Concept Maps as an Assessment Tool for Evaluating Students' Perception of Entrepreneurial Mind-set

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Abstract

With today's growing competitive economic market, having an entrepreneurial mindset can be instrumental for success. An entrepreneurial mindset encompasses the way a person thinks about a new idea, product, or innovation [1]. It can include elements such as approaches to product development, the ability to mitigate risk, creating new professional networks, and the ability to accept failure [2]. Students in both engineering and business can benefit from these skills, as these skills have widespread application in today's professional environments.

In order to better understand how both business and engineering students perceived the term "entrepreneurial mindset," this study utilized concept mapping to visually elicit business and engineering students' perspectives. Concept mapping is a useful assessment tool since it outlines relationships between ideas and concepts [3]. Using a concept map, it is possible to observe how students connect different attributes and topics to an overarching theme (in our case: "entrepreneurial mindset"). Two different methods of scoring concept maps were used: traditional and holistic. Using the concept maps, this study aimed to determine whether there were any observable differences between the two scoring methods. It also sought to determine whether concept maps produced by engineering undergraduates differed from those produced by business undergraduates

In total, 19 engineering students and 6 business students participated in this study. We found that holistic and traditional scoring methods provided similar evaluation of the concept maps. The scoring methods were only able to reproducibly score the lower scoring concept maps whereas the remaining maps showed more variability. These differences may be due to the priorities of each scoring method. Traditional scoring is based on the quantity of information portrayed and the ability to create connections between topics. Holistic scoring is based on the range of topics involved with the main subject, the structure of the concept map, and the quality and correctness of each concept and connection. There were no statistically significant differences found between the traditionally and holistically scored concepts maps for either major although a medium effect size was observed when comparing participants' holistic comprehensiveness scores across disciplines.

Results from this study demonstrate that when seeking to evaluate students' perceptions of an entrepreneurial mindset, the application of holistic scoring methods may be more effective in distinguishing detailed conceptual knowledge. Alternatively, the traditional scoring method may be more helpful when seeking a broader understanding of students' knowledge of a concept. Overall, each scoring method has its own benefits and disadvantages; therefore, the evaluation method selected should be based upon the focus of the research.

Introduction

Concept mapping is an educational tool that allows a user to represent their understanding of a topic in a visual format. Through the development of a concept map, the user is able to interconnect concepts within a larger topical area, which can allow for a deeper understanding of the topic itself [4]. Concept mapping is different than other knowledge mapping tools because it focuses the map around a central question or term. It is this central component that drives the thought process for coming up with sub-topics and interconnections within the map [3].

Moore et al. [5] states, "They (concept maps) are primarily used in one of two fashions: 1) An expert-generated concept map is used as an overview or framework before more detailed information is presented, or 2) students are asked to generate maps as a reflective activity at the end of a unit." Therefore, concept mapping can be used to gauge class and individual student understanding of a topic. It can also be used to aid instructors by helping them identify what parts of their curriculum need more attention [5]. For instance, a study was conducted where civil engineering students were asked to prepare a concept map around the phrase "civil and environmental engineering" which allowed faculty to gauge the students' current understanding of the field [6]. Concept mapping has also been implemented to allow for assessment of student growth through pre- and post-evaluations. Students created concept maps centered around the phrase, "teaching and learning" at the beginning and end of a 10 week program. The maps helped determine student development throughout the program since the faculty were able to see how a student's understanding of the subject area changed from their participation in the program [7].

In addition to being a tool to assess students, concept maps have been used by an instructor in order to provide students a "road-map" of what to expect within a topic or a course [8]. The interconnection of sub-topics allow students to make stronger connections within a topic, and can help them understand how things connect. For example, concept mapping has been used to provide an overview of the key concepts that students would be learning throughout their four years as an undergraduate within a mechanical engineering program [8]. These concept maps were expected to be beneficial for both students and professors because they allowed a visual representation to be made of how the topics aligned and were connected. As time passed, the use of concept mapping moved from just a method to assist with organizing a course, to a method to aid instruction.

In this study, we are examining how concept mapping was capable of capturing undergraduate student' perceptions of an "entrepreneurial mindset." Entrepreneurial mindset is of importance within a college education because a student learns real world application and can apply their major within real world business operations [9]. By employing concept mapping as a way for students to visualize the "entrepreneurial mindset," the ideas employed relevant to this mindset can be seen in a broader context.

