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# Capturing Students' Perception of Entrepreneurial Mindset: Tools for What and Why

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## ABSTRACT

Despite an increased focused on developing and understanding engineering undergraduates' entrepreneurial mindsets, best practices related to assessing this mindset remain nascent. In an attempt to evaluate concept mapping as a potential assessment tool for entrepreneurial mindset and identify the knowledge, skills, and attitudes (KSAs) first-year engineering students associate with this mindset, we asked students to create "entrepreneurial mindset" concept maps[1]. These maps were scored using the Integrated Rubric for Scoring Concept Maps (Besterfield-Sacre, et al., 2004) – a holistic tool for evaluating concept maps' *organization*, *comprehensiveness*, and *correctness*.

Through the application of this assessment strategy, we not only demonstrated the promise of concept mapping, but also captured 1) the KSAs students believe are relevant to entrepreneurship and 2) students' perspectives regarding the connections between KSAs. Our findings afford program directors and educators the opportunity to prepare educational activities that meet first-year students' program/course objectives *and* build upon students' current understanding. More generally, assessment using concept mapping offers educators a window into students' mental models and the baseline understanding needed to enhance student learning.

**Key words:** Assessment Tools, Concept Maps, Entrepreneurship

[1]Concept maps are graphical tools that can enable individuals to organize their thoughts, perceptions, and theories surrounding a topic.

## BACKGROUND

### Engineering Entrepreneurship Research

The field of engineering education has seen the number and breadth of engineering/technology-focused entrepreneurship programs grow, especially in recent years (Byers, et al., 2013; Duval-Couetil, Shartrand, & Reed-Rhoads, 2016; Gilmartin, et al., 2014; Besterfield-Sacre, et al., 2011; Shartrand, et al., 2010). Beyond "state of the field" (Gilmartin, et al., 2014; Shartrand, et al. 2010) and program/course descriptions (e.g. Mendelson, 2001; Ochs, et al., 2006; Standish-Kuon & Rice, 2002), engineering entrepreneurship research is an evolving and nascent discipline (see Besterfield-Sacre et al., 2016; Duval-Couetil, Reed-Rhoads, & Haghighi, 2011; Duval-Couetil, Reed-Rhoads, & Haghighi, 2012; Shartrand et al., 2008; Yasuhara, et al., 2012). Specifically, engineering entrepreneurship-focused research has sought to understand areas including:

- entrepreneurship knowledge and content within engineering (Besterfield-Sacre, et al., 2013),
- assessing engineering entrepreneurship (Purzer, Fila, & Nataraja, 2016; Bilén, et al., 2005),
- engineering students' interest in entrepreneurship (Duval-Couetil, Reed-Rhoads, & Haghighi, 2012; Rodriguez, et al., 2016),
- gender in engineering entrepreneurship (Morton, Huang-Saad, & Libarkin, 2016),
- engineering entrepreneurship's ability to meet ABET 3(a-k) criterion (Ochs, et al., 2006; Duval-Couetil, et al., 2015), and
- faculty members' perspectives on entrepreneurial mindset and teaching entrepreneurship (Hochstedt, et al., 2010; Besterfield-Sacre, et al., 2014; Zappe, et al., 2013).

While some of these existing studies sought to understand perceptions, attitudes, and beliefs, the existing literature is limited in direct attempts to measure students' entrepreneurial mindsets or beliefs. Therefore, this work sought to 1) evaluate concept mapping as a means to measure students' entrepreneurial mindsets or beliefs and 2) answer the question: How might first-year engineering students conceptualize "entrepreneurial mindset"?

### Assessing Students' Entrepreneurial Mindsets

The limited entrepreneurial mindset assessment literature is not without cause. As discussed in Shekhar and Huang-Saad's as well as Zappe's papers from this issue, a common taxonomy and operationalized definition of entrepreneurial mindset and its many existing subconstructs has yet to be achieved in engineering education. As Zappe points out, this makes measuring one's entrepreneurial mindset difficult. In light of this challenge and based on our review of existing assessment best practices in engineering education, we chose concept maps as the tool to assess students' baseline perception of an entrepreneurial mindset because it represents an approach to communicate and organize knowledge in a graphical manner (Novak & Canas, 2006). Concept maps have been used previously in a number of engineering disciplines including civil engineering (Roberts, et al., 2014), mechanical engineering (Pierre-Antoine, Sheppard, & Schar, 2014), computer and electrical engineering (Calvo, et al., 2011), and biomedical engineering (LaSota, Parker, & Bodnar, 2015). They have also been used to evaluate first-year engineering programs (Barella, Henriques, & Gipson, 2016) and particular interdisciplinary concepts within a course (e.g., sustainability practices (Bielefeldt, 2016) and green engineering (Borrego, et al., 2009)). Importantly, concept mapping can afford students the ability to add any sub-concept and make any connections they deem relevant without being influenced by another's guidance. For this reason, concept mapping served as an ideal assessment tool for both the evaluation and investigation of students' perceptions of entrepreneurial mindset.

