

Visualizing Learning in College-level Science Courses: Using Concept Mapping as Note Taking Strategy

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Abstract: Most undergraduate students take an introductory science course during their first two years. For higher education science faculty, one of the challenges of teaching an introductory science course is the reality that many undergraduate students are not prepared to be self-directed learners. Given recent high school experiences, many students expect to earn a grade of A or B. However, the failing results of the first exam can be disappointing, if not frustrating, to these students. Not only do the students not develop mastery of the science content they studied, they had more difficulties retaining and recalling key and relevant information. During the Fall 2015 semester, the researchers assigned approximately 139 students within a Principles of Biology I (BIOL 1107) lecture course to one of the three note taking category identified for this study -- 1) Traditional note taking, 2) Concept mapping, and 3) Visual mapping. Findings, based on quantitative data, showed no significant differences between and among note taking strategies and exam averages. However, using descriptive statistics, researchers found that students with a prior GPA of < 3.0 before taking the class (i.e., C and below) and using the traditional note taking strategy seemed not to be performing well on unit exams. Qualitative data, overall, suggests that the students found their specific note taking strategy to be beneficial, especially when it came to preparing for the cumulative final exam.

Introduction

Recent years saw initiatives to reform science education using innovative strategies (Wood, 2009). It is because science education in general is heavily teacher-centered (Brinkerhoff & Booth, 2013). It often relies on repetition and rote learning as well as examination averages as an indicator of knowledge learned. Rozalski (2008) identified that the problem lies within the fact that students do not know *how to take notes* especially in recognizing key ideas or concepts. Also college instructors report that many of their students do not know *how to study in most courses especially in their science courses*. Students get overwhelmed when studying simply due to the amount of information written and documented in their notebooks. Lastly, students lack the needed critical thinking skills in science courses (Hager, Sleet, Logan & Hooper, 2003; Rowe, Gillespie, Harris, Koether, Shannon & Rose, 2015). It seems difficult for many students, especially, at the freshmen level, to apply what they are learning to the real world.

Concept Mapping. Typically science courses are taught using lectures accompanied by demonstrations and hands-on laboratory work (Ajaja, 2013; Wood, 2009). The amount of content covered that serves as foundation could be daunting to undergraduate students, even science majors, who used to excel in their high school classes. Further, non-majors struggled more due to lack of skills in organizing the amount of information read, collected, and retained that will be recalled in the near future or in another context. Novak (1998) states “meaningful learning results when the learner chooses to relate new information to ideas that learner already knows” (p. 23). This led to a demonstration of organizing concept words and propositions into concept labels connected together using linking words. Novak and his team identified this strategy as concept mapping.

Concept maps are graphical tools for organizing and representing knowledge (Hay, Kinchin, Lygo-Baker, 2008; Novak, 2010; Sakiyo & Waziri, 2015). Major concepts are enclosed within circles or boxes and connections in the form of lines or arrows are used to demonstrate a connection between two related concepts. Along with the lines or arrows, one must include a descriptive linking relationship, further demonstrating the relationship between or among major concepts. Novak (2010) stated that concept maps are represented with a hierarchal or pyramidal structure with broad concepts located at the top and less general, or more specific, concepts located on the bottom. It is most helpful to construct concept maps in reference to a question. This allows organization of ideas and knowledge. A major goal of concept map construction is to reorganize existing knowledge with already acquired knowledge (Ajaja, 2011; Briscoe & LaMaster, 1991; Nesbit & Adesope, 2006). Novak stated that “concept maps were a good way to help a teacher organize knowledge for instruction, and a good way for students to find the key concepts and principles in lectures, readings or other instructional materials” (p. 33).

Finally, the research literature reports that concept mapping could foster increase in student performance in science courses (Ajaja, 2011; Ogonnaya, Okafor, Abonyi, & Ugama, 2016). Others report that students find the concept mapping experience helpful in making sense of the content being learned by linking related concepts (Bunting, Coll, & Campbell, 2006). Finally, in comparing the use of concept mapping to instructional strategies, Udeani and Okafor (2012) found that those who used concept mapping “performed significantly better than their expository counterparts” (p. 139).

