A Framework for Entrepreneurial Mindsets and Behaviors in Undergraduate Engineering Students: Operationalizing the Kern Family Foundation's "3Cs"

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ABSTRACT

The increasing interest in cultivating the entrepreneurial mindset among engineering students necessitates a shared language around what this looks like in terms of attitudes and behaviors, and frameworks provide this. A framework was developed to characterize the entrepreneurial mindset in light of the Kern Family Foundation's 3C's: curiosity, connections, and creating value. The framework was developed based on three rounds of reviewing the literature for relevant frameworks and assessment tools. The resulting framework that is presented in this paper includes twelve attitudes and seventeen behaviors that map to the 3Cs. This framework can serve as the basis for assessments and experiences designed to cultivate an entrepreneurial mindset among engineering students.

Key words: Entrepreneurship, Undergraduate Education

INTRODUCTION

Over the past decade, there has been an increasing interest in entrepreneurship within the engineering education community. This interest is commonly expressed in the form of new courses, certificates, minors, extracurricular activities, and a growing body of scholarship on this topic.

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However, when people use the term entrepreneurship, this term may mean different things and look differently for various stakeholders. What is missing from the discussion are conceptual frameworks that articulate what it meant by the use of the term. While framework is a term that can generally be used for any exercise that involves organizing objects (Nickerson, Varshney, Muntermann, 2013), for the purposes of this study we are adopting Schwartz et al.'s (2007) perspective which states that a framework is "a set of assumptions, concepts, values, and practices that constitute a way of understanding the research within a body of knowledge" (p. 41).

This paper presents a framework that characterizes the entrepreneurial mindsets and behaviors. Such frameworks are important to engineering educators when designing related curricula and assessments. Our work is influenced by the Kern Family Foundation (KFF). KFF is one of few organizations within the engineering education ecosystem with a solitary focus on cultivating an EM among engineering faculty and students. KFF's primarily activity is to provide financial support for the Kern Engineering Education Network (KEEN). KEEN consists of 28 partner institutions with the shared mission to graduate engineers with an entrepreneurial mindset so they can create personal, economic, and societal value through a lifetime of meaningful work (http://engineeringunleashed. com/keen/about/). KEEN takes a specific approach to defining the entrepreneurial mindset along three components: curiosity, creating value, and connections. These components are referred to as the "3 C's" and they guide the network's activity including curricular development, faculty workshops, student engagement, etc. (e.g. Fry, 2016; Rayess, 2016; Thoroughman, 2014; Reid, 2011; Ferguson, 2016; Gerhart, 2014; Riofrio, 2015; Condoor, 2009). Also of note is the "3Cs" framework has a specific focus on the social and societal aspects of entrepreneurship and intentionally separates itself from competencies associated with commercialization aspects of entrepreneurship.

Though succinct and memorable, the extent to which the "3Cs" framework aligns with existing literature on EM has not been explored. Greater granularity around the dimensions of each of the "3Cs", informed by existing scholarship, would address this need. Thus, the purpose of this study is to develop a more detailed conceptual framework to operationalize the "3Cs" framework. We suggest that this framework will be useful both for members of the KEEN network wishing to align their work within the broader EM community and for scholars not conducting work within the KEEN network who wish to leverage the insights from those who are immersed in a network focused explicitly on this topic.

METHODS FOR FRAMEWORK DEVELOPMENT

The overarching goal of this study is to develop a framework for organizing engineering faculty and students' entrepreneurial behaviors and mindsets according to the "three Cs" put forth by the Kern

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Family Foundation (KEEN, 2017): 1) curiosity - demonstrate constant curiosity about our changing world and explore a contrarian view of accepted solutions; 2) connections - integrate information from many sources to gain insight plus assess and manage risk; and 3) creating value - identify unexpected opportunities to create extraordinary value and persist through and learn from failure. For this research, we build from Yeager & Dweck's (2012) notion of an implicit theory to consider a mindset to be an attitude, belief, or idea that creates a framework for explaining events and, so, impacts a response to and/or interpretation of a situation. We consider a behavior to be the way in which one acts or conducts oneself in response to a particular situation or stimulus.