## METHODS

### Study Design

To achieve our objectives, first-year engineering students (N=36) at a medium-sized, mid-Atlantic research university created concept maps as part of their normal course activities in a common first-year engineering course. The course introduces first-year engineering students to concepts such as design, technical communication, engineering tools, and laboratory experiments. Although concepts associated with an entrepreneurial mindset are implicitly woven into students' fall and spring engineering courses, these concepts were not explicitly part of the courses' instruction prior to the concept mapping activity. While students' discipline-specific engineering majors varied and were not accounted for in the demographics of this study, approximately one-third of the participants had previously indicated a committed interest to entrepreneurship. To ensure that all students had familiarity with creating concept maps, a member of the research team instructed students on the basic steps involved in creating a concept map prior to the activity. The topic of this training was general to avoid biasing the activity. The concept mapping activity took approximately 15–20 minutes of the class period and occurred at the end of the fifth week during the spring semester. Human subjects' approval was obtained prior to conducting this study and we collected no identifying information that would allow students to be linked to their concept maps.

### Concept Map Scoring

Students' concept maps were scored using the Integrated Rubric for Scoring Concept Maps (IRSCM) (Besterfield-Sacre, et al., 2004), which evaluates the map based on three criteria: *comprehensiveness*, *organization* and *correctness*. This scoring method was selected, as compared to alternative methods such as the traditional and categorical scoring method, because IRSCM has been found to be useful in capturing students' conceptualization of a subject area as a whole (Watson et al. 2016). As described by Besterfield-Sacre et al. (2004), *comprehensiveness* is used to determine how well the students define the subject matter in question and what level of breadth and depth they incorporate into their maps. *Organization* is the dimension that examines how students are connecting the concepts they add to their map and the logical or hierarchical approach they select for portraying these concepts. *Correctness* is applied to evaluate any misconceptions the students may have about the subject matter and the level of accuracy surrounding the concepts included. For each criterion, maps are rated using a three-point scale, of which 1 represents the lowest rating and 3 represents the highest rating. During our scoring training session, however, we found that scoring the maps required additional nuance; therefore, we added half-point scores (1.5 and 2.5) to address these situations.

Prior to scoring the maps, two raters established the criteria required to properly analyze the concept maps. Generally speaking, entrepreneurial mindset was taken to capture knowledge, skills and attitudes associated with entrepreneurial activity as defined by Purzer, Fila, & Nataraja, 2016. More specifically, *comprehensiveness* was assessed based on the inclusion of sub-concepts that both raters, who have taught, researched and/or engaged in engineering entrepreneurship for over four years, associated with an entrepreneurial mindset. These concepts included:

- *innovation* (creativity and ideas were also categorized under this heading);
- *entrepreneurial affect* (including concepts such as risk, failure, ambiguity, empathy);
- *product development* (related to commercialization, prototyping, design);
- *money*;
- *customers* and/or *stakeholders*;
- *value*;
- *problem solving*;
- *business skills* (such as marketing, sales, legal, etc.);
- *professional skills* (such as teamwork, communication, time management, etc.);
- *technical skills* (such as those related to engineering); and
- *opportunity identification.*

Considering the current ambiguity in entrepreneurial mindset definition/subconstructs and the fact that the participants were first-year students, a map was scored a 3 (the highest score) if students captured roughly two-thirds of the above concepts (or six concepts). We made this decision on the basis that first-year engineering students are in the introductory stages of their training and may have limited existing KSAs associated with entrepreneurship. Thus, it would be unrealistic to hold them to the full breadth of concepts listed above. The *comprehensiveness* score would then decrease based on the fraction of concepts students included. As with past uses of the concept map rubric, *organization*

***Table 1. Inter-Reliability Values for Concept Map Scoring.***

| Rubric Dimension | Reliability Score Based on Intra-class Correlation Coefficient (ICC) |
|---|---|
| Comprehensiveness | 0.75 (excellent) |
| Organization | 0.87 (excellent) |
| Correctness | 0.56 (fair to good) |
| Overall | 0.90 (excellent) |

of the maps was evaluated based on the types of connections that students were making between these concepts and whether the maps branched out linearly or utilized feedback loops. Finally, *correctness* was scored solely on the basis of whether the concepts and connections between concepts had a logical link. This means that students were not penalized for connections that they did not include.