Introductory Undergraduate Biology. An undergraduate science course with high enrollment at a southeastern state university was used for this study. It is taken mostly by science majors that includes pre-nursing students. The course usually enrolls more than 100 students and is taught in a large lecture hall three times a week for 50 minutes. Most instructors assigned to this course teach it in a lecture format and assess student learning using unit and cumulative final exams. The 3-credit course is paired with a credit-hour lab component taught by a graduate student.

The concept mapping strategy was implemented as one of the three note taking strategies during the first year (2015) to support students in acquiring new knowledge and skills. Report of positive outcomes pertaining to student performance from using concept or visual mapping during that first year made the researchers decide to focus on one note taking strategy during the second year (2016). It was decided to use concept mapping since there were many similarities between concept maps and visual maps. In addition, students expressed negative feelings about drawing pictures or images when asked to create visual maps.

Purpose

In 2015, the idea of using a note taking strategy was implemented to help students identify major concepts within a given unit and to easily make connections between or among major concepts. The researchers wanted to find out (1) if implementing a note taking strategy would help students retain and recall information after receiving instruction during the semester. Finally, it is important for the researchers to understand (2) if students positively or negatively perceived the use of a note taking strategy in learning the course material, and preparing them for the unit and cumulative exams. For this first year of implementation, the researchers used three note taking strategies: Traditional, Concept Mapping, and Visual Mapping.

Based on the first year results of the study, the researchers found (see Table 1) that there was no significant relationship among gender, major, prior credits earned with any of the note taking strategies (Baylen, Duckett, Parker, & Arellano, 2017). There was also no significant relationship for students who are freshmen or have GPAs above a B average in all note taking categories. However, the researchers did find a significant relationship between students following the traditional note taking strategy and have a GPA less than a B. It appears that students with less than a B average are not benefitting from the traditional note taking strategy based on their final average for the course (Table 1). The first year study results made the researchers consider revisiting the research design for implementation in the next academic cycle.

Table 1. Prior GPA and note taking strategies, Year One.

Prior GPA	Types of Note Taking Strategy	95% Confidence Interval			
		Mean	Standard Error	Lower Bound	Upper Bound
N = 139					
Freshmen, First Semester	Concept Mapping	83.894	1.678	80.573	87.214
	Visual Mapping	81.617	2.056	77.550	85.684
	Traditional Note Taking	86.902	1.625	83.687	90.117

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Prior GPA Below B	Concept Mapping	83.490	3.064	77.428	89.552
	Visual Mapping	80.802	3.064	74.740	86.864
	Traditional Note Taking	70.811	2.772	65.327	76.294
Prior GPA Above B	Concept Mapping	83.687	3.475	76.813	90.561
	Visual Mapping	87.066	3.475	80.192	93.940
	Traditional Note Taking	86.959	2.457	82.098	91.819

Methodology

In 2016, the researchers decided to extend their study on investigating the impact of note taking strategies in an undergraduate introductory biology course at a southeastern state university. They made adjustments to strengthen the design of the study by only asking the students to use concept mapping as a note taking strategy in each chapter from the text that was covered during the class lecture. With this change, they also developed a rubric and used it for assessment of student performance in completing the concept maps.

Research Questions. Given what was learned from the previous year about implementing note taking strategies in the undergraduate science classroom, the researchers wanted to find answers to these questions (1) “What is the impact of implementing concept mapping as a note taking strategy to information retention and recall?” and (2) “How does the students perceive the use of a note taking strategy in learning the course material and preparing them for the unit and cumulative exams?”