An entrepreneurial mindset encompasses more than just the skills necessary for starting a business but rather looks at the knowledge, skills, and attitudes that help stimulate innovation and create new business opportunities [10]. This mindset is not limited to students studying business but has become increasingly important within many fields, such as engineering education, to provide the tools and knowledge to innovate and lead in multidisciplinary teams [11, 12]. The entrepreneurial mindset allows students to better understand the global market and how their career aligns with different business models. Narayan found chemical engineering seniors who took part in an entrepreneurship class were able to take what they learned in their engineering classes and apply it to making their own "start-up" [13]. The technical information learned over the four academic years was able to be utilized in real world applications that aligned with their future careers.

As part of this research study we were interested in examining two specific research questions:

1. *Are there any observable differences that occur when applying traditional and holistic scoring to concept maps on entrepreneurial mindset?*
2. *Do concept maps produced by engineering undergraduate students differ from those produced by business undergraduate students on the basis of either holistic or traditional concept map scoring methods?*

Individuals within the ENT community could find value in this paper as it provides a comparison of two documented methods for scoring concept maps derived on the topic of entrepreneurial mindset. Although, procedures for performing this assessment have been described previously for concept maps in general [14, 15], this paper is the first to our knowledge to focus on this form of assessment of students' entrepreneurial mindset. Additionally, this paper provides a comparison of engineering and business students' perception of entrepreneurial mindset highlighting how differences in curriculum impact students' perception of this particular construct. The observations shared could lead to new insights on how to structure curriculum for teaching concepts related to entrepreneurial mindset to students from each of these disciplines.

Methodology

Study Design

Students from the college of business and engineering were invited to attend an innovation kickoff event where they could learn more about the innovation and entrepreneurship activities and resources available on campus and network with like-minded students. A total of 35 students attended this innovation event. A concept map activity was incorporated during the event to allow students to create a visual diagram of their baseline understanding of the term "entrepreneurial mindset." Prior to completion of their own individual concept maps, the facilitators of the session went through an example concept mapping activity using "ice cream" as the foundational element of the map. This concept mapping example showed students how

concepts are added to a map, how concepts can be built out based on relevance, and how cross-links can be built between different branches to connect to one another. After the completion of the concept mapping activity, students were provided the opportunity to consent to have their concept maps included as part of this research study. Afterwards, the innovation kickoff event continued with a series of guest speakers that discussed different elements of the innovation and entrepreneurship ecosystem on the university campus.

In total, 19 engineering students and 6 business students agreed to have their concept maps included as part of this study. Initial training in scoring the concept maps was performed by five raters (two undergraduate students, one graduate student and two faculty members) on a set of 4 concept maps. The remaining 21 concept maps were used for inter-rater reliability between the two undergraduate students and one graduate student. All concept maps were assigned a numeric identifier throughout the analysis process. Once all analysis was complete, the maps were then identified by discipline to complete statistical analysis comparisons. Proper human subjects' approval was obtained prior to the conduct of the study.

Concept Map Scoring

Two approaches to concept map scoring were applied as part of this study: holistic and traditional scoring. The following sections will describe in detail the approaches undertaken when scoring the maps using each method.

Holistic Scoring of Concept Maps

Holistic scoring involves evaluating concept maps on the basis of: comprehensiveness, organization, and correctness. Each category has its own individual set of criteria for evaluation. Once the numeric scores for each category were agreed upon, the total scores were determined by summing all three category scores.

Comprehensiveness

Besterfield-Sacre et al. [14] define comprehensiveness as a "student's ability, as portrayed through the map, to define the subject area, his or her level of knowledge of the area, and the breadth and depth of that knowledge." Comprehensiveness of the entrepreneurial mindset was initially determined based on the incorporation of terms that fell within the following eleven categories: *Innovation/Creativity, Entrepreneurial Affect, Product Development, Money, Customer and/or Stakeholders, Value, Business Skills, Professional Skills, Technical Skills, Opportunity Identification, and Problem Solving* based upon prior work by two of the paper authors [16]. Upon review of these topics, it was determined that both *Problem Solving* and *Opportunity Identification* didn't represent specific categories in their own right. For this reason, these categories were eliminated as they could be captured within the other categories already present. For example, opportunity identification is a key component of the product development cycle and could be scored underneath that heading.

In the process of reviewing the comprehensiveness scores, there was variability in the scoring. For instance, there was discussion over the phrase "Problem Solving." Some scorers categorized the term under *Product Development*, whereas others placed it under *Technical Skills*. It was decided that "Problem Solving" should be categorized as *Technical Skills* since it relates to a skill set often exemplified in technical disciplines. There was also discussion over whether *Product Development* and *Innovation/Creativity* were distinct categories or fell under the same category. After discussion it was determined that they were indeed two separate categories because it wasn't always guaranteed that innovation/creativity would lead to or involve product development.