### Reliability Analysis

After setting the criteria and training on a subset of the maps (N=5), the two raters independently scored the remainder of the concept maps (N=31). The Intra-class Correlation Coefficient (ICC) – a measure for consistency analysis – was calculated using the "average measures" function in SPSS (Norusis, 2005). The results from the inter-rater reliability analysis are shown in Table 1. According to Fleiss (1986), excellent reliability is based on ICC values greater than 0.75 while fair to good reliability is based on ICC values between 0.4 and 0.75. After calculating the reliability measures, the raters discussed any ratings in which there was disagreement until they came to consensus on the final scores for each concept map.

## RESULTS AND DISCUSSION

Table 2 shows the average results of the concept map scoring broken down by each dimension of the Integrated Rubric for Scoring Concept Maps.

It is evident from this analysis that first-year engineering students have a moderate conceptualization of entrepreneurial mindset; one that largely focuses on knowledge and skills rather than

***Table 2. Concept Map Scoring Rubric Results.***

| Dimension | Definition | Average Score (max 3) |
|---|---|---|
| Comprehensiveness | Broadness of knowledge; completeness of subject definition | 2.00 |
| Organization | Branches are well defined and properly placed | 1.86 |
| Correctness | Accuracy of information; spelling and/or grammar mistakes | 2.81 |

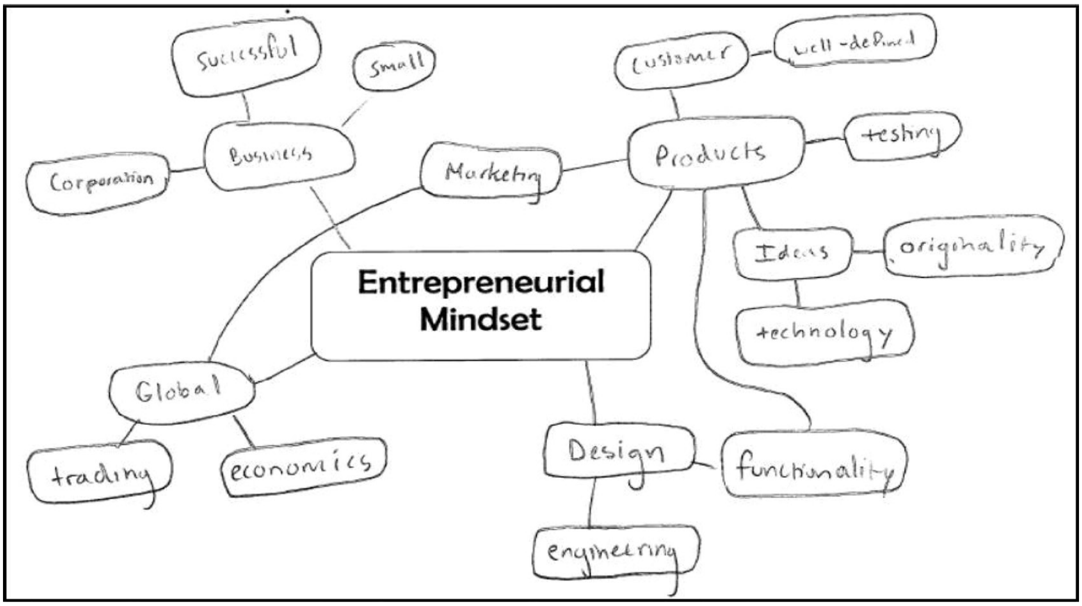


***Figure 1. Example Concept Map from a First-Year Engineering Student.***

attitudes. On average, students included 4 of the 11 fundamental concepts that the raters associated with an entrepreneurial mindset. Common concepts that were included in the student maps were *business, money, and customers*. Less often students referenced technical skills such as *engineering*, *problem solving,* and *value*. This demonstrates that first-year engineering students may associate an entrepreneurial mindset more with the commercialization of technology and business-related concepts than with the roles that engineers serve in the entrepreneurial process.

Another interesting result is that students' maps demonstrated primarily hierarchical relationships between concepts, as opposed to a concept map showing many inter-connections across concepts (see Figure 1). 16 maps scored below a 2 on organization, 11 maps scored between a 2 and 3, and only 4 maps met the benchmark for a score of 3. We believe this occurred because many first-year engineering students are just beginning to learn fundamental entrepreneurship KSAs. These students are in opposition to an individual with significant technical entrepreneurship experience who will likely have more understanding of the nuanced interconnections between business and engineering.

The concept maps also showed that overall the students were thinking correctly about the concepts included in their maps (a high average correctness score of 2.81/3).

