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# Assessing Entrepreneurial Mindset in Computer Science Students Using Concept Mapping

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# Assessing Entrepreneurial Mindset Using Concept Mapping in Computer Science Students


## Abstract

The purpose of this research is to improve computer science and engineering student's understanding of the entrepreneurial mindset and how it affects STEM undergraduates. Computer science and engineering students are often taught through theory and computations. Concept maps provide a creative approach to teaching and assessment that connects current education to real world topics. The research team created a module for three undergraduate computer science courses to build a concept map on how computer scientists and engineers create value. Eighty-six maps were evaluated using two methods: quantitative using standard concept mapping methods, qualitative using established rubrics. This paper reviews the data from the study to explore how concept maps are received by undergraduate computer science and engineering students. The results indicate that computer science students generated an average of 13 concepts and scored 2.15 out of a 3.00 on the standard rubric. This is well aligned with baseline data from the literature for other groups of undergraduate students.


## Introduction

Science, engineering, technology, and mathematics (STEM) undergraduate students beginning their college experience may not yet see the connection between their theoretical studies and their future careers. This paper explores the entrepreneurial mindset as the connection to a career frame of mind that undergraduate students may lack. Mitchell et al. describes entrepreneurial mindset (EM) in terms of its cognitive aspect as, "the knowledge structures that people use to make assessments, judgments, or decisions involving opportunity evaluation, venture creation, and growth" [1].

The purpose of this research is to improve computer science student's understanding of the entrepreneurial mindset and how it affects STEM undergraduate students. Through an activity presented in multiple computer science courses, students were exposed to the method of concept mapping as a way to develop metacognition. The activity goal was to improve their understanding of the entrepreneurial mindset and what that means to computer scientists and engineers. The main research question this poses is *how does concept mapping affect STEM students' understanding of entrepreneurial mindset?*

ABET Computing Criteria lists these three student outcomes:

1. Communicate effectively in a variety of professional contexts.
2. Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.
3. Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline. [2]

In order to implement these principles effectively, the research team integrated an activity that pushes undergraduates to think about the different aspects of an entrepreneurial mindset. Value creation is the conceptual method in which this was discussed by students through the interactivity of concept mapping. This paper in turn describes how concept mapping can help STEM students connect their theoretical learning to real world topics that can be implemented into their future professions.

# Background

Concept mapping as a method for metacognition has been implemented into classrooms for at least twenty years [3,4]. Combining the efforts of Martine et al. [5] and Ferguson et al. [6], Weber et al. [7] utilized both quantitative and qualitative methods to gauge the understanding of engineering students and their connection to the Entrepreneurial Mindset. As a continuation of this work, this paper involves both computer science and engineering students to connect their theoretical learning to that of their future careers.

**Table 1.** Similar Research Performed at Universities Involving STEM & Concept Mapping

| Author(s) | Year | Student Focus | Activity | Results |
|---|---|---|---|---|
| Chiou [8] | 2008 | Accounting | 124 students at the School of Management of a university in Taiwan were enrolled in an advanced accounting course and partook in a concept mapping activity meant to deepen their understanding of concepts in their course. | The students had their thoughts on course subjects clarified while also increasing their interest in their major. |
| Arhandi et al. [9] | 2023 | Computer Science | With a test approach, computer science students are placed into pre and post groups to determine the benefits of concept mapping. | Post test groups did perform higher than the pre test groups. |
| Weber et al. [7] | 2022 | Engineering | Engineering undergraduates were given a concept mapping module and post activity survey within their Statics course meant to enhance career value creation. | The students indicated that the activity is beneficial to their ability to reflect on their mindset and technical knowledge. |

| | | | | |
|---|---|---|---|---|
| Kaivola and Lokki [10] | 2010 | Computer Science | Concept mapping was used as a note taking tool for computer science students with a focus on their ability to find it useful. | The students preferred drawing the maps by hand or with Cmap tools. Although, the method of drawing out maps during class was too quick for lecture. |
| **Present work** | **2024** | **Computer Science** | Three undergraduate computer science courses are tasked to complete a concept map pertaining to the **entrepreneurial mindset** and the career value creation that stems from engineers and computer scientists in society. | Their scores aligned well with other studies of a similar nature representing that they understood the assignment and the effect of an entrepreneurial mindset. |

The table above expresses the different methods used to involve concept mapping in the curriculum of undergraduate education. Kaivola and Lokki [10] had the most diverse methods implementing note taking skills as opposed to the activity distribution technique. One common denominator is the desire to expose students to a variety of learning styles that fit their needs. This study produces a unique data set that measures computer science student's concepts around value creation and EM.