Comprehensiveness was scored on a three point scale, including half points, and was based on the number of topics that the students portrayed in their map. The addition of half points was made based on prior work on concept map scoring using the holistic method for situations where the map didn't clearly fit within any of the three main category headings [17]. If the map contained two of the nine categories they would receive a 1, a map would be scored a 1.5 with 3 to 4 categories, 2 with 5 to 6 categories, 2.5 with 7 to 8 categories, and 3 for all 9 categories showing mastery of the content related to the entrepreneurial mindset. It was determined that when reviewing the concept map for key terms, raters should reference the adjacent branches to the term in question, if there was any uncertainty, to determine which category it best represented.

Organization

Organization is defined as "the student's ability to systematically arrange the concepts, the hierarchy of concept placement, and the connections/integration of the branches" [14]. Within the organization category, scores are based on two subcategories: the branches of the concept maps and the number of feedback loops, or connections between branches, contained within the map.

Maps which score 3 points in the organization category contain many branches and sub-branches as well as several feedback loops. This illustrates a knowledge of the concepts incorporated under an entrepreneurial mindset and the connections which exist between them. In contrast, a map which scores a 1 in organization is arranged very linearly, with no connections between the map's main branches. Half points, which exhibit traits from the higher category and lower category, are also used as the map may not correctly fit into either category. For example, a map scoring 2.5 points may have all of the branches and sub-branches of a 3-point map, yet have the feedback loops of a 2-point map.

Correctness

Concept maps are scored based upon their level of correctness, in which the team gauges whether the student was correctly applying a term associated with an entrepreneurial mindset.

When scoring maps, the team members each began with a default score of 3 for the correctness category, but half a point was deducted for each inaccuracy or misconception within the map. Inaccuracies and misconceptions are found by analyzing the direct connections made between adjacent terms to determine whether they can be successfully related. For example, a link between "market" and "customer" shows that a student is accurately aware of the connection between the customer and the market. However, a link between "invention" and "helpful," shows that the student has an inaccurate or unclear understanding of at least one of the concepts. It was observed that scoring based upon spelling and grammar may artificially reduce students' correctness scores since the score should assess their application of the concept. So, it was decided that scoring based upon spelling and grammar would not be included in the assessment of the concept maps.

Traditional Scoring of Concept Maps

Traditional Scoring of concept maps is based on concept map components such as hierarchy levels, propositions, and cross-links as described by Novak and Gowin [15]. Within their scoring, Novak and Gowin did account for validity of concepts and correctness between the hierarchy level and concepts [15]. However, validity of correctness between concepts was neglected for the current study to reduce time and have "an efficient, reproducible method" [14]. The sub-scores as defined by Novak and Gowin can be related to knowledge breadth, depth, and connectedness [15, 18].

Watson et al. stated that knowledge breadth is found through the Number of Concepts (NC) that the student includes in their map [18]. The Highest Level of Hierarchy (HH) is used to find knowledge depth. The HH denotes the number of connections within a branch with the greatest number of concepts in a single chain [18]. For example, a map with a HH of 1 would have all concepts connected directly to the center, while a map with an HH of 5 would contain at least one branch that extends outward to five concepts linearly. The Number of Cross-links (NCL) determines knowledge connectedness [18]. One must count the number of single connections made between branches, to determine the number of cross-links with no consideration of correctness.

Finally, once the numeric measurements have been obtained for each of these components, Equation 1 below is used to obtain the total Traditional score [18].

$$Total = (NC) + (HH) \times 5 + (NCL) \times 10 \qquad (1)$$

The equation assigns the most weight to NCL, and the least weight to NC. For example, if a concept map contains a total of 10 concepts, excluding "Entrepreneurial Mindset," has 3 levels of hierarchy, and has 2 cross-links, the scores for the map would be NC = 10, HH = 3, and NCL = 2 for a total score of 45.

This method is able to be conducted within this simplified form to reduce the time scoring each map, where no consideration for the correctness or quality of the concepts is needed; the score can just be based off the amount of components and visible hierarchies present within the map.

Statistical Analysis

Due to the subjectivity associated with the holistic scoring method, each concept map was scored by three independent raters. The raters included two undergraduate engineering students and one graduate engineering student. Prior to the independent scoring, the raters trained on a subset of 4 concept maps where they would independently evaluate the maps according to the elements of the rubric and would then meet with the two faculty members associated with this study to discuss their results and come to mutual agreement on the scoring for the concept map in each of the designated categories.