Participants. Students enrolled in BIOL 1107, an undergraduate freshmen level course, were recruited for the study. This course was required for pre-nursing majors as well as science majors. The course is worth a total of three credit hours plus an additional credit hour for the co-requisite laboratory work. One hundred twelve were enrolled, and 111 students agreed to participate in the study. Of the 111 students, more than fifty percent were pre-nursing majors, followed by science majors (i.e. Chemistry, Geology, Physics, or Computer Science). The remaining participants were non-science or undeclared majors.

Data Collection Strategy. Students completed a course assignment requiring them to create concept maps for their chapter notes. This data collection procedure was highly similar to the one used the previous year.

On the day of each unit exam covering one or two chapters from the assigned textbook, notebooks were collected and graded. The total points awarded for the notebooks contributed 10% to the final grade. An undergraduate student research assistant was responsible for the task of reviewing all notebooks for content accuracy, awarding points using specified guidelines, and returning the notebooks to their respective student owners by the next lecture meeting. It should be noted that the research assistant is a biology undergraduate; therefore, she has extensive knowledge in the material she was reviewing. (Baylen et al, 2017, p.5)

Other data collected included demographic information, such as the students' gender, current major, and earned credits for data analysis. Similar to the 2015 study, the researchers also collected data including the points earned from the assessment of concept maps using a rubric, unit exams and the final comprehensive exam.

On the day of each unit exams every student was required to turn in his/her notebook in order for it to be graded. The notebook grading was completed by an undergraduate biology student with extensive knowledge in the material covered in the notebooks. She was responsible for ensuring that the information within the notebooks was accurate, making sure connections among major concepts were correct and relevant, and also ensured that the students followed the specific guidelines outlined by their specific note taking strategy. The research assistant then assigned a grade out of a possible 10 points and communicated this information to the instructor. Notebooks were then placed outside the instructor's office door in order for the students to pick them up prior to the next scheduled lecture. The student research assistant also compiled demographic information with the help of the lecture instructor. This way, it was easier to monitor any correlations among the students, their demographics, their exam scores, as well as their notebook grades. The student assistant kept track of all this information within Excel spreadsheets (Baylen et al, 2017, p.5).

Finally, qualitative data generated by open-ended questions pertaining to student perceptions of concept mapping as a note taking strategy was collected during the third and final exams. Student responses were coded in order to ensure anonymity, converted to quantitative data for basic statistical analysis while the qualitative data were categorized into common patterns or themes for further analysis.

Results and Discussion

The researchers analyzed the collected data using descriptive statistics to report if there was an impact on student retention and recall. Also, the researchers analyzed the qualitative data collected to identify student perceptions of concept mapping as a note taking strategy.

Impact on Retention and Recall. Based on what was learned from the 2015 study, the researchers redesigned it by focusing on *just* one note taking strategy (concept mapping) and implemented it in fall of 2016. Tables 2, 3 and 4 provide information on the results. Similarly, the 2016 study reported that students' GPA prior to taking the Biology course seemed to influence student performance as demonstrated by the final exam score (see Table 2). This meant that students with a "B" and above GPA would receive a similar if not better final letter grade in the course.

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Table 2. Prior GPA and Final Exam Score - Using Concept Mapping Note Taking Strategy, Yr 2.

Earned Grade Point Average (GPA) Prior	Final Exam Score		95% Confidence Interval	
	Mean	Standard Error	Lower Bound	Upper Bound
N = 111				
Freshmen, No College GPA	84.287	17.764	79.072	89.503
Prior GPA C and Below (0.01 - 2.99)	71.560	31.822	60.277	82.844
Prior GPA B and Above (3.00 - 4.00)	86.728	24.341	77.800	95.657

Students with a "C" and below GPA would most likely received a similar, if not worst final letter grade. Also, a similar pattern seemed to exist for the notebook average points (see Table 3).

