Concept Maps as a way to Improve Understanding and Organization of Concepts within a Subject

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Table of Contents

Abstract ................................................................................................................................. 4

Chapter 1: Introduction ........................................................................................................ 5

Chapter 2: Literature Review .............................................................................................. 9

Chapter 3: Method ............................................................................................................... 17

Chapter 4: Results ............................................................................................................... 22

Chapter 5: Discussion, Conclusions, Recommendations, and Implications for Practice ..... 48

References ........................................................................................................................... 61

Appendix A ........................................................................................................................... 64

Part 1: Assessment Questions for First Unit ........................................................................ 64

Part 2: Assessment Questions for Second Unit .................................................................... 68

Appendix B ........................................................................................................................... 72

Part 1: Pre-Survey ............................................................................................................... 72

Part 2: Post-Survey ............................................................................................................. 73

Appendix C ........................................................................................................................... 75

Part 1: Concept Map from First Unit .................................................................................. 75

Part 2: Concept Map from Second Unit ............................................................................. 76

IRB Approval ......................................................................................................................... 77

Plagiarism Check ................................................................................................................ 78
Abstract

This study investigated the use of concept maps to improve student understanding and organization of a subject. The research questions this study aimed to answer were: Does the use of concept maps as a learning tool significantly increase test scores? Did students’ feelings about the use of concept maps as a learning tool change after using them? How do students feel about concept maps and do students feel that concept maps help them learn? Are there common themes amongst how students organize concepts within a unit? The participants in this study were students in two elective biology classes at a rural high school in Southeast Ohio. This study was conducted across two units of human anatomy. During each unit, one class served as a treatment and the other as a control. Both classes were taught the same, but one class used concept maps as an additional learning tool. Pre- and post-test scores and survey responses, and student-constructed concept maps were used as instruments to collect data. The pre- and post-test score data revealed that the use of concept maps did not significantly increase test scores. The pre- and post-survey revealed that students’ feelings towards concept maps did change after using them and that a majority of students felt positively towards concept maps, but found them somewhat challenging to make. For the first unit of this study, the Likert scale statements on the pre- to post-survey revealed that, on average, students in the treatment class did not feel the concept maps helped them learn, visualize concepts within a unit, visualize the relationships between concepts within a unit, or like creating concept maps, but that students, on average, did like utilizing concept maps as a study tool and did like reading concept maps. For the second unit of this study, the Likert scale statements on the pre- to post-survey revealed that, on average, students in the treatment class felt that concept maps helped them learn, visualize concepts within a unit, visualize the relationships between concepts within a unit, liked utilizing concept maps as a study tool, and liked reading concept map, but that students’ feelings towards creating concept maps did not change after using them. The open-response questions on the post-survey revealed that a majority of students felt positively about concept maps, but also found them a bit challenging to make, which may be due to students not being very comfortable with creating or reading concept maps or due to the sometimes complex material being studied. Analysis of student-constructed concept maps revealed that there were common themes in how students organize information in a concept map, including the identification of the main concept for the maps and connecting concepts to each other as they were taught in the class notes. Though the use of concept maps did not significantly increase test scores, they do help students organize information. To better utilize concept maps, students need to have more practice in creating, using, and reading them to help students feel more comfortable when using them in the classroom. To see if test scores do increase due to the use of concept maps, it is recommended that more concept maps be used in the unit of study, such as having students create concept maps on their own, and letting students interact with them in their notes, on various assignments, and on homework. This would give students more time with concept maps and also strengthen the study to see if concept maps are indeed the source to increased test scores and learning.
Chapter 1: Introduction

Background

To help make learning more meaningful for students, teachers need to find and implement ways to help students fit new knowledge into their schema of existing knowledge of a subject and/or to create a schema for newly constructed knowledge. One way that teachers can do this is through the use of concept maps in the classroom. Concept maps are a way for students to organize information within a subject and show how the concepts are related to each other. Through the use of concept maps, students can create visual representations of how they believe concepts are related to each other within a subject. This information can also allow teachers to learn how students organize concepts and if students have any misunderstandings or misconceptions within a subject.