Upon completion of the training, a total of 21 maps were then scored independently by the three raters. The inter-rater reliability measure determined as a function of the intraclass correlation coefficient can be seen in Table 1 below.

Table 1. Inter-Reliability Values for Concept Map Scoring

Rubric Dimension	**Reliability Score Based on Intraclass Correlation Coefficient (ICC)**
Comprehensiveness	0.826
Organization	0.900
Correctness	0.557

According to Fleiss, intraclass correlation coefficients between 0.400 and 0.750 can be taken to represent fair to good reliability whereas values above 0.750 can be shown to represent excellent reliability [19]. It is believed that the value for correctness was lower than the other two categories as it was more subjective and could vary based on experience and knowledge expertise associated with the terminology related to entrepreneurial mindset.

To perform comparisons between concept maps that were generated by undergraduate business students and engineering students, an independent samples t-test was performed. However, due to the low sample size associated with this study, a non-parametric Mann Whitney test was also conducted to verify the results observed from the t-test. Effect size was used in each comparison and used as additional information when analyzing the differences observed between these two

populations of students. Since the two sample populations in the study had different sample sizes (19 for engineering and 6 for business), a Hedge's g value was also calculated to account for the different sample sizes.

Results and Discussion

Research Question 1: Are there any observable differences that occur when applying traditional and holistic scoring to concept maps on entrepreneurial mindset?

Research Question 1 Results

The range for the total traditional score of the concept maps as part of this study was 0 to 105 whereas the range for the total holistic scores was 0 to 8.5. As seen in Figure 1, when comparing the different scoring methods, the lower scored maps reflect similar scores between the two scoring methods, but more irregularities in scores were observed between the two methods as the maps grew in complexity. This may be indicative that due to the different weights and focus areas of these scoring methods they aren't capable of producing similar results overall.

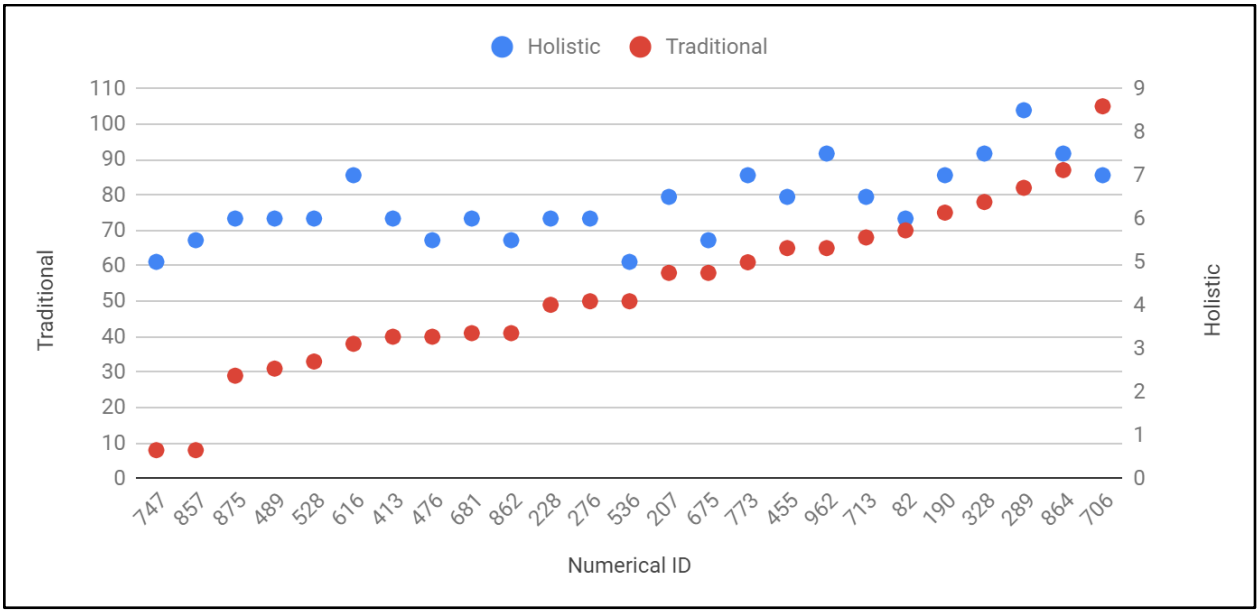

Figure 1. Line Chart of Holistic and Traditional Scores by Participant

When using the traditional scoring method, the highest scoring concept map, as shown in Figure 2, had a score of 105. This total score was due to the map having 8 cross-links, the most cross-links of any concept map scored. When the map was scored holistically the total score was a 7. Even though the holistic score is high the map was lacking in the categories of comprehensiveness and correctness. For instance, this map only included Innovation/Creativity, Entrepreneurial Affect, Professional Knowledge and Skills for a total of 3 categories out of the 9 possible categories that could be present giving it a 1.5 in comprehensiveness. The score for correctness is a 2.5 due to the weak connection between the concept "organization" and

