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Work in Progress: Evaluation of the Concept Mapping in a Student-Centered Biomaterials Course

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Introduction

Concept mapping is a reflective technique used for teaching practices in science and engineering classrooms. It requires students, either individually or part of a team, to create an intellectual framework that shows major ideas and emphasizes their interrelatedness[1-7]. More specifically, concept maps enable students to internalize the information they have learned, identify the key concepts, and document relationships between these key concepts by drawing physical connections between them[1, 2, 5]. Through concept mapping, the focus of the classroom shifts from traditional lecture to an active learning environment[2, 7]. Concept maps encourage students to be conscious of their learning style[2, 7] and to determine which aspects of the material are difficult for them[1-3]. Further, concept mapping has shown to be effective in increasing student engagement and learning in many studies[1, 2, 3, 6] as well as lead to more efficient use of classroom time by more clearly understanding topics students need to be clarified[7]. This work evaluates various facets of evidence-based concept mapping in a junior-level Biomaterials course.

In this study, the student-centered class begins with a Muddiest Points exercise. Muddiest Points are unclear concepts that students identify which are then reviewed at the beginning the next class[8-10]. While Muddiest Points session is not required of a student-centered classroom, it allows students the opportunity to ask questions regarding course material, homework assignments, or relevant terminology. For this study, the Muddiest Points session is followed by a concept mapping session of the previous class' material (including material revisited in Muddiest Points) and a mini-lecture enhanced with Clicker questions. During the concept mapping session, students work in groups created by CATME (Comprehensive Assessment of Team-Member Effectiveness) which groups students based on desired team attributes. For each homework assignment, each group creates concept maps about the related content, using a free software package, CMap (Concept Map) or MindMup. Students then evaluate their group members using CATME's peer evaluation capability. The result of this peer evaluation contributes to the students' homework score in the final course grade.

More specifically, this pilot study evaluates the use of concept maps in a junior-level, student-centered Biomaterials course in terms of achievement, attitude, and persistence. As demonstrated by others[1-4, 6], by using concept maps as a learning strategy, instructors are giving students the opportunity to improve their critical thinking skills, to visualize the complex relationships between concepts, and to personalize their learning; however, further research is need to prove the benefits of concept mapping[6, 7], especially in the Biomaterials setting.

Methods

Concept Map, Grade, and Attitudinal Survey Data Collection

In this pilot study, students were grouped and tasked with creating a concept map of key concepts and their relationships for three chapters of course material. The maps were collected

before the third midterm exam and students were then incentivized to take the "Student Value of Concept Mapping Survey" to determine the interest, success, and cost associated with the creation of the concept map (IRB STUDY00003563). The maps were scored as explained below and the map scores were compared to the survey results and final course grades.

Assessment of concept mapping in the Biomaterials course focuses on three areas: achievement, attitude, and persistence. The achievement is measured indirectly by the academic performance (final course grades). Attitude is tracked with a custom survey based on the previously validated survey "Student Value of Muddiest Points Survey"[8, 9] based on motivation theory. More specifically, students provide feedback on the interest, success, and cost associated with concept maps. Each survey item ranges from 1 – strongly disagree to 4 – strongly agree. Last, persistence is measured by students enrolled on the 21st day of class who take the final exam.