# Methods

The method of this study consisted of four stages: activity creation, software training, activity completion, and data analysis. Each stage was distributed across a period of time. Due to this timeline, certain stages were carried out by different members of the research group resulting in multiple papers explaining the different portions of the study. Figure 1 describes the process of creating and analyzing the different concept activities.

### Stage 1: Activity Creation

Before the students could be introduced to concept mapping or the topics that come with it, the research team needed to develop an activity that provided enough insight into the process of creating a successful concept map. The team came up with some criteria that the instructions should cover:

1. What does a concept map look like?
2. What is the topic of the concept map, and where should that be located?
3. Where does the map's information come from?
4. What are tips that encourage them to connect their ideas?

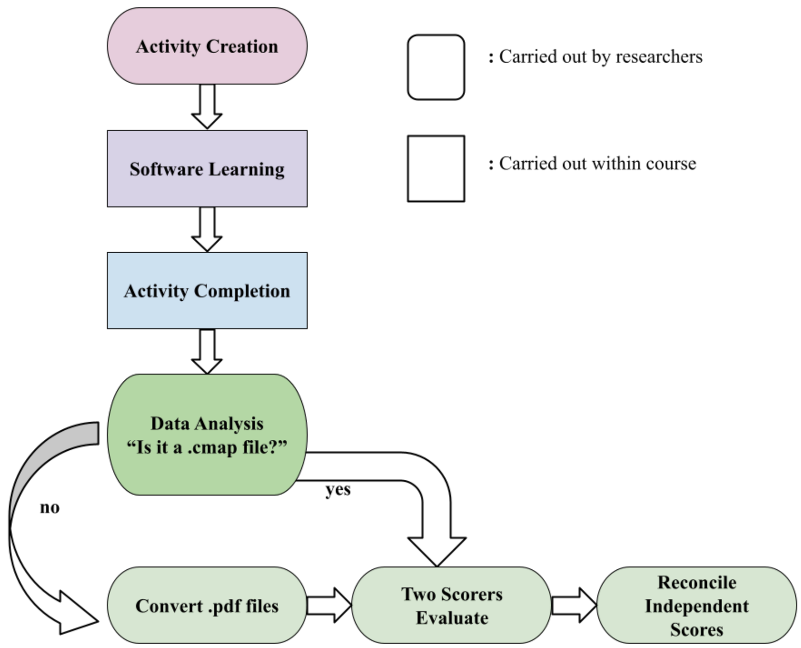


**Figure 1.** Methods Process for Each Course Section

Ultimately the answers to these questions were described as steps for the students to create a concept map. Question 3 for example, led to a note that some of their concepts could be related to work they have done through internships, prior classes, and information they researched. Another step that came from question 4 indicates that the students should be able to describe how the concepts are connected. Instructions specifically require that no connection includes a " ???? " as referenced in Figure 2.

## Stage 2-3: Software Training & Activity Completion

The next step in this process was to teach the students how to properly create a map with the software provided. CmapTools [11] is a free software that is used to create maps and file them according to their questions and topics. Video resources on how to use the software and additional steps were added to the activity creation stage.

The first time the activity was run in a course, the students were not required to use the CmapTools software. This led to many hand drawn maps and missing connecting works. After the first course offering the students were required to use the software, which increased the quality of the concept maps. For this study, the hand drawn maps were converted to CmapTools when possible.

Once the students understood the assignment and reviewed the activity instructions, they were allowed to create their own concept maps. Each map was completely unique to the individual student and had little to no input from instructors past the initial instructions phase.