“discipline” as organization is not necessarily a result of discipline. It can be seen that the creator of the concept map fully understood connections between different concepts but did not have full comprehension about the breadth and depth of Entrepreneurial Mindset, which can be seen by the small amount of concepts included on the map. This resulted in the low score of comprehensiveness from the holistic scoring.

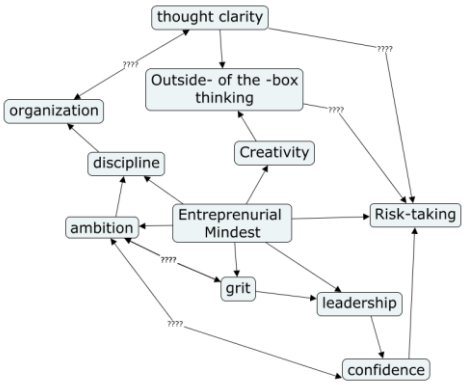

Figure 2. Highest traditional scoring map

The map shown in Figure 3 is the highest scoring map using the holistic method with a score of 8.5. The connections made between the concepts are all correct with a non-linear structure earning the map a 3 in both organization and correctness. The high score for the holistic scoring can be attributed to the high comprehensiveness score, its inclusion of 7 categories, Innovation/Creativity, Product Development, Resources needed, Customer and/or Stakeholders, Business Knowledge and Skills, Professional Knowledge and Skills, Technical Knowledge and Skills. This map also received a high score using the traditional scoring approach. Its score was 82, which is the third highest traditional score. The traditional score for this map is attributed to the 5 cross-links between main branches and the 22 total concepts. This map demonstrates a strong and deep understanding of the Entrepreneurial Mindset overall.

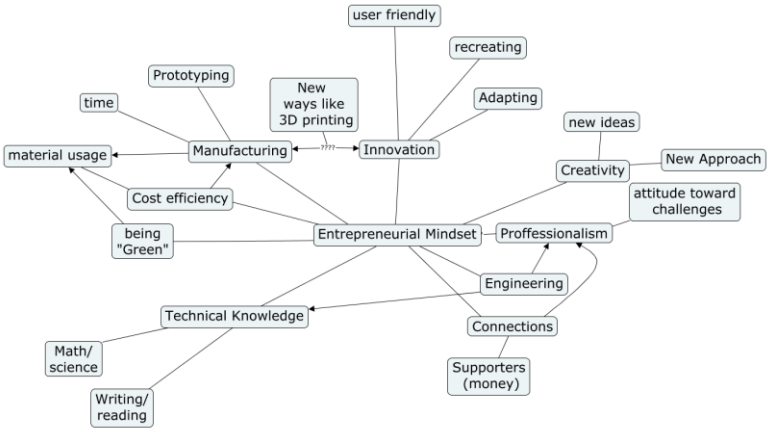

Figure 3. Highest holistic scoring map

The lowest scoring map from the traditional method is shown in Figure 4. This map is very different and would not be considered a typical concept map. There may have been some misunderstanding by the individual of what information a concept map is supposed to display. Rather than creating a map of related concepts to Entrepreneurial Mindset, "The 'Entrepreneur's Path,'" a chronological map of the process of creating a product to be sold, was created. This concept map has no levels of hierarchy and no cross-links. Each step of the map was counted as a single concept resulting in a traditional total score of 8. Even though this is not a true concept map, it can be seen that the participant fulfills the categories of comprehensiveness, organization, and correctness in reference to the Entrepreneurial Mindset to some degree. Therefore, the map receives some points. The map received a 2 in comprehensiveness from the 6 categories of comprehensiveness shown: Innovation/Creativity, Entrepreneurial Affect, Product Development, Customer and/or Stakeholders, Business Knowledge and Skills and Professional Knowledge and Skills. Organization was scored as a 1 due to the linear form. By viewing the connections as chronological the correctness score is a 2.5 due to the step "mitigate risk" which should have been placed earlier in the step pattern. This map was found to show a limited amount of knowledge of the entrepreneurial mindset.

