How Not To Lose Your Students With Concept Maps

By Francoise Judith Benay Bentley, Sarah Kennedy, and Katharine Semsar

Four physiology courses participating in a science education program used concept maps for the first time. At the conclusion of the term, students responded to an end-of-term survey about the activity. Following varied results, we sought to identify factors that students indicated are important for the acceptance of the technique. To encourage high student value of concept map exercises, instructors should consider achieving the following: (1) designing exercises to meet educational goals, (2) providing timely feedback by instructor and peers, and (3) clearly aligning exams/assessments with the concept map exercise. Following these three principles, students will not only value but will also see the connection between the concept map exercise and the course assessments.

In the reformation of teaching practices in science courses, concept maps have been increasingly introduced as a tool that promotes meaningful learning and integration of ideas (Allen and Tanner 2003; Briscoe and LaMaster 1991; Michael 2006; Modell 1996; Novak and Canas 2008; Rendas, Fonseca, and Pinto 2006; Silverthorn 1995). When creating concept maps, students construct a chart that represents the relation between various concepts (or ideas) of a topic (Novak and Canas 2008; e.g., see Figure 1). Strengths of this technique are that it requires students to organize knowledge in a new way, articulate relationships between terms/concepts, and promote the integration of new knowledge with previously learned knowledge (Hay, Kinchin, and Lygo-Baker 2008; Hilbert and Renkl 2008; Kinchin 2001; Novak and Canas 2008). When compared with more traditional techniques such as reading, attending lectures, and note taking, concept mapping is more effective for learning conceptual knowledge (Horton et al. 1993; Nesbit and Adescope 2006; Novak 2003; Novak and Canas 2008). There is also modest evidence that concept mapping is more effective than other summarizing techniques such as outlining (Novak and Canas 2008). Furthermore, when used as an assessment tool, concept mapping has been useful in demonstrating student progress toward expert-like organization of knowledge (McGaghie et al. 2000; McGaghie et al. 2004; West et al. 2008).

When bringing a new learning technique into the classroom, student motivation and perception of the technique can be critical for its effectiveness (NRC 2000). Although several studies have demonstrated that students can find concept mapping helpful for meaningful learning of course concepts (Briscoe and LaMaster 1991; Moni, Beswick, and Moni 2005; Rendas, Fonseca, and Pinto 2006), student resistance to and discomfort with this technique is not uncommon. Two studies documenting motivational factors relating to acceptance of mapping have found that students who are interested in meaningful learning (conceptual relationships) rather than surface learning (factual knowledge) are more likely to find concept mapping helpful (Laight 2006; Moni, Beswick, and Moni 2005). Although this may help explain why some students may inherently find concept maps helpful, there are likely other factors relating to implementation that are both important to students finding maps helpful as well as important to promoting a desire to learn material in a more meaningful way.

In this study, we examined student perceptions of usefulness of concept mapping across four different physiology courses that varied in their implementation. Students in one of these courses found the concept mapping activities significantly more helpful than in any of the other three courses. In light of this finding, we further examined end-of-term survey questions, conducted faculty and teaching assistant interviews, and reviewed course materials to look for factors that were unique to the course with the highest level of student value in the concept mapping technique. Several factors emerged as possible explanations for students' positive attitudes that should be taken into consideration when instructors implement concept mapping in their courses.

Methods

This study was conducted by faculty specializing in science education research as part of a campuswide science education program and in conjunction with the faculty teaching courses in a science department. The study combined student surveys that measured student perceptions about the use of concept mapping

as an educational activity with interviews with faculty and teaching assistants (TAs) and examination of course materials to characterize how the concept mapping activities were presented and used. Administration of end-of-term surveys and interviews were approved by the Institutional Review Board (exempt status, protocol 0108.9).