The first step in the development of the framework was to capture the research team's initial perceptions about entrepreneurial mindsets and behaviors using a process similar to bracketing. "Bracketing" is a practice that is commonly used by qualitative researchers who conduct phenomenological research; it includes documenting past knowledge and intuitions about a phenomenon that the researcher is about to begin studying such that full attention can be given to the insights that emerge from the data and analysis (Patton, 2015). Notably, a constraint on the starting point for the framework was the mapping of ideas contained within the framework to the Kern Family Foundation's 3C's: curiosity, creation of value, and connections. As such, some concepts related to entrepreneurship (i.e., those that did not map to one of the 3Cs) were intentionally excluded.

After the creation of preliminary draft framework, the research team engaged in a process of iteratively reviewing and synthesizing literature related to measurement of the entrepreneurial mindset with the goals of: 1) modifying and grounding the contents of the draft framework in existing literature; and 2) expanding the draft framework to include ideas reflected in the literature that were not among the researchers' initial perceptions. The starting point for the first round of literature was based on combinations of terms associated with the "measurement" of the "entrepreneurial mindset" in "engineering education". Said differently, we were looking for literature on the approaches that scholars were taking to quantitatively assess students' EM in an engineering context. This approach is consistent with what is commonly referred to as a "state-of-the-art" review (Grant, Booth, 2009). In each iteration of this process, articles related to measurement or assessment of the entrepreneurial mindset and behaviors were identified and read by at least two members of the research team. From each article, readers identified relevant topics that were already included in the framework as well as those that should be considered for inclusion. The research team then met to synthesize the ideas that were generated across publications.

Once the newest ideas from the set of articles were agreed upon by the research team, they were compared to the framework. Those that met the criteria for inclusion were added to the framework. One criterion for inclusion was that topics should be as specific as possible; for example, broad topics like "leadership" that are multi-faceted were broken down into related components (e.g., appreciation

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for different disciplinary knowledge and skills, willingness to change directions on an idea) prior to inclusion in the framework. This was done in an effort to facilitate translation of the framework into a survey instrument for measuring entrepreneurial mindset as part of future work. Additionally, given that the purpose of the framework is to capture the unique and distinguishing characteristics of the entrepreneurial mindset, topics that are taught as part of an accredited undergraduate engineering curriculum (e.g., communication and teamwork) were considered extraneous and were not included. Given the Kern Family Foundation's focus on the social betterment aspects of entrepreneurship, *mindsets* related to the for-profit commercialization of ideas were also excluded. (Notably, some *behaviors* that relate to business acumen and are a typical part of social entrepreneurship were included). Finally, we made an effort to exclude ideas for which other well established instrument already exist (e.g., self-efficacy) or for which broad support within the examined literature was not found. The process of obtaining insights from the literature and updating the framework continued for three iterations, when saturation, or the point at which no new information emerged from collecting additional data (Patton, 2015), was achieved. The next section provides details on topics that were pulled from the literature during each round.

FINDINGS

Table 1 shows the mapping of relevant topics from the literature in each of the three iterations of the process. For each identified mindset or behavior, the article(s) that contained these ideas are referenced. Superscripts indicate the final status of each topic in relation to inclusion or exclusion in the final version of the framework. Items with an asterisk (*) were included. Others were excluded for one of three reasons: Not Well-grounded in literature (i.e., only identified one time); or a Broad Construct.