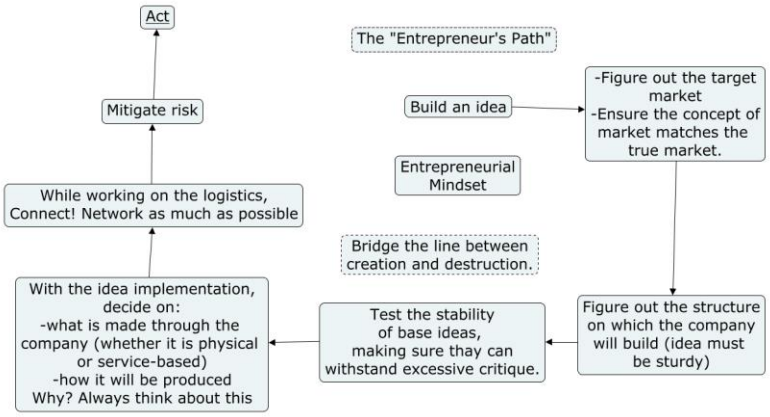

Figure 4. Lowest traditional scoring map

The lowest scoring concept map using the holistic method is shown in Figure 5, and had a score of 5. There are only two categories of comprehensiveness shown: Product Development and Professional Knowledge and Skills. The score for organization is a 1 due to the lack of feedback loops and no levels of hierarchy. However, the map was fully correct from its simplicity, therefore it received a score of 3 in correctness. When scored using the traditional method the map received an 8, also being one of the lowest scoring concept maps according to this scoring method. The map only contained three total concepts and lacked cross-links as well as levels of hierarchy which is what resulted in its low score. Overall, this map demonstrates very little knowledge of the entrepreneurial mindset.

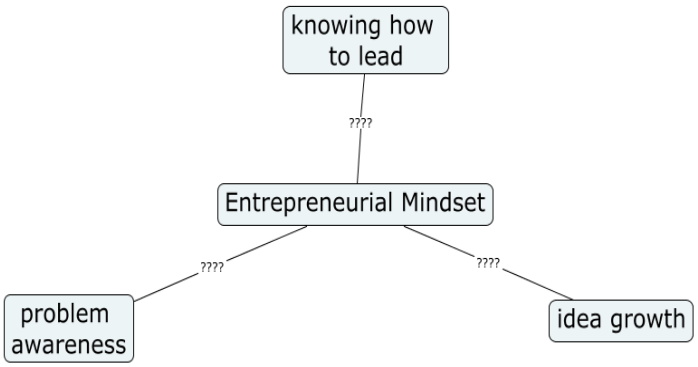

Figure 5. Lowest holistic scoring map

Research Question 1 Discussion

The traditional scoring method focuses on the quantity of information contained within the map itself and not necessarily the quality of these concepts [18]. This method places high importance on connections between concepts using cross-links. It places emphasis on the structure of a map and as such is an easy scoring method for completing in a short period of time. However, traditional scoring is known to be restrictive and can be shown by how the method does not have a grading aspect of correctness [18]. Cross-links are the simple connections that are interpreted by the participant from one concept to another. As a result of the cross-link's value, the placement of the concept map's scores are dependent on their placement. Any concept maps with four or more cross-links are within the top 10 scores. The connections could be wrong but the participant will still receive points. Also, if someone created a concept map with concepts that have no relationship to the central topic, the traditional method would still provide this map with points.

While the traditional scoring focuses on the quantity of total concepts, cross-links, and levels of hierarchy, holistic scoring is a method based on the judges' interpretations of the concept maps. Holistic scoring places equal importance on the three aspects of the concept map: comprehensiveness, organization, and correctness. The comprehensiveness is based on the amount of categories which the participant included in the map. A trend observed is that the maps that have a high comprehensiveness score also have a large amount of concepts, therefore giving it a higher traditional score. A similar grading component to the two methods is feedback loops and cross-links. The holistic method uses feedback loops rather than cross-links because feedback loops are specific to make connections between main branches rather than the simple cross-links that are only based on whether any two concepts are linked together. Cross-links and feedback loops are similar in that feedback loops often count as cross-links in the traditional scoring method. When a concept map has more cross-links, the traditional score increases, the structure of the map is no longer linear, and in return, the organization score for holistic scoring increases.