In a departmental effort to promote active learning in the classroom, science education faculty led a seminar training series on various active learning techniques, including concept maps. Faculty received instruction on how to construct a map (Novak and Canas 2008), worked in groups to construct their own maps, and then reflected on the experience. In addition, the group discussed pedagogical theory of concept maps, including importance of linker terms, expert/novice thinking, integration of physiological concepts within and between topics, and the advantages of working with peers in groups. Following these training sessions, four faculty independently implemented the use of concept maps in their individual courses. Each of these courses (Endocrinology, Exercise Physiology, Immunology, and Neurophysiology) is part of the upper-division core classes required for the major. All students in these courses were juniors and seniors who had completed prerequisite courses in biology, statistics, and human physiology.

To determine student perceptions of the learning value of the technique, students were surveyed at the end of each course regarding the use of concept maps (respondents: total students in class; Endocrinology 115:122, Exercise Physiology 16:28; Immunology 120:147, Neurophysiology 25:27). Although some questions differed among the course surveys, all students were asked the following: "Please rate how helpful for your learning concept maps are in this course: 1 = *not helpful*, 2 = *a little helpful*, 3 = *somewhat helpful*, 4 = *a fair amount*, 5 = *a great deal*." Distributions of helpfulness scores were compared across courses using analysis of variance (ANOVA; SPSS).

In Endocrinology and Exercise Physiology, students were also specifically asked on the survey to comment why they found concept maps helpful or not helpful. In Immunology, students were asked to comment why they found "recitation activities" (which included concept mapping) helpful or not helpful. In these open-ended questions, the numbers of students with and without specific reasoning for their opinion were as follows: Endocrinology 41:25, Exercise Physiology 6:5, Immunology 38:10. Among these, each student comment specifically related to concept maps was coded and categorized as follows. First, all authors read through all student comments, individually developed a set of categories that would encompass all of the responses, and then together decided on a classification rubric. Next, using the rubric, each author individually coded the entire set of responses resulting in an interrater agreement of 76%. All comments for which there was disagreement among the three authors were discussed, and a unanimous coding decision for each response was reached. In addition, a revised rubric was given to a fourth scorer who reached 87% agreement with the unanimous coding decision. This process resulted in four main classifications: map structure, feedback, exam alignment, and learning styles/study habits (examples listed in Table 1).

In addition, we gathered data from the universitywide standard faculty course questionnaire (FCQ) on student ratings of general course evaluation and general instructor ratings to investigate if any of the four courses were rated higher overall that could correlate with perceptions of mapping. Finally, to document how concept maps were used in the respective courses, faculty and TAs were interviewed following the courses, and teaching materials (example maps, syllabi, and exams) were collected where possible.

FIGURE 1

Concept map depicting the factors found to influence positive student attitudes about concept mapping in this study.

Results

Student response

As shown in Figure 2, students in the Endocrinology course rated the concept mapping activities significantly more helpful to their learning on a Likert scale than did students in any of the other courses (ANOVA; $F = 24.8$; $p < .001$; post hoc for homogeneous subsets: Student-Newman-Keuls 3.83, $p < .05$). When students had the option to provide a rationale for their helpfulness scores, students who had negative attitudes were more likely to provide a specific rationale for their attitudes than were those with positive attitudes. Among those who did respond positively on the Likert scale, comments were most often vague (i.e., "I don't think I could have been successful at all in this course without concept maps") or provided a specific rationale about a reason why they were not completely satisfied (i.e., "These were very helpful, but . . . if there was a way to check if the right connections were made it would be very helpful"). Thus, most of the comments were about how to improve concept mapping. However, when students did provide specific reasons why concept maps were helpful, all the comments focused on the idea that the concept maps were helpful for exam preparation. Meanwhile, the specific reasons for negative attitudes (or further improvement of the activities) were grouped within four categories: structure of map activity, learning styles, feedback, and alignment with exams (Table 2).

When comparing the three courses with optional rationales to their helpfulness scores to determine if there was anything unique about the Endocrinology course, Endocrinology students were found to more often cite concept maps as helpful with exam preparation and had fewer comments than Immunology students about exams being "busy work" (Table 2). In addition, when compared with Immunology students, fewer Endocrinology students asked for additional feedback (Table 2).

Data for the Exercise Physiology course is not shown in Table 2 as student comments were overwhelmingly dominated by the structure of the activity. Students were asked to create a map at the beginning of the semester and add relationships to it every day for the duration of the course. Students found this structure too big for review to help them draw relationships between concepts with 83% of students commenting on mapping activities in this manner. The only other com-

TABLE 1

Examples of student comments.

