

Student Perceptions of Concept Mapping in a Foundational Undergraduate Engineering Course

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Introduction

Engineering dynamics is a foundational undergraduate engineering course that nearly all students in mechanical, aerospace, civil, biological, and biomedical engineering programs are required to take. Covering numerous fundamental concepts such as motion, force, work, energy, impulse, momentum, and vibration, this course is widely regarded by many students as one of the most difficult undergraduate engineering courses^{1,2}.

To enhance student conceptual understanding in engineering dynamics, a variety of educational interventions, such as computer simulations, computer animations, and video games, have been developed and implemented in the classroom^{3,4}. Among these interventions, concept mapping receives growing attention in recent years, as it serves as an effective tool for knowledge visualization, organization, representation, and elicitation⁵. A significant amount of evidence has shown that concept mapping improves student learning in many academic disciplines⁶⁻¹¹. In a concept map, concepts are arranged in either hierarchical or network form, with labeled nodes in circles or boxes denoting concepts. The linking words and phrases specify relationships among concepts. Two or more concepts are connected by linking words/phrases to form a proposition¹².

The present study was funded by an NSF TUES-Type 1 program. An important goal of the project is to use concept mapping to improve student understanding of the relationships among different concepts in engineering dynamics. This executive summary reports student perceptions about their concept mapping experiences. Innovations of the present study are described, followed by a description of research methods, data collection, example concept maps generated by students, and student perceptions of concept mapping. Discussions and conclusions are made at the end of this executive summary.

Note that this paper is about student perceptions of concept mapping. The evaluation of concept mapping via a before-after survey and control and case groups is beyond the scope of this paper and will be discussed in a future separate paper.

Innovations of the present study

The present study is innovative in two aspects. First, students themselves, rather than the instructor, construct concept maps. In traditional educational practices, the instructor develops concept maps for students and then shows and explains his/her concept maps to students¹³⁻¹⁵. This is still passive learning by watching and listening, rather than active learning by doing.

Second, the present study reports both positive and negative student comments, helping the engineering education community develop a better understanding of the strengths and limitations of concept mapping. The vast majority of current literature reports positive student comments about concept mapping. For example, it is reported that “[A concept map] helps show how all

those formulas and concepts are related, which helps me to understand new ones based on old ones I'm already comfortable with.”¹⁵ Even though students are diverse in many aspects such as in learning styles and cognitive skills, negative student comments about concept mapping, or why some students do not like concept mapping, are rarely reported in the literature.

Research method and data collection

The present study involved 71 undergraduate students who took an engineering dynamics course during a recent 16-week semester. The instructor of the course is the author of this executive summary. The 71 students (64 males and 7 females) were from the Department of Mechanical and Aerospace Engineering (34 students), Department of Civil and Environmental Engineering (21 students), Department of Biological Engineering (11 students), and other departments (5 students). Throughout the semester, students learned eight learning topics (in the form of eight textbook chapters) covering kinematics of a particle (1 chapter), kinetics of a particle (3 chapters), kinematics of a rigid body (1 chapter), and kinetics of a rigid body (3 chapters).

Throughout the semester, each student used a free and user-friendly IHMC Cmap Tool¹⁶ to construct a concept map for each textbook chapter after completing the chapter. The IHMC Cmap Tool allows students to easily move a concept from one place to another and edit the entire concept map. Students submitted their concept maps to the instructor. At the end of the semester, students responded to a questionnaire survey describing their experiences. Content analysis was performed to analyze student comments. The analysis involved coding, or categorizing, the collected data and then counting the frequency of a particular code.

Example concept maps generated by students

Figures 1 and 2 provide the excerpts of two example concept maps generated by two students. Although both maps focus on the same concepts of impulse and momentum, the two students organized their maps in different ways. In Fig. 1, the student shows the relationship among different concepts, for example, how the Principle of Linear Impulse and Momentum is related with the Conservation of Linear Momentum. In Fig. 2, the student shows the difference between impulse and momentum. Both students included many mathematical equations on their maps.