During the first round of the literature review and synthesis process, five articles were selected based on their potential to inform the development of a unified framework to describe entrepreneurial mindset across engineering programs and institutions: Abdulwahed, et al. (2013); Bodnar, Clark, and Besterfield-Sacre (2013); Duval-Couetil, Reed-Rhoads, and Haghighi (2012); Gibson and Partington (2015); and Menold, et al. (2015). Much of the entrepreneurship literature within engineering education includes a focus on interventions conducted within a single classroom (or program) at a single university, and there remains a lack of consensus around what skills and knowledge an entrepreneurship program should teach as well as a lack of "hard evidence" that these programs accomplish their intended goals (Duval-Couetil, et al., 2012). As such, the broader scope of the papers chosen for the first round of review by the research team was important. During the review

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Mindset or Behavior	Source(s) – Round 1	Sources – Round 2	Sources – Round 3
	Table 1. Entrepreneurial Mindsets and Behaviors Mentioned in Literature Review.		
Hard Work / Drive [A]	Bodnar, Clark, & Besterfield-Sacre (2015)		
Interpreting the role of entrepreneurs in society [A]		Phillips & Jackowski. (2012)	
Leadership and Teamwork [B]	Gibson & Partington (2015); Bodnar, Clark, & Besterfield-Sacre (2015); Abdulwahed, et al. (2013)	Phillips & Jackowski (2012);	
Problem Solving [B]	Bodnar, Clark, & Besterfield-Sacre (2015); Abdulwahed, et al. (2013)	Phillips & Jackowski (2012);	
Recruiting an appropriate support team / utilizing the expertise of others / networking*	Bodnar, Clark, & Besterfield-Sacre (2015); Duval-Couetil, Reed-Rhoads, & Haghighi (2012)	Taatila & Down (2012)	
Vision / Passion / Optimism*	Bodnar, Clark, & Besterfield-Sacre (2015); Abdulwahed, et al. (2013)		Davis, Hall, Meyer (2016)
Growth Orientation / Openness to change*	Abdulwahed, et al. (2013)		Lau, et al. (2010); Shartrand et al. (2008)
Tolerance for ambiguity/ Limited Structure*	Bodnar, Clark, & Besterfield-Sacre (2015); Duval-Couetil, Reed-Rhoads, & Haghighi (2012)		Kriewall & Mekemson (2010); Davis, Hall, Meyer (2016)
Interpersonal Skills*	Bodnar, Clark, & Besterfield-Sacre (2015); Abdulwahed, et al. (2013); Duval-Couetil, Reed-Rhoads, & Haghighi (2012)		Pittaway, et al. (2007); Davis, Hall, Meyer (2016)
Customer Needs/Focus/ Empathy/Accepting of Others Ideas*	Bodnar, Clark, & Besterfield-Sacre (2015); Duval-Couetil, Reed-Rhoads, & Haghighi (2012)		Pittaway, et al. (2007)
Flexibility*	Bodnar, Clark, & Besterfield-Sacre (2015); Abdulwahed, et al. (2013)		Lau, et al. (2010);
Self-confidence / self-efficacy [B]	Bodnar, Clark, & Besterfield-Sacre (2015); Abdulwahed, et al. (2013)	Oosterbeek, Praag, Ijsselstein (2010)	Davis, Hall, Meyer (2016)
Risk Taking*	Menold, et al. (2015); Bodnar, Clark, & Besterfield-Sacre (2015); Abdulwahed, et al. (2013); Duval-Couetil, Reed-Rhoads, & Haghighi (2012)	Oosterbeek, Praag, Ijsselstein (2010); Taatila, Down (2012)	Shartrand, et al. (2008); Bolton et al. (2012); Davis, Hall, Meyer (2016)
Creativity / Innovation / Nonconformity/ Idea Generation [B]	Gibson & Partington (2015); Bodnar, Clark, & Besterfield-Sacre (2015); Abdulwahed, et al. (2013); Duval-Couetil, Reed-Rhoads, & Haghighi (2012)	Oosterbeek, Praag, Ijsselstein (2010); Taatila, Down (2012)	Kriewall & Mekemson (2010); Fry & Pistrui (2011); Bolton, et al. (2012); Davis, Hall, Meyer (2016)
Resilience / Persistence Through Failure/ Dedication*	Gibson & Partington (2015); Bodnar, Clark, & Besterfield-Sacre (2015); Abdulwahed, et al. (2013)	Oosterbeek, Praag, Ijsselstein (2010)	Kriewall & Mekemson (2010); Fry & Pistrui (2011); Davis, Hall, Meyer (2016)

