International Journal for Educational Media and Technology
2017, Vol.11, No. 2, pp. 22-28

Concept Mapping as Note-Taking Strategy in University Science Courses

Danilo M. Baylen
University of West Georgia, USA
dbaylen@westga.edu

Erin Duckett
University of West Georgia, USA
educkett@westga.edu

Elvira Arellano
West Visayas State University
Iloilo, Philippines
elvie_a2001@yahoo.com

The researchers assigned undergraduate students enrolled in a Principles of Biology I (BIOL 1107) lecture course to one of the three note-taking categories identified for this study -- 1) Traditional note-taking, 2) Concept mapping, and 3) Visual mapping. Students were asked to demonstrate their assigned note-taking strategy in notebooks collected at the day of each unit exam. The notebooks were collected and reviewed based on demonstrated understanding of detailed content based on major concepts within a given unit. Researchers used demographic information (prior GPA, gender, earned credit hours, declared major) and correlated them with the note-taking strategy and exam averages. Findings showed no significant differences between note-taking strategies and exam averages. However, 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.

Keywords: concept mapping, higher education, note-taking strategy, science courses, undergraduate students

Introduction

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, but they also had more difficulties retaining and recalling key and relevant information.

Recent years saw initiatives to reform science education using innovative strategies (Wood, 2009). It is because of 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 a 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, retained, and then, recalled for application to other contexts. Novak (1998) states "meaningful learning results when the learner chooses to relate new information to ideas that learner already knows" (p. 23). The activity led to a demonstration of organizing concept words and propositions into concept labels connected 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). The individual circles or boxes the major concepts, and then use lines or arrows to demonstrate a connection between two or more related concepts. Along with the lines or arrows, one must include a descriptive linking relationship, further demonstrating and expanding the knowledge acquired about the relationship between or among major concepts. Novak (2010) stated that a hierarchal or pyramidal structure with broad concepts located at the top and less general, or more specific, concepts located on the bottom usually represents concept maps. It is most helpful to construct concept maps about a question. The structure allows the 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 an 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 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

The study used an undergraduate science course with high enrollment at a southeastern state university. 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 the unit and cumulative final exams. The 3-credit course pairs 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 of this research project (2015) to support students in acquiring new knowledge and skills. Report of positive outcomes about student performance from using the 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. Also, 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 make connections easily 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 between gender, major, prior credits earned with any of the note-taking strategies (Baylen, Duckett, Parker, & Arellano, 2017). There was also no significant relationship between 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	
N = 139		Mean	Standard Error	Lower Bound	Upper Bound
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
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. Students created concept maps for each chapter from the text 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

Lessons learned from the previous year about implementing note-taking strategies in the undergraduate science classroom helped the researchers to formulate new questions. For this study, the researchers wanted to find answers to the following questions:

1. What is the impact of implementing concept mapping as a note-taking strategy to information retention and recall?
2. How do 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

The researchers recruited students enrolled in BIOL 1107, an undergraduate freshmen level course, for the study. Pre-nursing majors, as well as science majors, populated this course. 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 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 for the students to pick them up before 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, the researchers collected qualitative data generated by open-ended questions about student perceptions of concept mapping as a note-taking strategy during the third and final exams. Student responses were coded to ensure anonymity, converted to quantitative data for basic statistical analysis. Also, researchers categorized the qualitative data collected 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

From the lessons learned in the 2015 study, the researchers restructured the study design 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 before taking the Biology course seemed to influence student performance as demonstrated by the final exam score (see Table 2). The result meant that students with a "B" and above GPA would receive a similar if not better final letter grade in the course.

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

Earned Grade Point Average (GPA) Prior	Final Exam Score		95% Confidence Interval	
N = 111	Mean	Standard Error	Lower Bound	Upper Bound
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 receive a similar, if not a 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, Year Two.

Earned Grade Point Average (GPA) Prior	Notebook Average Points		95% Confidence Interval	
N = 111	Mean	Standard Error	Lower Bound	Upper Bound
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, Year Two.