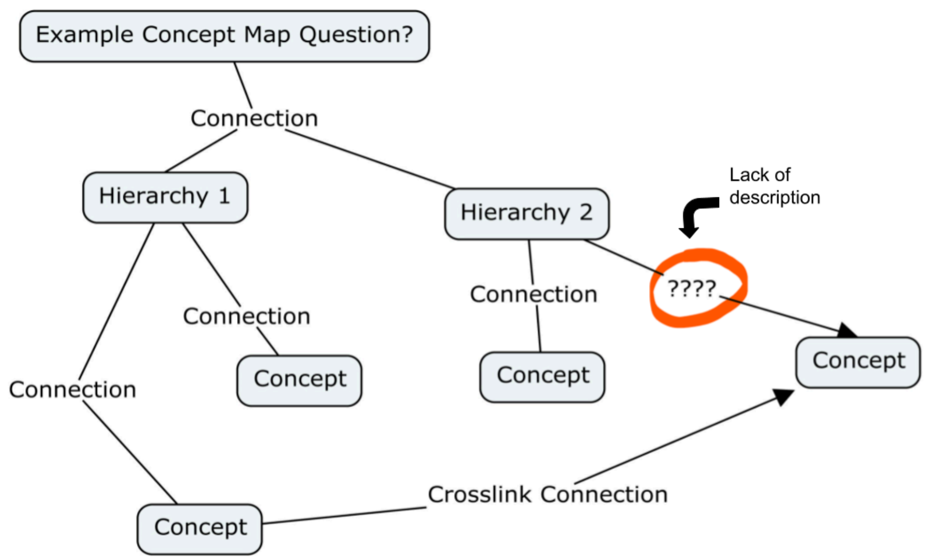


**Figure 2.** Example concept map showing what was considered hierarchies, concepts, and crosslinks.

### Stage 4: Data Analysis

After all files were converted exactly as written to concept map files, two independent scorers began analyzing each concept map under two sets of criteria: quantitative and qualitative. Both methods were conducted under the processes developed by M. Besterfield et. al. [12].

Quantitative scoring can either be graded by counting the components of the map, or by comparing the map to an “expert concept map”. For this analysis, the team counted components. This allows the maps to be described numerically without bias and later compared to other studies performed. The three components counted included the number of concepts (NC), the highest hierarchies (HH), and crosslinks (NCL). The number of concepts describes the general idea of how in depth the map may have gone. The highest hierarchies show how far one train of thought leads. And the number of crosslinks insinuates that the student is making connections between the different concepts and the kind of complex thinking that goes into the student’s thought process. Quantitative analysis provides a great connection to the next set of scoring qualitatively.

Qualitative scoring has most to do with the topics within a student’s map using a holistic rubric. The rubric covers three areas: comprehension, organization, and correctness. As the subject for this set of concept maps revolves around the bridge to entrepreneurial mindset, the comprehension score was based on the map’s ability to touch on a number of subjects. Some of these subjects included “Entrepreneurial Effect”, “Customer/Stakeholders”, “Professional Skills” etc,. [12]. The original scoring rubric includes half points. For our study, we decided not to include half points, this allowed for some overlap of scoring. With two scorers, all judgment for final scores was deliberated to allow for more objective data.

The next qualitative portion is the organization of the concept map. This score is directly related to how complex the map organization is. A map with a score of one follows a linear path and does not make crosslink connections or have intricate branches. Inversely, a map with a score of three for organization has multiple crosslink connections that branch along a myriad of concepts.

Deliberation of these scores concluded the process of the study. Each scorer had their own scores and notes on each concept map were discussed in  a session to deliberate on why maps were marked down and to come to an agreement on the final values. All scores for this study's concept maps were agreed upon by the team of researchers.

## Results

There are many studies in regards to concept mapping that could be compared to this research. However, the concept question the student's are asked: "How do engineers and computer scientists create value?", requires comparison to other studies that  focus on the entrepreneurial mindset. Table 2 provides a summary of the prior studies we compared our computer science student EM maps to. As shown, the prior studies had smaller sample sizes. The study at Rowan University used a slightly different EM prompt for the concept maps.

