinarity explains the use of wide range of theories. Our presented work is a preliminary effort that examines student participation using PEEP model which was developed by coalescing multiple theories from disparate fields (Shekhar et al., 2018). It is important to note that with the exception of the life transitions identified in SEE; TPB, SEE, and SCCT contributed to only internal factors of the PEEP model (entrepreneurial self-efficacy, entrepreneurial intent, and desirability). Our results show that the external factors derived from the Chain-of-Response (COR) model of adult learning were also influential in informing student decisions. These results show that the internal factors identified in the three theories apply to student participation and simultaneously highlights that the three theories are mostly inward-facing and fail to include external factors. Lattuca and Stark (2011)'s work on college curriculum is an exemplar work that researchers can learn from to holistically examine entrepreneurship education by investigating internal and external socio-cognitive factors.

In addition, since our sample included mostly students who participated in EEPs, future work with students who opt out of EEPs may identify different factors and/or the factors may lead to different meanings and themes. Also, because our coding process analyzed the factors separately for conceptual synthesis, future studies can explore the interrelations between the factors. Our exploratory work provides an initial model for researchers to ground their work and we encourage future studies that assist in refining and rethinking the PEEP model by studying different student populations using other research designs and methodologies. For example, a mixed-methods study using qualitative data to develop a large-scale quantitative survey can investigate interactions between different factors. Likewise, findings of quantitative survey data can be further examined through follow-up qualitative work. Such work will greatly assist in deeply investigating factor relationships and consequently developing a more complete understanding of student participation in EEPs.

Lastly, while our model hypothesized that life and academic transitions impact students' participation, our results note that academic transitions may play a greater role for undergraduate engineering students. Interesting aspects of the results are the reasons behind students' differing preferences for the suitable year for exposing them to EEPs. This sheds light on how students' academic status might interact with other variables—entrepreneurial intent, information and resources, and opportunities and challenges. For example, on the one hand, early exposure will allow students who want to start their company (entrepreneurial intent) to plan their curriculum to meet degree requirements (opportunities and challenges). On the other, early years have a risk of students being overwhelmed with information about different opportunities (information and resources), occupied with required engineering courses (opportunities and challenges), and not being in a position to make decisions about entrepreneurial career options (entrepreneurial intent). This calls for more research examining when and in which format EEPs should be introduced or integrated in the engineering curriculum.

Conclusion

In this article, we used a theory-derived model to examine student participation in EEPs. As the field is still in a nascent stage, engineering entrepreneurship education has demonstrated minimal connection to theory (Huang-Saad et al., 2018). As a result, in our efforts to determine how to encourage engineering students to seek out elective EEPs, we leveraged the PEEP model, a framework grounded in adult participation and entrepreneurship theories, to inform research and practice. Our findings demonstrate that students' non-compulsory participation is not a single act, but is regulated by multiple factors. Guided by this theory-driven model, we were able to provide actionable guidance for EEPs to encourage engineering students' participation and provide directions for future research. This work also offers the engineering entrepreneurship practice community an example of how theory-driven research can impact engineering entrepreneurship education.

Limitations

While significant insights can be gained from our results, it is important to recognize that there are limitations to our study. Particularly, the participants of our study were from a single university. Therefore, our results are limited in terms of transferability to other contexts. However, the intent of our qualitative work was not to

generate broad results, but rather build a deeper understanding of factors that inform engineering students' participation in EEPs. While the results are not exhaustive due to the limited sample size, they do provide empirical support towards the factors derived from commonly used entrepreneurship theories and adult participation literature. While most of the predominantly noted themes were reported in the results, we acknowledge that future work in different settings will help in identifying themes that were not frequently emergent in our participants' responses. We also acknowledge that future longitudinal studies will be critical to build a deeper understanding of student pathways to EEPs and produce broadly transferable results. Lastly, we followed a qualitative, interpretative approach, which can be prone to misinterpretation and bias. Thus, we purposefully designed a thoughtful qualitative research study and followed the Walther et al. (2013)'s qualitative research quality framework (Walther et al., 2013) to ensure trustworthiness of our results. We believe the use of this research quality framework in developing and handling of our data allowed us to mitigate threats to credibility, transferability, dependability, and confirmability of our results.

Abbreviations

EEPs: Entrepreneurship Education Programs; COR: Chain-of-Response; PEEP: Participation in Entrepreneurship Education Programs; STEM: Science, Technology, Engineering, and Mathematics; TPB: Theory of Planned Behavior; SEE: Shapero's Entrepreneurial Event Theory; SCCT: Social Cognitive Career Theory

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