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Table 1. (Continued)

Mindset or Behavior	Source(s) – Round 1	Sources – Round 2	Sources – Round 3
Recognizing Opportunities / Future Focus/ Strategic Action/ Action Orientation/ Proactiveness/ Execution*	Gibson & Partington (2015); Bodnar, Clark, & Besterfield-Sacre (2015); Abdulwahed, et al. (2013)	Oosterbeek, Praag, Ijsselstein (2010); Taatila & Down (2012); Phillips & Jackowski (2012)	Lau, et al. (2010); Pittaway, et al. (2007); Kriewall & Mekemson (2010); McGee, et al. (2009); Shartrand, et al. (2008); Fry & Pistrui (2011); Davis, Hall, Meyer (2016)
Business Acumen (e.g., Negotiation, Financial, Sales, Intellectual Property, Marketing/ Branding, etc.)	Gibson & Partington (2015); Bodnar, Clark, & Besterfield-Sacre (2015); Abdulwahed, et al. (2013); Duval-Couetil, Reed-Rhoads, & Haghighi (2012)	Phillips & Jackowski (2012);	Kriewall & Mekemson (2010); McGee, et al. (2009); Fry & Pistrui (2011)
Knowledge / Technical Depth*	Bodnar, Clark, & Besterfield-Sacre (2015); Duval-Couetil, Reed-Rhoads, & Haghighi (2012)	Phillips & Jackowski (2012);	Kriewall & Mekemson (2010); Fry & Pistrui (2011)
Communication[B]	Gibson & Partington (2015); Bodnar, Clark, & Besterfield-Sacre (2015); Duval-Couetil, Reed-Rhoads, & Haghighi (2012)	Phillips & Jackowski (2012);	Kriewall & Mekemson (2010); McGee, et al. (2009); Fry & Pistrui (2011)
Social Orientation/ Solving a Social Problem*	Abdulwahed, et al. (2013); Duval-Couetil, Reed-Rhoads, & Haghighi (2012)	Oosterbeek, Praag, Ijsselstein (2010)	Kriewall & Mekemson (2010); Fry & Pistrui (2011)
Need for Achievement, Autonomy/ Independence, and Power	Abdulwahed, et al. (2013)	Phillips & Jackowski. (2012); Oosterbeek, Praag, Ijsselstein (2010)	Lau, et al. (2010); Pittaway, et al. (2007); Bolton, et al. (2012); Davis, Hall, Meyer (2016)

Exclusion Criteria: [A] Not Well-grounded in literature (i.e., only identified one time) | [B] Broad Construct
* Indicates which of these were eventually included in the framework.

of these articles, twenty unique topics were identified, eleven of which were ultimately included in the framework.

Following round 1, a backward citation search was conducted to identify articles the following four articles for the second round of review during the framework development process: Oosterbeck, van Praag, and Ijsselstein (2010); Phillips and Jackowski (2012); Shinnar, Pruett, and Toney (2009); and Taatila and Down (2012). The themes identified from these articles included many of the same themes identified in the first round. In fact, as shown in Table 1, only one new theme ("Interpreting the role of entrepreneurs in society") was identified. Given that these articles were selected via backward citation from the original five articles, the similarities in topics were not surprising.

