The Impact of Concept Map Development on Student Synthesis of Course Information

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Abstract

Concept maps are a pedagogical tool that encourages students to recognize and develop links between what may appear to be disparate ideas. Identifying these connections encourages a higher cognitive understanding and greater synthesis of broader ideas, both within a course and across multiple courses. In an attempt to reduce concerns about a comprehensive final, and demonstrate the interconnectedness of topics, concept map activities were integrated into a junior level geotechnical engineering course. This paper will provide background on the course and a description of the assignments, activities, and resources used. Results and assessment will be presented, including multiple methods of evaluation such as quantitative and qualitative analysis of generated concept maps, and student survey results regarding the value and impact of the activity. The future direction of the project will also be included.

Keywords

Concept maps, reflection, scaffolding

Introduction

Concept maps are an organizational tool used to represent relationships between multiple concepts. The value lies not only in the identification of key concepts but also in the expectation that connections and relationships are also acknowledged. Asking students to develop these concept maps aligns with Ausubel's assimilation theory of cognitive learning[1] and constructivist learning principles[2-4]. Previous studies have integrated concept maps into the learning environment and used these maps as a means of assessing conceptual understanding and learning gains[5-10]. The work presented in this paper seeks to complement previous work as well as supplement results with the student perception of the assigned tasks.

Course Background

The geotechnical engineering course at Florida Gulf Coast University (FGCU) is a 3-credit course required of all Civil Engineering majors. The course is taught in the spring semester of the junior year, with a required follow-on course taught in the fall of the senior year. The course meets three times a week for 85 minutes each time and combines both lecture and lab within this timeframe. Course grading is 40% quizzes, 30% labs, and 30% for the cumulative final. Assessment includes five quizzes, roughly 1 every 3 weeks, with the lowest score dropped. Labs consist of roughly a dozen activities (varies by year) and includes group lab reports, table discussion summaries, and an individual lab portfolio. From a grading perspective, concept map activities were included in both table discussion and individual lab portfolio assignments.

Assignments and Activities

Concept map activities were integrated into the course in multiple formats. Prior to each of the five quizzes, 10-15 minutes of a class was dedicated to performing a think-pair-share activity. Students were given 2 minutes to individually list the key concepts they believed were important on the quiz. They were then given 5 minutes to compare these lists and generate a “table” list which was compiled on the white board for each group. As a class, the various table lists were analyzed and the resulting summary of key concepts posted on the Canvas (course LMS) page for student reference.

Prior to the first think-pair-share activity, students received and introduction to concept maps and their purpose and were informed they would be developing their own concept map with the previous lists as their starting point. This introduction discussed the purpose of concept maps in general, the reason behind concept map integration into the course, and a brief process for concept map generation. In addition to this introduction in class, the course Canvas page also contained resources on concept map generation and use. These resources included a paper by Novak and Cañas[11] discussing concept maps, as well as two brief YouTube videos[12, 13] the author felt were focused, informative, and relatively engaging. Both the article and videos mention computer programs that can be used for concept map generation. As the development was an out of class activity, some students chose to take advantage of the software option, while others opted to create their maps by hand.

For this particular class, a set color scheme was required with key concepts in black, student developed connections in blue, additional key ideas from this class or others in green and related personal ideas (e.g. from work, internships, etc.) in red. Students were required to submit their individual concept map prior to the final class period. During the last day of class, students brought a copy of their concept map and were assigned to a small group. These small groups compared concept maps and discussed course topics and students received additional colors to augment their current concept maps based on these discussions. Students were required to submit an electronic copy of their revised concept map but were also able to keep a copy to use when studying for the final exam.

Survey and Assessment Results

The effectiveness of the activities has currently undergone three means of evaluation. First, the initial concept maps were evaluated based on the number of hierarchies, branches, and cross-links including quantitative counts of the various items as well as qualitative comparisons of items beyond those initially provided (e.g. connection terms, additional key ideas, related course topics, and personal topics). Second, the revised concept maps underwent the same evaluation, as well as comparisons between initial and revised versions of the maps to determine the increase in complexity of the concept maps. An analysis of whether or not the complexity of the connections increased relative to the complexity of the topics was the primary focus of this comparison. Third, students were given a brief survey regarding their impression of the value and impact of the concept map activities on their preparedness for the final exam. Results of these surveys serve as the third means of evaluation.

Quantitative and Qualitative Analysis of Initial Concept Maps

A sub-group (n=9) of the complete class (n=40 [3 students did not complete the activity however]) was selected that is considered a representative population. This group represents 24% of the class who completed the activity, and includes 3 students from the upper quartile, 3 from the lower quartile and 3 from the mid-range section of the course. The overall course average for the sub-population is within 0.1% of the overall course average for the entire class. Table 1 summarizes the results of quantitative analysis in four different areas including overall number of concepts, longest chain of concepts, number of labeled connections, and number of main branches off the initial concept.