**Table 2.** Sample Size & Holistic Average Score Comparisons Between Studies

| Research | Weber et al. [4] | Rowan University [9] | This study |
|---|---|---|---|
| **Sample Size (# of maps examined)** | 9 | 19 | 86 |
| **Student Population** | Mechanical Engineering Students | Business Students | Computer Science Students |
| **Holistic Average Score** | 2.15 | 2.16 | 2.15 |

Figure 3 presents three different studies of a similar nature and compares the average scores for each holistic rubric item. Weber et al. was performed by the University of Washington-Tacoma prior to this study [4]. Rowan University also conducted similar research in the attempt to find the best methods for creating an entrepreneurial mindset concept map [9]. Our results had a standard deviation of 0.6 for "Comprehension", 0.8 for "Organization", and 0.6 for "Correctness".

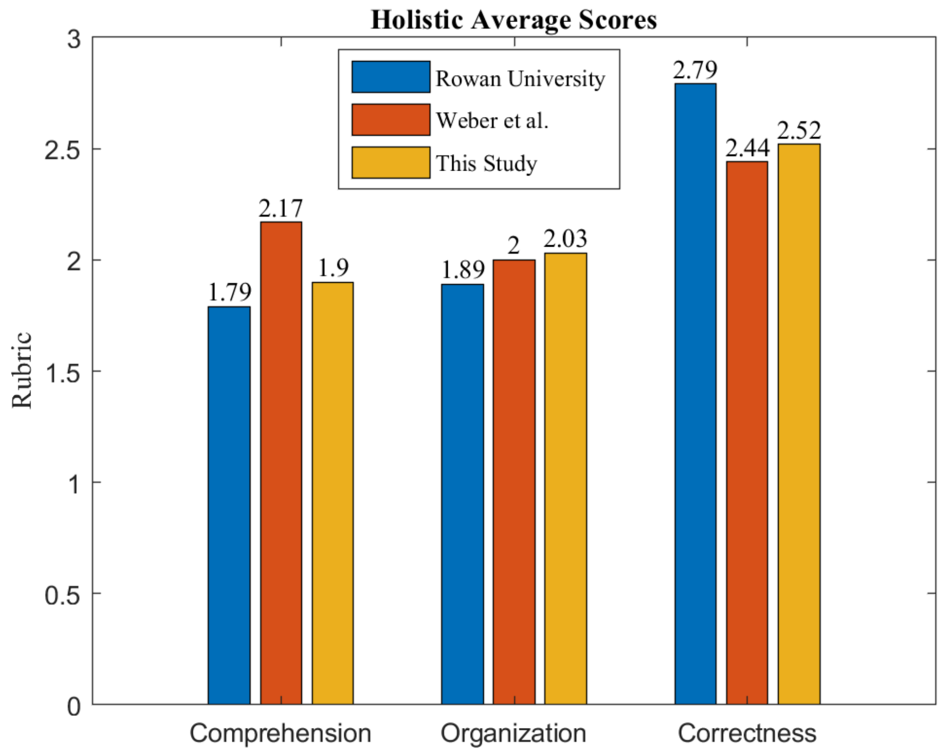


**Figure 3. Holistic Rubric Item Scores Compared Between Three Different Studies**

The 10% difference in "correctness" between the studies could be due to the sample size, the reviewer methods, or the student populations. In general, the student group scores for EM concept maps are similar.

Figure 4 compares the three studies including the numerical rubric scoring. This study found a lower number of concepts and slightly higher hierarchy in the student maps. An important note is the difference in sample sizes. Table 2 demonstrates that this study had at least a 77% larger sample size than the other studies. With three courses analyzed under the same conditions, this exhibits a more accurate average of possible scores for a similar experiment. Even with varying sample sizes, this table also shows that the average holistic score across all holistic categories is approximately the same under each study.