In the final round of the framework development process , the team started with set of seven new articles, which included: 1) a primary focus on published tools and instruments for assessing or measuring entrepreneurial behaviors and mindsets outside the scope of engineering education and 2) a secondary focus on papers that use the "3Cs" to operationalize the entrepreneurial related

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ideas. Eight articles were reviewed in the final round of the process: Bolton and Lane (2012); Fry and Pistrui (2010); Kriewall and Mekemson (2010); Lau, et al. (2012); McGee, et al. (2009); Pittaway, et al. (2009); and Shartrand, et al. (2008); Davis, Hall, Meyer (2016). After reviewing these articles and synthesizing the findings across team members, the ideas shown in column 3 of Table 1 were identi-fied. Notably, no additional ideas (i.e., rows in Table 1) were added based on the review of the seven new articles. These articles provided a fresh starting point for the identification of new constructs related to the entrepreneurial mindset (versus those in the second round, which were derived based on backward citation). Consequently, the fact that no new, salient ideas about the entrepreneurial mindset or behaviors were identified led the team to conclude that saturation had been achieved.

FINAL FRAMEWORK

The final framework, shown in Table 2, consists of twelve mindset outcomes and seventeen behav-ioral outcomes categorized using the "3C's". Notably, mindsets and behaviors were not designed or

Table 2. Framework for documenting faculty and student outcomes related to the 3 C's.

3C's	Mindset outcome (Idea or Attitude)	Behavioral outcome (Action)
Curiosity	1. Inherently interested in a wide variety of things 2. Thinking from both an epistemic and divergent perspective 3. Empathetic to perspectives and viewpoints of others 4. Comfortable with ambiguity 5. Willingness to challenge accepted solutions	a. Critically observes surroundings to recognize opportunity b. Explores multiple solution paths c. Gathers data to support and refute ideas d. Suspends initial judgement on new ideas e. Observes trends about the changing world with a future-focused orientation/perspective f. Collects feedback and data from many customers and customer segments
Creation of Value	6. Willingness to take risks 7. Persistence through setbacks and willingness to overcome failure 8. Willingness to change direction on an idea (pivot) 9. Motivated to make a positive contribution to society	g. Applies technical skills/knowledge to the development of a technology/product h. Modifies an idea/product based on feedback i. Focuses on understanding the value proposition of a discovery j. Describes how a discovery could be scaled and/or sustained, using elements such as revenue streams, key partners, costs, and key resources k. Defines a market and market opportunities l. Engages in actions with the understanding that they have the potential to lead to both gains or losses
Connections	10. Appreciation for different disciplinary knowledge and skills 11. Aware of one's own limitations in knowledge and skills 12. Willingness to work with individuals with different skill sets, expertise, disciplines, etc.	m. Articulates the idea to diverse audiences n. Persuades why a discovery adds value from multiple perspectives (technological, societal, financial, environmental, etc.) o. Understands how elements of an ecosystem are connected p. Identifies and works with individuals with complementary skill sets, expertise, etc. q. Integrates/synthesizes different kinds of knowledge

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intended to be directly correlated with one another. Instead, each mindset and behavior was placed based on alignment with the broad category (i.e., Curiosity, Creation of Value, or Connections).

IMPLICATIONS AND FUTURE WORK

The presented framework was developed and designed for use by practitioners (i.e., engineering education instructors) and other researchers investigating entrepreneurial mindset. The steps taken to create the final version of the framework are not without limitations. The initial grounding in the "3Cs" focused our literature review toward mindsets and behaviors directly relevant to curiosity, connections and creating value. This approach may have omitted some concepts from our framework. For example, the framework focuses primarily on social betterment aspects of entrepreneurship as opposed commercialization. We acknowledge this as a limitation of our framework that would not be present had we begun with a broader starting point and point the interested reader to Shekhar & Huang-Saad (2018) as an example of such a review.

For engineering educators, we suggest using the presented mindsets to frame activities undertaken in the classroom. The presented behaviors should be observed by students within class if the activity is successfully designed around the desired mindsets. For engineering education researchers, the framework can be used to theoretically frame studies about the entrepreneurial mindsets of undergraduate engineering students. Current work is being done using this framework as the foundation for the development of an instrument to measure entrepreneurial mindset that can be used to assess the entrepreneurial mindset students bring to a course and the impact the course or targeted entrepreneurial mindset activity had on a student's entrepreneurial mindset.

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Engineering Students: Operationalizing the Kern Family Foundation's "3Cs"

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