Table 1: Summary of quantitative analysis for nine concept maps from the course

Topic Area	CM1	CM2	CM3	CM4	CM5	CM6	CM7	CM8	CM9
# of concepts	174	280	163	127	110	73	74	269	98
Longest chain	9	11	8	4	5	6	4	10	5
# of labeled connections	0	186	0	63	0	0	0	155	0
# of main branches	5	8	4	8	5	8	5	5	5

In addition to quantitative differences, the analyzed concept maps had notable qualitative similarities and differences. From a similarity standpoint, all concept maps used a majority of the class generated key terms and made at least some attempt at incorporating additional terms or concepts. From a layout standpoint, maps fell into one of two categories – hierarchical or hub and spoke. Figure 1 illustrates the difference in appearance of these two layouts. From the sub-group selected, CM1 & 2 utilized the hierarchical approach, while the remaining students employed the hub and spoke approach. While these can be differentiated visually, ultimately the choice of approach is more a personal preference as complexity and connectedness differences did not increase with the use of one method over the other.

Qualitative differences fell into two categories. First was what could be considered cross-connections. While all nine concept maps included a number of connections between ideas, stronger maps included connections across different modules on a more extensive basis. These cross-connections demonstrated a greater awareness of relationships between concepts covered in earlier course modules with later course topics. Since many of the application concepts at the end of the course build upon soil properties and characteristics introduces at the start of class, these connections should not be surprising. Since quizzes are not explicitly comprehensive however, students often compartmentalize these ideas – relegating early concepts to previous modules rather than maintaining the connections recognized in the more complex concept maps.

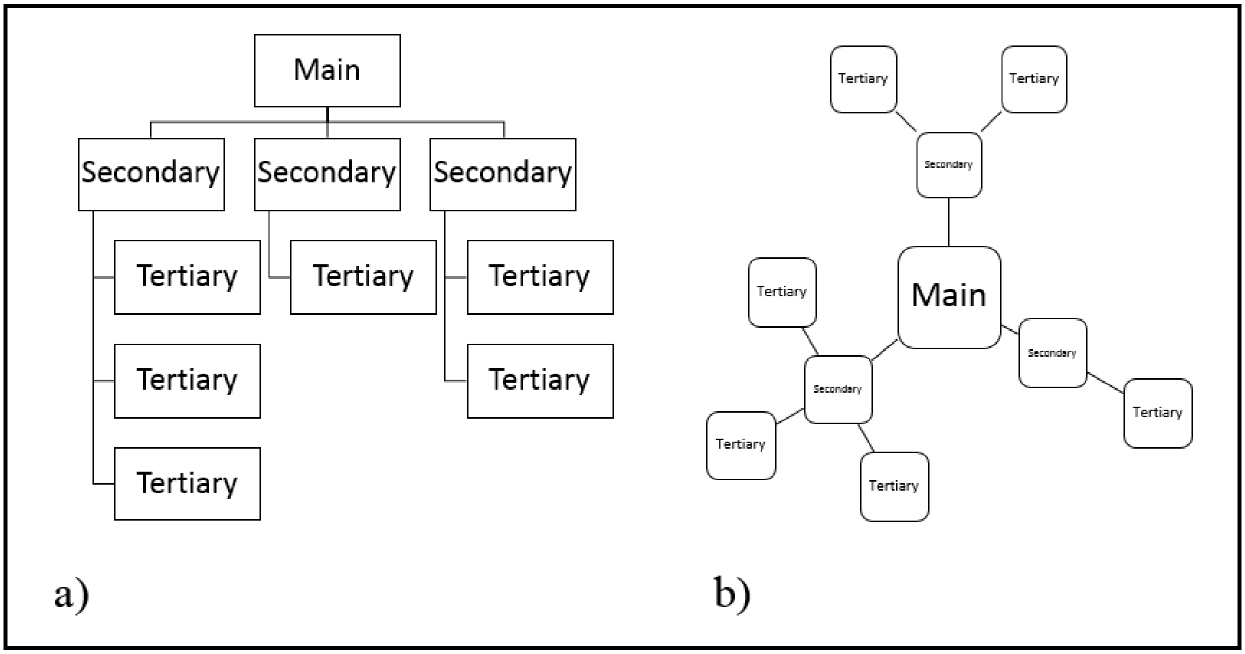

Figure 1: General layout of an a) hierarchical and b) hub and spoke concept map

The second dominant qualitative difference was the inclusion of personal ideas. These inclusions related less to the complexity of maps and more to a key characteristic of the students. Those students who held (current or previous) engineering related jobs or internships were more likely to include personal ideas. While some of these ideas were related to their work experiences, concept maps that included these ideas were also more likely to include connections to concepts and ideas in other courses. Conversely, students who had little to no engineering related external work experience were less likely to include any personal ideas – even though these students were enrolled in the same classes and exposed to the same classwork and ideas mentioned by the other students. The difference is suggestive of the importance alternative learning experiences have on bridging "silo-ed" learning experiences encountered in much of traditional classroom learning.