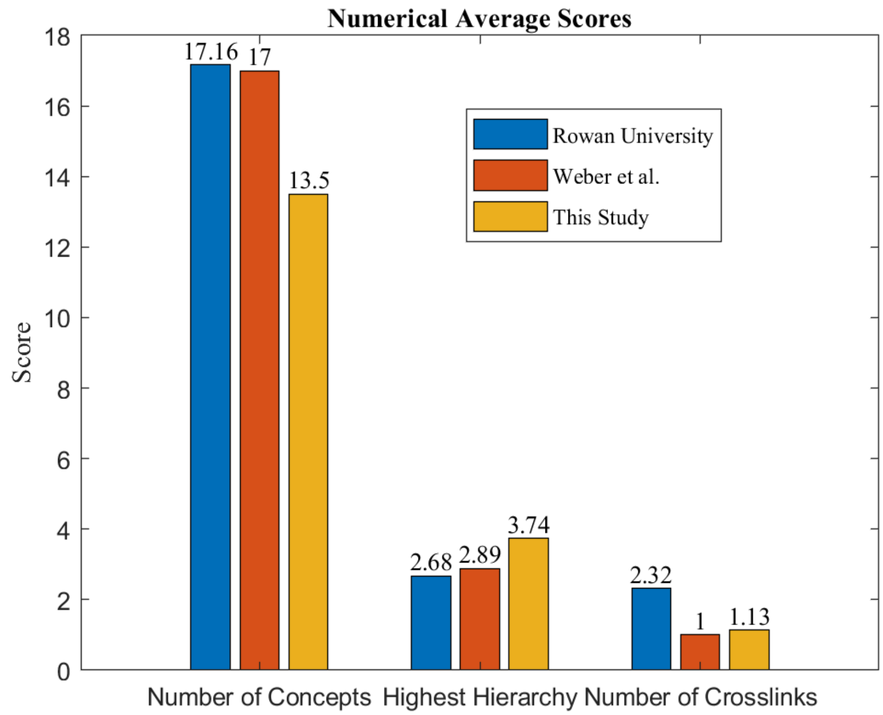


**Figure 4. Numerical Rubric Item Scores Compared Between Three Different Studies**

“Organization” also ranked higher for both in house studies than that of Rowan University. Researchers were not there to participate in the teaching of the modules, but there were specific instructions to connect multiple ideas. If performed correctly there should be some correlation between the number of crosslinks, number of concepts, and their organization score. Below Figure 4 displays a concept map that received a three out of three in all holistic categories. With three cross-links and seventeen concepts that touch eight out of the nine topics, the map met all of the qualifications for the team to score it accordingly. This is an example of a concept map that may have received a half point, but instead was discussed amongst researchers to determine the level of comprehension it indicates.