Concept Map Scoring

A traditional scoring method[7] is used in this pilot study to score the students' concept maps, as done in previous concept map studies[2, 6, 7]. First, each map receives one point for each proposition, each circled concept on the map. This aspect captures the map's completeness and comprehensiveness. Second, each map receives five points for each hierarchy level. To obtain these points, more general concepts need to be placed above more specific concepts. Third, ten points are awarded if connections are drawn between different branches of the concept map. These points show that students are able to think deeply about how aspects of the course material relate to other parts. Last, one point is given if examples are provided. Figure 1 highlights an example of the selected scoring method.
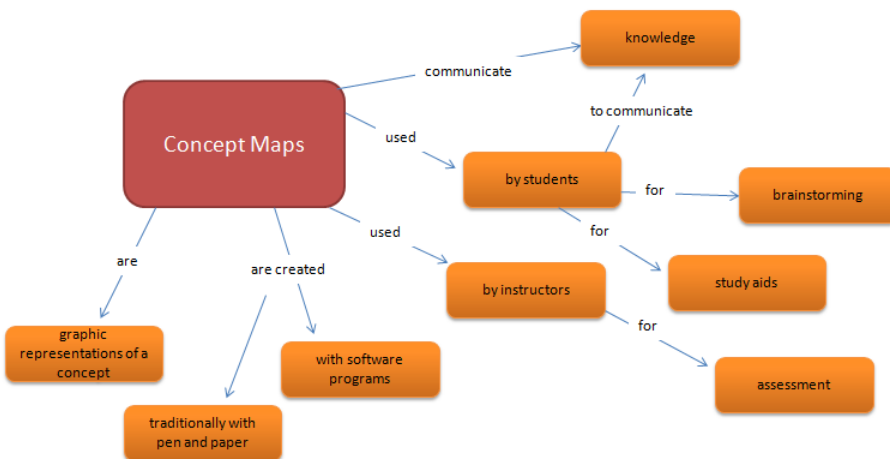

Figure 1. Example of a scored concept map. Because 10 propositions are present, 10 points are earned. Because each branch contains at most 2 levels of hierarchy, 10 points are awarded. One crosslink is drawn, adding 10 points to the final score. Last, no examples are present. The total score for this map is 30 points[7].

Results

The average concept map score was found to be 322 ± 76 points. The "Student Value of Concept Mapping Survey" results were grouped into three categories: interest or attainment value, cost,

and success. Overall, the pilot study (n=48) showed that 32% of students found interest or attainment in the concept map assignment, 54% thought there was a cost to completing the assignment, and 37% percent thought it would help them be successful.

The class persistence was calculated to be 98% and average final course grade for participants was 82%. No correlation was found between the concept map scores and their final course grades (0.1731).

Discussion

For the purposes of the pilot study, the widely used scoring method was used[1, 2, 6]; however, a scoring method more specific to the classroom completing the concept maps could be established[5, 7]. A particular limitation of this scoring method is the subjective assessment of the validity of the examples and crosslinks present in the maps. As has been identified in previous works[7, 11], it is difficult to determine who is "qualified" to determine appropriate examples or crosslinks. There are suggestions that this scorer needs to be an expert in the field to ensure valid examples and crosslinks[7, 11]; however, in certain cases, especially large classes, this may not be feasible. In this study, a former student scored the concept maps.

As mentioned above, implementation of concept mapping as a team-based, in-class and homework activity was assessed in terms of persistence, achievement, and attitude. Persistence and achievement were high throughout the class; however, student attitude as assessed by the three categories of the "Student Value of Concept Mapping Survey" yielded relatively low interest and success values at high cost. To improve implementation of this exercise, several changes were made in the following semester and evaluation of these changes is ongoing. More specifically, the students currently complete the entire concept map assignment in class instead of as homework. It is predicted that students believe concept mapping will be less of a cost to them if a majority of the assignment is completed in class relative to homework. In addition, with the new method of allowing students time to work on the maps in class, the overall course material is reduced and more time is spent synthesizing the material through concept maps. This could lead to greater understanding and increased long-term recall in the future which will be measured by exam grades.

No correlation was found between concept map scores and final course grades. Previous studies have found evidence that in challenging classes, achievement and attitude do not correlate[11-13]. Achievement was measured indirectly with final course grades. In future studies, exam scores will be analyzed as a direct assessment of the course material that was mapped instead of the current strategy of the final course grade which includes participation and homework scores. With the removal of these extraneous, confounding variables, it is possible a stronger correlation between academic achievement (exam scores) and concept map scores will exist, indicating more complete understanding of course material.

Overall, this work studied the achievement, attitude, and persistence with regards to concept maps in a junior-level Biomaterials class. More evidence is needed to support the positive effects of concept mapping and determine the best implementation method.

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