<u>Quantitative and Qualitative Analysis of Revised Concept Maps</u>

This assessment did not yield significantly different results from the initial concept map results. Due to the overly complex nature of the initial concept maps, the majority of revised maps contained relatively few additions and modifications. On the final day of class students were asked to group themselves with individuals with whom they typically did not interact and discuss their concept maps. Changes to their concept maps were made in orange with additions to their concept maps in purple. Revised concept maps were submitted at the end of the class. For the subset of concept maps presented above the number of changes / additions varied from 1 – 64 (specific values in ascending order = 1, 1, 8, 10, 11, 16, 25, 27, 64) with an average of 18 per individual. The addition of 64 was to CM5, one of the more moderate from above, and included primarily an additional layer of concept details throughout the map. The majority of the other maps focused on identifying additional connections and cross-links between topics rather than additional concepts. While students seemed to appreciate the time for discussion with others about their concept maps, the act of revising their concept map was considered by them not to be as valuable.

Student Survey Results

Thirty-one students (31/37 = ~84%) elected to complete the anonymous survey which was given on the last day of class. The survey included six open ended questions as well as a Likert scale ranking of self-assessed competency of all course learning objectives. Table 2 presents a summary of the open ended questions. Results of half of these (questions 1, 2, and 6) will be presented here. Results of the Likert scale responses are outside the scope of this paper.

Table 2: Open-ended Survey Questions Related to Concept Map Activities

Number	Question
1	What do you think is the single most significant benefit of creating a concept map for this course? Why?
2	What do you think is the single biggest limitation (or detriment) of creating a concept map for this course? Why?
3	While we developed a list of key concepts prior to each quiz, we only created a concept map using these lists at the end of the semester. Do you believe creating a concept map prior to each quiz would assist you in studying for the quizzes? Why or why not.
4	How do you think you might use your concept map to help you study for the final? How helpful (or not) do you think it might be and why?
5	What suggestions do you have to make this activity more effective?
6	I would like you to think on the concept map activity and list the first 5 things that come to your mind with regards to this activity.

Single Most Significant Benefit of Creating Concept Maps

Three themes resulted from this question. The first was that the activity was effective for review. Survey responses included benefits when reviewing for quizzes as well as the final and providing a review of what needed to be studied or what the focus of studying should be upon. The second theme was that of organization. Students recognized that concept maps were a method to organize their thoughts. Connecting everything was the final benefit mentioned by students. This included mention of helping tie everything together, linking ideas from day one to the last day, providing an overview of the course and demonstrating how everything in the course related and was connected.

Single Biggest Limitation (or Detriment) of Creating a Concept Map

A single theme of complexity emerged from this question. Details on this complexity included everything from comments on the number of terms, the number of links / connections, space limitations for topic coverage, the realization that the activity could continue indefinitely, challenges with program utilization, and the fact that something this complex equated to something very time consuming.

The First Five Things That Come to Mind with Regards to Concept Map Activity

When asked this question 74% of the students included terms that would be considered to be related to the concept map activity itself. The remaining students either elected to leave the question blank or included terms that would be classified as more relevant to the overall class rather than specifically to the concept map activity. Of the terms provided, 101 were categorized as relating to the concept map activity. Forty-eight were considered to be positive terms, while fifty-three were classified as negative terms. The most common positive terms were helpful and organization, while the most common negative term was time consuming. Overall time consuming was the term included most often, with 15 instances of time (e.g. time consuming, waste of time, tedious) being included in the list.

Conclusion and Future Direction of Project

Overall the initial implementation of concept maps in the course was effective. The concept maps developed by students, most if not all of which had never previously completed an activity of this sort, showed many of the connections between course topics and provided a visual summary of the course complexity. The main concern is that a complete concept map for the entire course is probably not the best approach. Almost universally students commented on the excessive complexity (and associated logistical difficulties) of a single concept map. While one of the author's goals was to demonstrate the complex interconnectedness of the topics across the course, even the author began to see the reduced value when connections were physically difficult to identify / follow. Based on discussions with students and survey feedback, the following changes are under consideration for the next cycle of the assignment:

- Create separate concept maps for each module
- Create concept maps for select lessons where relations to previous lessons are most critical
- Assign concept map activities based on topics where weak performance on initial quizzes is demonstrated to strengthen understanding for future exams
- Assign small groups of individuals to create smaller concept maps and then use class to identify connections between these maps
- Create concept map with a focus on relating the course in general to other courses and / or student experiences

Integration of all of these changes into the next cycle is neither feasible nor desired. From a course-focused perspective, one of the first four would be the most logical. On a more holistic basis, the implementation of the last idea has the strongest merit. While this may not result in stronger student performance on the course final exam, it could begin to demonstrate how geotechnical engineering ties into other civil engineering sub-disciplines. For students committed to an alternate sub-discipline, this recognition could help in comprehending the value of the course topics as linked to their primary interest area. Additionally, all students are required to take the second geotechnical engineering course. Since this design-based course heavily links geotechnical engineering to the other sub-disciplines, earlier exposure to these relationships may correlate with a more ready acceptance to the complexity inherent in design.

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