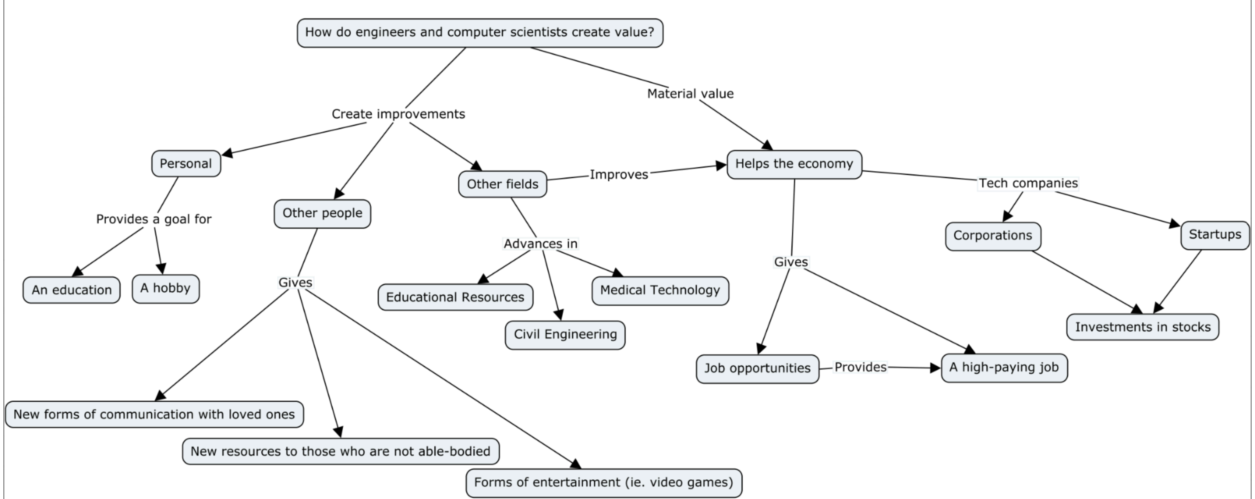


**Figure 5. Example Concept Map Scoring A 3 Across All Holistic Categories**

# Conclusions

With a thorough sample and analysis of results compared to other studies, this research indicates that the students completed and understood the objectives within the same capabilities as other university courses. Both Rowan University and the research from University of Washington-Tacoma's 2022 sample have smaller sample sizes but are still aligned with our current data. The research question, "How does concept mapping affect computer science student's understanding of the entrepreneurial mindset?", is then addressed in part. Concept mapping is an effective tool in helping undergraduate's connect their academic understanding with that of their future professions.

Although the scores were promising, room for improvement could be addressed in a multitude of ways. One of the factors that possibly increased the organizational score for this sample was the additional step indicating that the students should consider connecting multiple ideas. The importance of crosslinks could be made even clearer with more examples of in-depth concept maps. Another addition to future in-class activities would be to provide resources or a pre-assignment activity that gives more insight into what entrepreneurial mindset is. This could then broaden the scope of how impactful the computer scientists and engineers are on society. Comprehension questions are better answered when the motivation behind the research is understood. If a specific set of resources is provided to the professors to help in their understanding of the research, they are in turn equipped for the execution of relaying instructions.

Asking students to reflect about how their profession creates value allows them to explore important aspects of the entrepreneurial mindset. For future studies we plan to revisit the concept mapping activity after the students have been exposed to EM activities. Changes in the concept maps over time will help us understand the best ways to help students explore EM further.

## Acknowledgements

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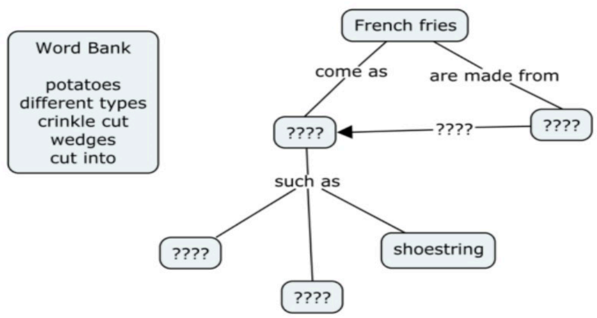
# Appendix A

## Concept Mapping Activity

***Objective:*** *Organize your knowledge of statics using a concept map.*

1. Consider the example concept map for the topic "french fries" below. A concept map is an organizational tool for communicating your knowledge about a particular topic. The structure of a concept map mimics the way neuroscientists think that your brain organizes and stores information, which makes them good learning tools. Take a minute to put the words in the word bank into the blanks in the concept map.




*"Picture your brain forming new connections as you meet the challenge and learn. Keep on going."*
*— Carol Dweck, Mindset: The New Psychology of Success*

2. For this assignment, you will complete a concept mapping exercise to help you organize your knowledge of statics. Each box is a topic in statics, and each line is a way the topics are connected. The lines are labeled with ways in which the topics connect. Typical line labels include subset, application, and methods.

4. Start to arrange your brainstormed concepts in a way that makes sense to you, with closely related terms being placed close together. You can keep adding new concepts.

5. Draw lines between the concepts that you consider to be related. At least one concept should be linked to "**Entrepreneurial Mindset**". Continue to create branches until each concept is connected to at least one other concept.

6. Label each line between concepts with the nature of the relationship between the terms (e.g., French fries "are made from" potatoes). Labels should be words or phrases.

7. Review the map and add additional concepts (if you can think of any) with labeled linking lines. Review the map and look for cross-links which link together different areas of your map. Add new linking lines with descriptions (e.g., potatoes "cut into" different types).

**Deliverable:** Upload a PDF or cmap file of your complete concept map. Use your code name as the filename.

**Evaluation**:

- Your map will be graded based on the correctness of your map and your application of the cmap software tool. No "???" should appear in your final map.
- Upload your cmap file to Canvas. The file name should be YOUR CODE NAME.cmap where your code name is: middle initial + number for your birth month + first two letters of your birth city. For example, M for Marie, 03 for March, IN for Indianapolis becomes M03IN.