Table 3. Prior GPA and Notebook Average Points - Using Concept Mapping Note Taking Strategy, Yr 2

Earned Grade Point Average (GPA) Prior	Notebook Average Points		95% Confidence Interval	
	Mean	Standard Error	Lower Bound	Upper Bound
N = 111				
Freshmen, No College GPA	8.221	2.695	7.430	9.013
Prior GPA C and Below (0.01 - 2.99)	7.158	3.353	5.969	8.346
Prior GPA B and Above (3.00 - 4.00)	8.781	2.112	8.006	9.555

Finally, the researchers looked into potential relationships between variables: Gender, Earned Credit Hours Prior, Earned GPA Prior, Notebook Average Points, and Final Exam Score. After running statistical analysis on data collected from 109 students, they found that there was a positive correlation ($r = 0.731$) between the notebook average points and the final exam score (see Table 4). The rest of the variables demonstrated minimal correlations.

Table 4. Pearson Correlation - Using Concept Mapping Note Taking Strategy, Yr 2.

	Gender	Earned Credit Hours, Prior	Earned GPA, Prior	Notebook Average Points	Final Exam Score
N = 109					
Gender		0.247	0.026	-0.112	0.058
Earned Credit Hours, Prior		1.000	0.386	0.449	-0.040
Earned GPA, Prior			1.000	0.197	0.200
Notebook Average Points				1.000	0.731
Final Exam Score					1.000

Student Perceptions on the Use of Concept Mapping as a Note Taking Strategy

The researchers were also interested in student perceptions on their use of concept mapping as a note taking strategy to help them in learning the course material and preparing for the unit and cumulative exams. Two data collection schedules were completed -- one at the third unit exam and the other at the final exam. Each data collection involved asking three open-ended questions that asked about how the note taking strategy helped them 1) learn the course content, and 2) review for the exams as well as 3) their overall opinion of the experience.

In exploring for themes or patterns from the qualitative data collected, the researchers manually review the responses to each question and categorize them as positive or negative towards the use of concept mapping as a note taking strategy (see Table 5). Overall, students seemed to perceive concept mapping as positively helpful as a note taking strategy in learning course content and in preparing for the exams.

Table 5 Category of Response as Student Perceptions of Concept Mapping as a Note Taking Strategy

Open-Ended Question on Use of Concept Mapping	N	Positive		Negative		NRR*	
		<i>f</i>	%	<i>f</i>	%	<i>f</i>	%
Note Taking Strategy Helps Learn the Course Content	111	74	66.667	31	27.928	6	5.405
Note Taking Strategy Helps in Reviewing for the Exams	111	70	63.063	34	30.631	7	6.306
Overall Opinion	111	69	62.162	30	27.027	12	10.811

* NRR = Did not answer the question or no response

Conclusion

As an exploratory and descriptive study, the researchers conclude that incorporating concept mapping as a tool to support note taking in the Biology classroom seemed to make a difference in student performance, especially with students having a GPA of a 3.0 and higher. Based on this result, the researchers plan to tweak their study design and collect more data to strongly demonstrate a positive relationship of using concept mapping on comprehension, retention, and recall of relevant content.

Other changes that the researchers plan to make in future in conducting similar research studies could include the availability of information to the students on what is expected from them. This could mean another revision of the rubric given to students on how to make their concept maps. Another possibility is in-class or one-on-one consultations to discuss the rubric in detail as an assessment tool on how the notebook submissions will be graded. Also, the course instructor could show exemplary concept maps created from past courses to provide ideas and inspire the current students.

Finally, concept mapping as a teaching and/or learning strategy in the classroom is not new. It has been in existence and used since Novak (1998) introduced it at least twenty years ago. It is one of the many tools that faculty members could share with their students to help them succeed

in their studies. The simplicity of creating one seemed to be its greatest benefit to those who want to do better in their courses.

At the end, the continued implementation and data collection on its impacts in the classroom could provide new information on factors enhancing or hindering its influence on student performance. This is what the researchers are interested to know more so that higher education institutions and its staff could be better advised on what strategies to use in effectively retaining and progressing students toward graduation.

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