Rather than an ability to know and connect concepts that have a possibility to be wrong, the holistic scoring method is more in depth and focuses on whether a participant has knowledge and understanding of the entrepreneurial mindset. The holistic method needs time for discussion, especially for the comprehensiveness category to ensure inter-rater reliability between the raters. As there can be different interpretations of whether a concept should be considered within one singular category, such as Innovation/Creativity or Product Development. In summary, each scoring method has its own advantages and disadvantages. The holistic method is a better assessment method of how much knowledge a participant knows about entrepreneurial mindset specifically. The traditional method is a better assessment method of how well a participant can connect the concepts and topics associated with entrepreneurial mindset. It is really up to the individual and what claim they are planning on investigating to determine the most appropriate scoring method for their work.

Research Question 2: Do concept maps produced by engineering undergraduate students differ from those produced by business undergraduate students on the basis of either holistic or traditional concept map scoring methods?

Research Question 2 Results

The statistical results for the traditional scoring method of the concept maps can be found below in Table 2. The average score was found for the Number of Concepts (NC), the Highest Level of Hierarchy (HH), the Number of Cross-links (NCL), and the Total Scores for each discipline. Additionally, p-values were calculated based on a t-test and the Mann Whitney test, as well as the effect size using Hedge's g.

Table 2. Traditional Concept Map Scoring Results for Business and Engineering Undergraduate Students

	Discipline		p-Value		Effect Size
Rubric Category	Business (n=6)	Engineering (n=19)	t-test	Mann Whitney	Hedge's g
Concepts (NC)	15.67	17.16	0.525	0.514	0.217
Hierarchy (HH)	2.83	2.68	0.739	0.598	0.118
Cross-Links (NCL)	2.17	2.32	0.877	0.926	0.070
Total (see eqn. 1)	51.50	53.74	0.801	0.828	0.094

The results from the data showed no statistically significant differences between traditionally scored concepts maps made by business students and engineering students. Although the

Number of Concepts within the maps has the highest Hedge's g of 0.217, this value still demonstrates only a small effect size between the two groups [20]. Additionally, the Level of Hierarchy with an effect size of 0.118 and the Number of Cross-links with an effect size of 0.070 show that there is little difference between the business and engineering concept maps. This result has also been found in other studies of traditionally scored concept maps. For instance, in Besterfield-Sacre et al. [14], while studying concept maps created about "industrial engineering", they found most of their variables had no significant differences between them when analyzing engineering students' concepts maps using a traditional scoring system [21].

Table 3 includes results for the holistically scored concept maps between business and engineering students. The average score was found for Comprehensiveness, Organization, Correctness, and the Total scores for each discipline. Additionally, p-values were calculated based on a t-test and the Mann Whitney test, as well as the effect size using Hedge's g.

Table 3. Holistic Concept Map Scoring Results for Business and Engineering Undergraduate Students

	Discipline		p-Value		Effect Size
Rubric Category	Business (n=6)	Engineering (n=19)	t-test	Mann Whitney	Hedge's g
Comprehensiveness	1.42	1.79	0.064	0.059	1.037
Organization	1.83	1.89	0.855	0.926	0.082
Correctness	2.67	2.79	0.337	0.4	0.476
Total	5.92	6.47	0.201	0.138	0.651

Similarly to the results obtained from the traditional scoring method, there were no statistically significant differences in the holistically scored concept maps created by business students and engineering students. However, the effect size, determined by Hedge's g, varies greatly between scoring categories. In the Comprehensiveness sub-score a large effect size of 1.037 can be observed, while the total score exhibits only a medium effect size of 0.651. Although the data is not statistically significant, it shows a trend that engineering students tend to have higher concept map scores than business students, particularly in their comprehension of an Entrepreneurial Mindset. These results may indicate that engineering students have a slightly greater knowledge of the various categories that are integral to the definition of Entrepreneurial Mindset. In particular, one study did find that in their undergraduate career, engineering students would develop a greater understanding in entrepreneurial mindset factors. These factors included topics such as stakeholder identification, SWOT analysis and concept selection or the product or service, economies of scale, and product life cycle [22]. This was found when analyzing the

difference between senior and freshmen students in the “Becoming an Entrepreneur,” “Product Ideation and Development,” “Finance & Accounting,” and “Sales and Marketing” subject areas [22].

Additionally, the concepts used by students in their maps tended to vary between majors as shown in Table 4. These proportions were calculated by counting the number of students in each major who included the concept in their map, then dividing it by the total number of undergraduate students in the major who participated in the study.