N = 109	Earned Credit Hours, Prior	Earned GPA, Prior	Notebook Average Points	Final Exam Score
Earned Credit Hours, Prior	1.000	0.386	0.012	-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. They completed two data collection schedules -- 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 reviewed the responses to each question and categorized 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		Positive		Negative		NRR*	
	N	*f*	%	*f*	%	*f*	%
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 the future conduct of similar research studies could include the availability of information to the students on participation expectation. Future changes 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 for the assessment of the notebook submissions. 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 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.

In the end, the continued implementation of this study and data collection on its impact in the classroom could provide new information on factors enhancing or hindering its influence on student performance. The researchers are interested to know more so they could advise higher education institutions and its staff on what strategies to use to retain effectively and support students toward graduation.

References

Ajaja, O. P. (2013). Which strategy best suits biology teaching? Lecturing, concept mapping, cooperative learning or learning cycle. *Electronic Journal of Science Education, 17*(1), 1-37.

Ajaja, O. P. (2011). Concept mapping as a study skill: Effects on student achievement in Biology. *International Journal of Education Science, 3*(1), 49-57.

Baylen, D. M., Duckett, E., Parker, R., & Arellano, E. (2017). Concept mapping as note-taking strategies in undergraduate science courses. In M. Simonson (Ed.), 39th *Annual Proceedings of Selected Research and Development Papers Presented at the Annual Convention of the Association for Educational Communications and Technology, Volume 1 Research and Development Papers* (pp. 1-7). Bloomington, IN: AECT.

Brinkerhoff, J. L., & Booth, G. M. (2013). The effect of concept mapping on student achievement in an introductory non-majors Biology class. *European International Journal of Science and Technology*, *2*(8), 43-72.

Briscoe, C., & LaMaster, S. U. (1991). Meaningful learning in college Biology through concept mapping. *The American Biology Teacher*, *53*(4), 214-219.

Bunting, C., Coll, R. C., & Campbell, A. (2006). Student views of concept mapping use in introductory tertiary Biology classes. *International Journal of Science and Mathematics Education*, *4*, 641-668.

Hager, P., Sleet, R., Logan, P., & Hooper, M. (2003). Teaching critical thinking in undergraduate science courses. *Science & Education*, *12*(3), 303-313.

Hay, D., Kinchin, I., Lygo-Baker, S. (2008). Making learning visible: The role of concept mapping in higher education. *Studies in Higher Education*, *33*(3), 295-311.

Nesbit, J. C., & Adesope, O. O. (2006). Learning with concept and knowledge maps: A meta-analysis. *Review of Educational Research*, *76*(3), 413-448.

Novak, J. D. (2010). *Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations* (2nd edition). New York, NY: Routledge.

Novak, J. D. (1998). *Learning, creating, and using knowledge: Concept maps as facilitative tools for schools and corporations*. Mahwah, NJ: Lawrence Erlbaum & Associates.

Ogonnaya, U. P., Okafor, G., Abonyi, O. S., & Ugama, J. O. (2016). Effects of concept mapping instruction approach on students' achievement in basic science. *Journal of Education and Practice*, *7*(8), 79-84.

Rowe, M. P., Gillespie, B. M., Harris, K. R., Koether, S. D., Shannon, L. Y., & Rose, L. A. (2015). Redesigning a general education science course to promote critical thinking. *Life Sciences Education*, *14*, 1-12.

Rozalski, M. E. (2008). Practice, practice, practice: How to improve students' study skills. *Beyond Behavior*, 17-23.

Sakiyo, J., & Waziri, K. (2015) Concept mapping strategy: An effective tool for improving students' academic Achievement in Biology. *Journal of Education in Science, Environment and Health*, *1*(1), 56-62.

Udeani, U., & Okafor, P. N. (2012). The effect of concept mapping instructional strategy on the Biology achievement of senior secondary school slow learners. *Journal of Emerging Trends in Educational Research and Policy Studies*, *3*(2), 137-142.

Wood, W. B. (2009). Innovations in teaching undergraduate Biology and why we need them. *Annual Review of Cell and Development Biology*, *25*, 5.1-5.20. DOI: 10.1146/annurev.cell.bio.24.110707.175306.