Category	Example quote 1	Example quote 2
Structure	"I think the concept maps aren't a bad idea, however, there are so many terms that are supposed to all go onto one map, perhaps it would be more beneficial to break up big lists to smaller ones that aren't as all over the place. I sometimes get confused as to what goes where because one branch often can lead to 5 different things."	"There is too much information to include on a flow chart, it just ends up looking like a mess no matter how big of a piece of paper is used."
Feedback	"Concept maps would have been useful if there had been some sort of key that you could compare your concept map to . . . in order to see whether or not you had all the components connected where they should be."	"They were not useful because there was barely any instruction or help from the TA. . . . There was never any active discussions about the course material."
Exam alignment	"The concept maps were very helpful for exam 3 and 2 because the test questions were more congruent with the use of the concept maps. The first test was more matching, and the concept maps did not really help with that as much."	"I did not find them useful most of time but thought they were a form of busy work."
Learning styles/study habits	"I don't really learn by using web diagrams with connector words. I like to learn things chronologically. When I am studying I write down a mechanism or an interaction based on the order of events, and I tie more and more other mechanisms into the one I am working on."	"I don't find concept maps very helpful because the information you can include in them is limited. I learn more from trying to integrate the information into diagrams and through answering critical questions."

ments were about the activity being busy work (33%). However, given the nature of the open-ended comments, it seems as the map structure was an overwhelming factor for students that masked any comments students had regarding other factors.

Descriptions of map use

Interviews with faculty and TAs revealed similarities and differences in the way concept mapping activities were conducted among the four courses (Table 3). Common to all courses were the instructors' goals for the activity: to help students put the pieces together into a bigger picture and begin to see the relationships between concepts. All courses also provided an opportunity at the beginning of the semester to learn about and practice mapping (as it was often the first time they encountered concept maps). Although all of these practice maps were done with the guidance and feedback of instructors, they varied in how familiar the initial topics were to students. Another difference among courses is how instructors structured the map itself, including the number of terms given, the source of the terms (instructor or student chosen), and the frequency of mapping activities in the course. Exercise Physiology was unique in that map terms were both chosen by students and accumulated throughout the course to include 75 terms in one large map. One additional notable difference was in Neurophysiology, where up to eight maps were given per week in a summer course. This practice received strong student (and TA) resistance and was dropped partway through the semester. Also varying among courses was the setting of the activity (in recitation or as homework), whether there was structured peer feedback, and the amount of instructor feedback to the students. Endocrinology was the only course that fully completed each of the concept mapping activities in recitations and provided structured peer feedback. No formalized feedback such as grading or written comments was provided to students in any course; however, both Endocrinology and Exercise Physiology instructors pro-

FIGURE 2

The degree to which students found concept maps helpful for their learning in four science courses. Students in Endocrinology found the concept maps significantly more helpful for their learning than did students in the other courses (ANOVA; $F = 24.8$, $p < .001$; post hoc for homogeneous subsets: Student-Newman-Keuls 3.83, $p < .05$).