Next, we examined the concept maps for key terms that students were using to describe an entrepreneurial mindset. Across the 36 concept maps, a total of 168 unique concepts were included. These concepts varied considerably from those important to running a business (i.e., marketing, sales,

***Table 3. Frequency Count of Entrepreneurial Mindset Categories.***

| Category | Example Concepts Associated with Assessment Categories | Frequency (Number of times concepts within each category appeared on students' maps) |
|---|---|---|
| Innovation | innovation, creation, idea, invention, originality, outside the box thinking | 37 |
| Entrepreneurial Affect | risk/reward, empathetic, motivated, perseverance, vision, integrity, drive, etc. | 67 |
| Product Development | products, materials, research, testing, etc. | 24 |
| Money | loans, banks, savings, money | 24 |
| Customers and/or Stakeholders | customers, customer needs, focus groups | 23 |
| Value | jobs/employment, global, productivity, benefits, promotes common good, etc. | 16 |
| Problem Solving | problem solving, reverse engineering, solutions, well defined | 8 |
| Business Skills | business, profit/loss, investments, supply/demand, economics, marketing, business model, business partnerships, cash flow, branding, etc. | 162 |
| Professional Skills | networking, ethics, teamwork, communication, time management, collaboration, decisions, negotiation, etc. | 25 |
| Technical Skills | engineering, technology, design, manufacturing, safety | 14 |
| Opportunity Identification | business opportunity | 6 |

investments, and employees) to personality traits that could be associated with an entrepreneur (e.g., driven, motivated, leader, empathetic, and demonstrating persistence through failure). Once all of the concepts were compiled, we determined how many students included each concept on his or her map. We then mapped the concepts back to the proposed categories used in our comprehensiveness scoring. The results of this count for each category are shown in Table 3. Some concepts included by students did not fit within any of the raters' categories (e.g., college education, longevity, and government).

Four out of the six top concepts are associated with business or money. Most students (28/36) included the general term "Business" on their concept maps, with the second-most common term "Money" (19/36), followed by "Profit/Loss" (14/36), and "Investments" (13/36). While this link between the entrepreneurial mindset and "Business" is encouraging, it demonstrates an opportunity for engineering educators to purposely teach entrepreneurially-minded business and monetary concepts in greater detail.

Our concept analysis, when combined with students' *organization* score, also reveals another opportunity for engineering educators; that being, conveying the importance of both the science/technical and business dimensions of entrepreneurship. Most students did not include science/technical concepts or aspects of the design process in their maps ("Engineering" – 7/36; "Invention" – 8/36). However, many entrepreneurial endeavors arise from scientific or technical breakthroughs, developed through engineering design, that result in new products, services, and startups. As engineering educators teaching entrepreneurship, we have the opportunity to clearly demonstrate how science, technology, and engineering are often closely linked to, or even precede, business considerations. This enhanced understanding also affords opportunities for improving the *organization* of first-year engineering students' entrepreneurial mindsets.

## LIMITATIONS OF STUDY

The study was conducted with a small number of first-year engineering students at a single university. While we have discussed potential insights, the results are limited at this stage and not yet generalizable. Additional research should be conducted to compare students' entrepreneurial mindset concept maps based on greater contextual diversity (e.g., university, degree, year in program, and academic standing). It would also be beneficial to compare and contrast these concept maps with groups such as entrepreneurially-minded students, practitioners, and faculty. Additionally, tracking how students' conceptualizations of entrepreneurial mindset change longitudinally could help educators understand how interventions impact entrepreneurial concept integration. Lastly, our decision to score the concept maps based on students' ability to derive two-thirds of the total number of concepts may have resulted in higher *comprehensiveness* scores than otherwise would have been the case. In future studies, additional entrepreneurship experts should be called upon to determine the breadth and depth required to produce a truly "comprehensive" concept map.

## CONCLUSIONS AND FUTURE WORK

Through this study, we sought to evaluate whether student-created concept maps could capture students' fundamental conceptualizations of "entrepreneurial mindset". Despite this work's limitations, our results demonstrated that concept mapping is a promising methodology. To this end, students' maps revealed that students have a baseline awareness of key entrepreneurial mindset characteristics and are able to accurately represent these ideas in the form of a concept map; however, there is room for improvement regarding the *comprehensiveness* and *organization* of the concepts. It was also observed that students' maps tended to prioritize the business-related aspects of entrepreneurial mindset over technology-based concepts such as engineering and design. This demonstrates that students early in their education may believe that business is more critical to entrepreneurial practices than engineering. Overall, these results reveal that, as other studies have also shown, concept mapping is an effective methodology for capturing perspectives, beliefs, and mental models. Immediate future work includes studying students' entrepreneurial concept maps in broader contexts, using the concept map methodology as a pre-/post-measure over the duration of a semester or a long-term program, and utilizing additional experts to refine our scoring methodology.

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