Table 4. Proportion of Categories Used in the Concept Maps for the Undergraduate Students

Scoring Category	Engineering Students	Business Students
Innovation/Creativity	0.79	0.83
Entrepreneurial Affect	0.63	0.67
Product Development	0.68	0
Resources needed	0.37	0.33
Customer and/or Stakeholders	0.47	0.17
Value	0.21	0
Business Knowledge and Skills	0.63	0.5
Professional Knowledge and Skills	0.68	0.5
Technical Knowledge and Skills	0.11	0.17

Research Question 2 Discussion

For example, more than half of engineering students mentioned “Product Development” within their concept maps, while the business students did not mention the topic once in any of their concept maps. A possible explanation for this is the differences between an engineering student’s curriculum and that of a business major. Often, engineering curricula have a strong emphasis regarding the area of product development. Even when attempts are made to bridge the gap between engineering and business curricula, product development is typically forgotten or barely mentioned in business programs [23, 24]. However, further study will be necessary to gain clear results.

Two more areas that showed higher levels of proportional difference were in “Customer and/or Stakeholders” and “Value.” In both these areas, engineering students demonstrated greater recognition of these categories than business students, although both accreditation boards recognize the importance of these categories. Updated Accreditation Board for Engineering and Technology (ABET) standards require engineering institutions to have “an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering,

science, and mathematics," where complex engineering problems involve the knowledge of understanding and "involving diverse groups of stakeholders" [25]. The solutions must also "meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors" [25]. The Association to Advance Collegiate Schools of Business (AACSB) specifies institutions to cover three general requirements: general skills, general business knowledge, and technology agility [26]. Under technology agility, institutions must show that their students can demonstrate "higher-order cognitive skills to analyze an unstructured problem, formulate and develop a solution using appropriate technology, and effectively communicate the results to stakeholders" [26]. Ultimately, the accreditation standards allow the institution to develop degree programs that reflect the required competencies in the general areas, so levels of comprehensiveness for "Stakeholders" and "Value" have the ability to vary between institutions [26].

Unlike Product Development, Customer and/or Stakeholders, and Value, the other six categories within the Comprehensiveness sub-score system (Innovation/Creativity, Entrepreneurial Affect, Resources Needed, Business Knowledge and Skills, Professional Knowledge and Skills, Technical Knowledge and Skills) appeared in students' concept maps in similar proportions between engineering majors and business majors as shown in Table 4.

Overall, though not statistically significant, the data seems to show little difference between engineering undergraduate students' and business undergraduate students' concept maps about the entrepreneurial mindset whether using traditional or holistic scoring methods. However, the medium effect size for correctness scores seems to indicate that engineering students tend to have slightly greater understanding of how the concepts behind an Entrepreneurial Mindset connect than business students.

Limitations

The limitations associated with this study include small sample size and data collection limited to a single institution. Although we recruited broadly throughout both the colleges of business and engineering for the innovation event, only a total of 35 students attended the event and just 25 students consented to allow their concept maps to be included within this research study limiting the generalizability of these results. Despite these limitations, we believe that these results show some preliminary interesting findings that will provide value to the engineering innovation and entrepreneurship education fields.

Conclusion

The development of the entrepreneurial mindset in both engineering and business undergraduates is beneficial for their future career prospects. Entrepreneurial mindset can provide students with the necessary knowledge and skills that will help them in their professional careers including the ability to recognize opportunity, manage ambiguity, and persist through failure. To measure

undergraduate students' knowledge and perception of entrepreneurial mindset, a concept map study was performed at a mid-size Atlantic University. The maps were graded independently by researchers using both the holistic and traditional scoring methods.

When the grading methods were compared, a weak relationship existed between how the maps ranked in relation to their two scores. Lower scored maps were often close in how they ranked, but the side-by-side comparison showed that the traditional method's weighted system may have caused greater levels of variation as maps increased in complexity. Discounting correctness in concept and hierarchical connections may also have impacted results within this method. When comparing the different disciplines, engineers reflected a greater inclusion of the categories "Customers/Stakeholder," "Value," and "Product Development." In particular, no business students included "Product Development" concept within their maps. These observations could be linked to the courses offered at the university, prior student experience, or extracurricular activities offered on campus since they might expose engineering students to concepts associated with an entrepreneurial mindset more broadly in terms of the product development cycle. Although there was no statistical difference in the scores using either scoring method in our current sample, the averages do seem to indicate an interesting trend that warrants further investigation.

Acknowledgements
We would like to thank the Rowan University SEED Fund and the Kern Family Foundation through the KEEN Network for providing the funding for this study. The authors are very grateful for this support.

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