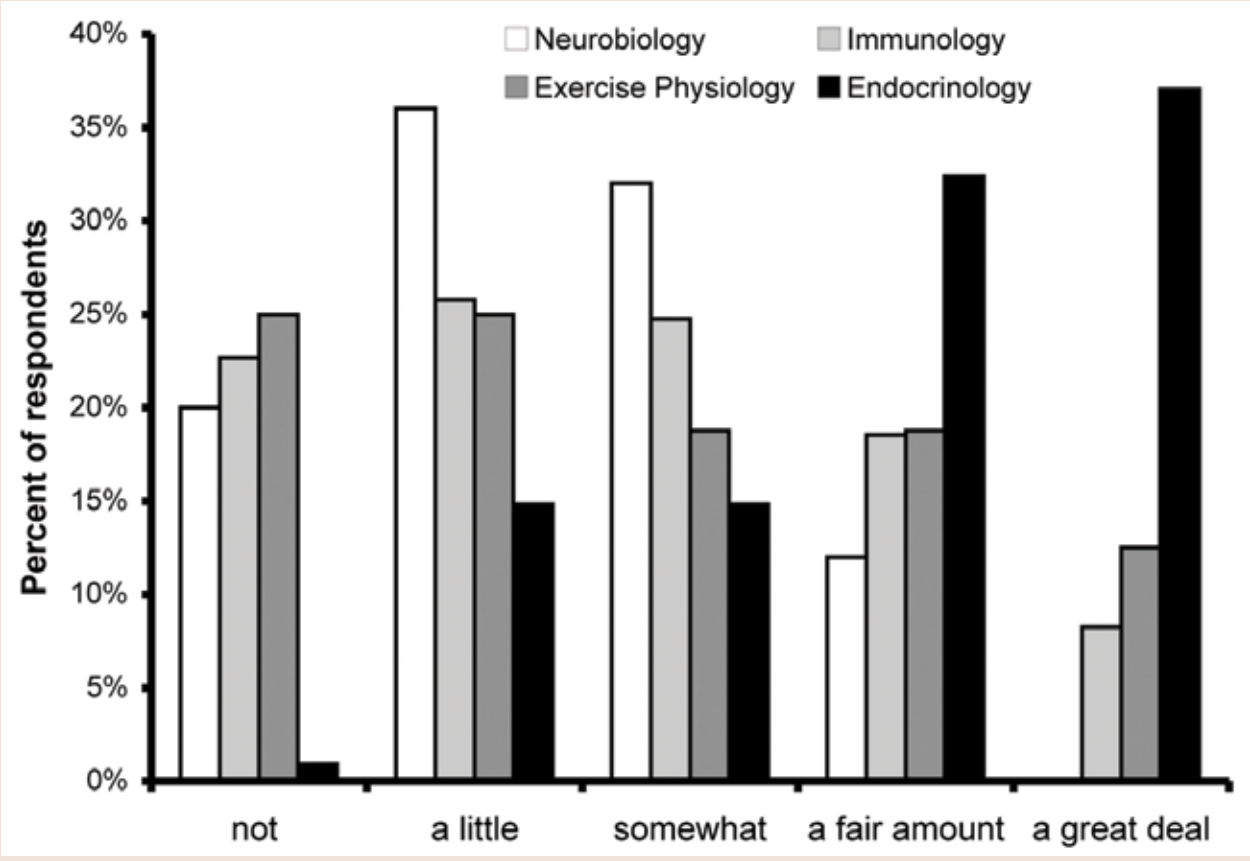

TABLE 2

Summary of specific reasons students gave for helpfulness of concept maps.

Specific reasoning categories	Endocrinology (n = 41)	Immunology (n =38)
Helpful		
Exam alignment: Helped with exam preparation	17%	3%
Not helpful		
Presentation	26%	23%
Size (too big)	(24%)	(13%)
Did not like group work	(2%)	(10%)
Feedback	35%	54%
Wanted answer key	(15%)	(8%)
Wanted more discussion	(20%)	(31%)
Wanted more encouragement	(0%)	(15%)
Exam alignment: "busy work"	2%	16%
Learning style/study preferences	27%	13%

Note: Values are shown as percentages of students giving specific reasoning. In some cases, students listed multiple reasons. n = number of students giving specific reasoning.

vided feedback to students when asked. Finally, courses varied in the extent to which exams were aligned with the concept map activities. No course directly used concept maps on exams. However, although some classes rarely tested on concept map material, Endocrinology tested almost exclusively on the ideas covered in concept maps (in matching, multiple choice, and essay formats). Finally, we did not feel it was appropriate to directly compare general course ratings or general instructor ratings on FCQs because of different modes of administration (online vs. in class) and the large variation of return rates. However, with this caveat there is no evidence that Endocrinology might have had higher course or instructor ratings (data not shown).