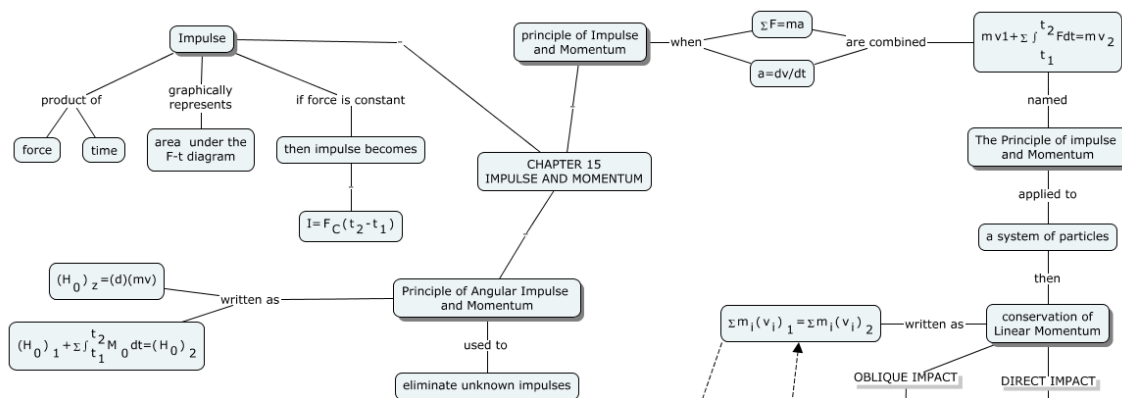


Figure 1. A student-generated concept map example 1

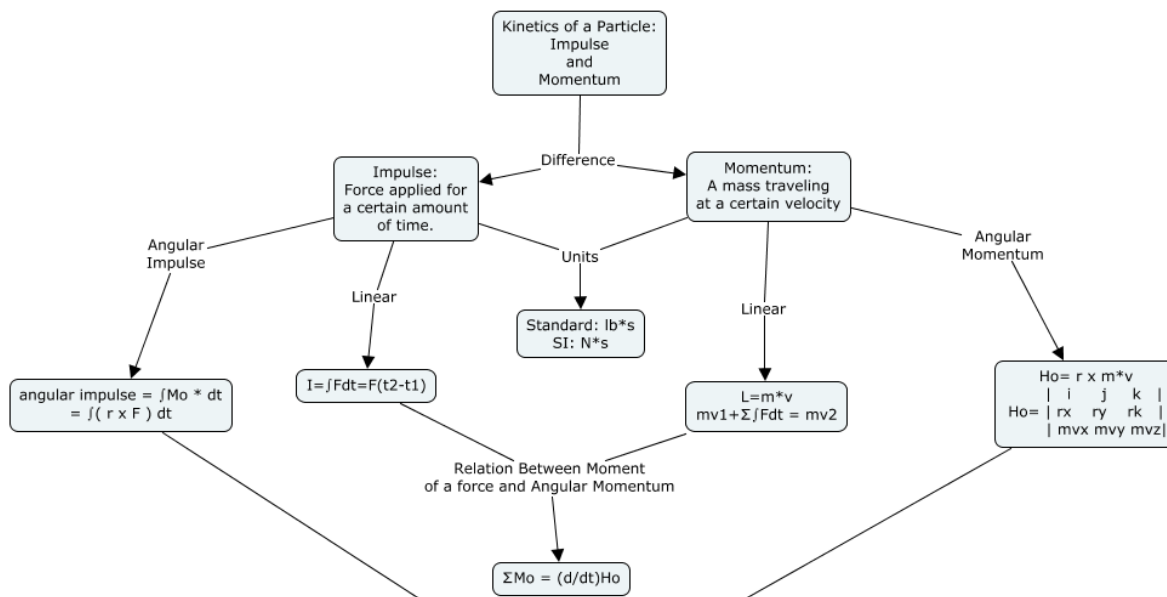


Figure 2. A student-generated concept map example 2

Student perceptions of concept mapping

Tables 1 and 2 summarize student perceptions based on their semester-long experiences. Based on the frequency of a particular code (category), the top four reasons students liked concept mapping (see Table 1) are 1) concept maps helped students make connections/links/ties among concepts (frequency: 32); 2) concept maps helped students review what students had learned (frequency: 23); 3) concept maps helped students visualize concepts (frequency: 14); and 4) concept maps helped understand concepts (frequency: 10). Students also indicated four reasons they disliked concept mapping (see Table 2). The top two reasons are 1) concept mapping was busy work (frequency: 9) and 2) concept maps did not help understand concepts (frequency: 6).

Discussions and conclusions

Based on the results shown in Tables 1 and 2, overall, student perceptions about concept mapping are highly positive. The total frequency of positive comments is significantly higher than that of negative comments: 97 vs. 20. Concept maps helped students make connections among concepts and helped them review what they had learned. As deep learning always takes time and effort, it also takes a great amount of time and effort to develop a quality concept map during the process of learning and re-learning. In this sense, concept mapping is indeed “busy work.” Prior to asking students to construct their concept maps, we need to emphasize the value of concept mapping, so students are willing to invest time in developing their concept maps.

Students also have diverse in backgrounds, experiences, expectations, learning styles, cognitive skills, and so on. Therefore, it is not surprising that students have different, sometimes completely opposite, viewpoints on the same matter. In the present study, 10 student comments indicated that concept maps helped them understand concepts, see Table 1; whilst 6 student comments indicated that concept maps did not help them understand concepts, see Table 2.

Table 1. Reasons that students liked concept mapping

Category	Freq.	Example comments from students
1. Helped make connections among concepts	32	“It was helpful to it is all laid out and how each piece is related to the other.”
2. Helped review what students had learned	23	“The concept maps provided an opportunity to go back through the chapter.”
3. Helped visualize concepts	14	“Building concept maps help me see how the derivations come together.”
4. Helped understand concepts	10	“They helped me understand the basics concepts of what we went over in the chapter.”
5. Helped organize concepts	9	“The concept maps helped me to organize my thoughts about each chapter.”
6. Helped see the bigger picture of dynamics	7	“It helped me pull it all together and see the bigger picture of how the concepts fit into the overall theme of dynamics.”
7. Helped think more clearly about concepts	2	“It forced me to think about how the concepts in the chapter related to each other. Usually it was a logical step from one concept to the next, but sometimes I had to think about it.”

Table 2. Reasons that students disliked concept mapping

Category	Freq.	Example comments from students
1. Was busy work	9	“I had no new insights or connections made as I creating concept maps. I felt like it was just busy work.”
2. Did not help understand concepts	6	“I feel that the concept maps served more to help review the material. It did not necessarily help me to understand it better.”
3. Was a small percentage of credit of the final course grade	3	“They are such a small portion of the grade that there is little motivation to do well on them.”
4. Students had other ways to learn concepts	2	“I don’t learn that way. I have my own way of learning concepts.”

Concept mapping is an effective way for students to understand the relationship among concepts and allows them to see the big picture. Nevertheless, concept mapping should not be regarded as a universal tool to solve all problems. Diverse, active learning approaches are needed to address diverse needs of students.

Acknowledgements

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