Discussion

Despite evidence from the literature showing that concept mapping can promote meaningful learning (Nesbit and Adescope 2006; Novak and Canas 2008), students do not automatically embrace them (NRC 2000), and without student engagement in activities, the potential benefits of the activity can be lost. In our examination of concept map implementation in four courses, students in only one of the four courses rated the concept map activity as being generally helpful for their learning. In examining the many factors that can account for this result, we focused our analysis on the statements provided by students that directly defended their reasoning for the general helpfulness rating. Although we also analyzed other factors that could influence student attitudes, we found these less useful for understanding our results. For example only Endocrinology students used concept maps throughout the entire traditional 16-week semester. However, no single student in the other three courses (that spent fewer weeks on maps) stated concept maps were unhelpful because they did not do enough maps throughout the semester or spend as much of the semester doing maps. Instead, their comments describing why they found maps unhelpful included four main responses: incongruence with preferred study habits/learning styles, too many terms (map structure), not enough instructor feedback/guidance, and unhelpful for exam preparation. The latter of these two categories matched what we knew about course structure in that there was little structured feedback in these courses, and none of the exams from these courses were aligned with material and goals represented by the concept mapping activities. Thus the student comments appeared most informative about what helped or hindered students from valuing mapping exercises, especially when the comments matched to known course structure.

In the Endocrinology courses, in which students had significantly more positive attitudes toward mapping exercises in both their survey ratings and comments, both positive comments and the lack of common negative comments helped identify what correlated with these positive attitudes. Overall, Endocrinology students had more comments that mapping exercises were helpful for exam preparation and fewer comments about maps being "busy work." Similarly, Endocrinology students had fewer comments about the lack of feedback than Immunology students. Thus positive student attitudes toward concept mapping in these courses may be influenced by the amount of instructor feedback and are most clearly influenced by visible alignment with course exams.

Overall, the major lesson based on analysis of student reasoning for their attitudes is that concept map activities should be clearly aligned with course exams. Students in Endocrinology had both fewer comments about concept maps being busy work and more comments about how concept maps helped for preparing for exams. In addition, these student statements aligned with known exam structure in Endocrinology, in which

the material on the concept maps was covered on the course exams (unlike other courses). Although exam alignment is clearly important, there are different possible reasons as to why. First, as grades can be a highly motivating factor for students, it is not surprising that if they can clearly see how an activity will help them do better on an exam, they will find the activity more helpful. Second, exams may define for students what they need to be learning. Thus they may feel that activities that are not targeted toward exam content are taking study time away from what they perceive as the most important material. In either case, students value concept mapping when the activity is aligned with exam material in a way that is not only clear to the instructors but also obvious for the student.

One way of helping students see the connections is to use concept maps on exams. As concept maps have grown in popularity, they have become used not only as learning tools but also as exam assessments (West et al. 2008). Although Endocrinology exams did not include concept maps per se, exam essay questions could be answered in words or flow charts that would have been similar in style to the concept maps they built in recitations. Several papers now offer tips in scoring techniques that can make grading of maps easier and help promote their use as both formative and summative assessment tools (Moni, Beswick, and Moni 2005; West et al. 2008; Yin et al. 2005).

A second factor mentioned by students that is likely influencing student value of concept maps is adequate instructor feedback. Overall, Endocrinology students had fewer comments about inadequate instructor feedback than did students in the Immunology course, where fewer students reported valuing the technique and more students requested additional TA encouragement and discussion. The most likely explanation for this difference is that whereas Immunology students often completed maps outside of recitation sections as homework with no further feedback, Endocrinology students were able to complete

TABLE 3

Concept map implementation in four courses.

	Endocrinology	Exercise Physiology	Immunology	Neurophysiology
Practice maps	**With instructor; endocrinology related**	With instructor; physiology related	With instructor; immunology related	With instructor; nonphysiology related
Number of terms	**15–20**	75	20	20+
Source of terms	**Instructor**	Students	Instructor	Instructor
Semester duration	**Fall semester (16 weeks)**	Summer term C (8 weeks)	Spring semester (16 weeks)	Summer term A (5 weeks)
Frequency within course	**1 per 4 weeks (4 maps)**	1 per 8-week course (1 cumulative map)	1 per 2 weeks for 8 weeks (4 maps)	8 per week for 2 weeks (16 maps)
Setting of activity	**Recitation**	Homework	Recitation and homework	Recitation and homework
Done in groups?	**Yes, groups also had to present their maps to other groups and were encouraged to give feedback to each other.**	Not necessarily, though students were allowed to work outside class together.	Yes, groups did not present their maps to other groups and did not necessarily work together outside of class to finish work.	Yes, groups did not present their maps to other groups.
Instructor feedback	**Some (when asked, discussed maps and helped clarify concepts and connections)**	Some (when asked, provided guidance on how to choose concepts for map)	No	No
Exam alignment with concept-mapping activity	**100% of corresponding exams**	N/A (because each student chose his or her own concepts to map)	6% of corresponding exams	N/A (due to cancellation of map activities)

Note: The course with the most students finding concept maps helpful is highlighted in bold in the color column.

their maps in recitation, resulting in more opportunities for both peer and instructor feedback. Therefore, although instructor feedback appears to be a major factor in student value of concept mapping as evidenced by our Endocrinology/Immunology comparison and pedagogical literature (Mayer 2008; NRC 2000), it was not a clear factor in this study.

Related to feedback is the opportunity for peer discussion. Although students did not mention peer discussion opportunities, Endocrinology's structured peer feedback in recitations may have contributed to the fewer requests for additional instructor feedback on the end-of-term surveys compared with Immunology. Both instructor and peer feedback have important influences on learning (Mazur 1997; NRC 2000; Smith et al. 2008).

Among other factors potentially contributing to student value of concept mapping as reported by students include whether activities are clear and manageable and whether students feel the activities match their preferred study methods/learning styles. Related to map structure, Exercise Physiology students commented most about the size of their maps. Eighty-three percent of students cited that they found maps unhelpful for their learning because the map was too large, resulting in a map that was too "confusing to review." In addition and similar to previous findings (Laight 2006; Moni, Beswick, and Moni 2005), students who felt that concept maps did not match their preferred study methods/learning styles (e.g., they preferred "listing," "making diagrams," "answering critical questions," and "reading complete sentences") did not find concept mapping useful. However, when looking for reasons why Endocrinology had more positive attitudes, the fact that Endocrinology had the highest percentage of students compared with other classes citing this as a rationale for their helpfulness scores only indicates that the class as a whole can find the maps helpful despite some feeling the activities do not match their preferred study style.

In addition to the student survey data we have discussed, we acknowledge that there are potentially other factors that can contribute to student perceptions of concept mapping. However, none of the factors we have been able to examine have provided a clear explanation as to why students in the Endocrinology course had significantly higher ratings of mapping. For example, the FCQ data, although difficult to compare among classes, had no indication of higher ratings for Endocrinology. Likewise, although faculty and TA cooperation was low in one course (Neurophysiology), it was only one of three courses not highly valued by students. Last, even though map implementation varied across classes, none of those variations (e.g., timing of maps, number of maps, course duration; Table 3) clearly matched with overall student rating of mapping exercises.

In conclusion, we have shown that students can respond very differently regarding their attitude toward the use of concept maps depending on how the concept mapping exercise is designed and implemented in a class. Although we have not provided data to support improved learning through the use of concept maps, we have specifically elucidated three factors associated with positive attitudes toward the use of concept maps (Figure 1). One, the mapping activity needs to be appropriately designed to meet the educational goals and not excessively complex. Two, there needs to be an adequate amount of feedback from some combination of teacher, TA, or peers. Three, and most important in our study, students have to see that the concept mapping and what they are learning from it is aligned with the exams. When these three factors are given proper attention by instructors, students are more likely to view concept mapping as a valuable tool in their learning of physiology and to engage in the activity. ■

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Francoise Judith Benay Bentley (francoise.benay@colorado.edu) *is a science education specialist,* ***Sarah Kennedy*** *is a science education specialist, and* ***Katharine Semsar*** *is a science education specialist, all in the Department of Integrative Physiology at the University of Colorado, Boulder.*

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Dept. of Biology,
State University of New York,
Buffalo, NY 14260-1300
(716) 645-2892
herreid@buffalo.edu