Concept maps are a type of graphic organizer. They consist of concepts represented in circles or rectangles. Lines with or without arrows are used to connect one concept to another concept to show a relationship between the concepts. Words or phrases found on the arrowed lines verbalize the relationship between the two concepts (Lee, 2013). An overall concept map can show how an individual understands and organizes concepts within a subject.

The Usefulness of Concept Maps in the Classroom

Concept maps are a learning tool that will be beneficial to students throughout their high school and post-high school education. Teaching students how to create, interpret, and use concept maps can help them in understanding and organizing information within a subject. This will allow students to be able to visually represent concepts within a subject and possibly identify any misconceptions and/or misunderstanding they may have when learning. This will
provide opportunity for students to correct these misconceptions and/or misunderstandings on their own. Utilizing concept maps as a learning tool can thus make learning more meaningful for the learner because it will allow them to see how they organize and understand a subject.

Concept maps are a tool that can be used in the classroom to connect prior knowledge to new knowledge, show relationships between concepts, and show student misconceptions and misunderstandings within a subject (Blunt & Karpicke, 2014; Clariana & Koul, 2008; Yang, Hwang, Hung, & Tseng, 2013). It is also a learning tool that can be used by both students and teachers. Students can use concept maps to create a structure of information they have previously learned and what they are currently learning. This will allow students to actually see how they organize this information. Teachers can also use concept maps to see how students organize information, but also to identify any misunderstandings and/or misconceptions a student may have. This can help teachers in developing their future instruction to clarify these misunderstandings and misconceptions (Vanides, Yue, Tomita, & Ruiz-Primo, 2005). These attributes of concept maps make concept maps a very versatile and potentially useful tool in any classroom.

There are multiple ways to create concept maps. There are software programs that can be used to create concept maps, but concept maps can also be created by any individual by hand. Thus, concept maps can be used by any and all learners, no matter what resources they may have. Any way to make learning meaningful to students will be valuable to all learners now and in the future. Studies have shown that concepts maps are a valuable tool because they can make learning meaningful (Karakuyu, 2011; Lim, Lee, & Grabowski, 2009; Yang et al., 2013). By showing students how to create and use concept maps in high school they can thus use it as a
learning tool during the rest of their high school career and in their future education past high school.

**Research Questions**

The purpose of this study is to see if the use of concept maps improves student understanding and organization of a subject. This study aims to answer these research questions:

- Does the use of concept maps as a learning tool significantly increase test scores?
- Did students’ feelings about the use of concept maps as a learning tool change after using them?
- How do students feel about concept maps and do students feel that concept maps help them learn?
- Are there common themes amongst how students organize concepts within a unit?

**Research Aim and Purpose of the Study**

This study aims to answer if the use of concept maps in a biology classroom improves student understanding and organization of a subject. There has been a great deal of research done on the usefulness and benefits of concept maps in education, but there is a limited amount of research on the benefits of concept maps in high school science classrooms. This research study can contribute to the current literature about concept maps and add to the research of concept maps being used specifically in high school science classrooms.

The purpose of this study is to see if students enrolled in an elective biology course at a rural high school in Southeast Ohio will benefit from the use of concept maps in their biology classroom. Two classes will be used during this study. During one unit of study in an anatomy unit, one class will be utilizing concept maps as a learning tool, while the other will not. During
the next unit of study the same method will be used, but the classes utilizing and not utilizing concept maps will be switched. If test scores of the class utilizing the concept maps are significantly increased in comparison to the class not utilizing concept maps, then it will be concluded that concept maps are effective at helping students to better understand and organize concepts within a subject. Surveys will also be used to determine students’ feelings towards concept maps and student-constructed concept maps will be analyzed to determine common themes amongst how students organize concepts within the studied units.
Chapter 2: Literature Review

Introduction

To make learning more meaningful, knowledge that is being learned should be fit into one’s mental schema of existing knowledge. This can allow students to build upon what they already know when learning new content. A possible way of developing such connections is through the use of concept maps in the classroom. Concept maps allow students to connect different concepts to show their relationships to each other. This method can be used across a wide range of subject areas. One such subject area could be in the secondary level biology classroom. This literature review will look at how concept maps are constructed, the effects concept maps have on learning, how concept maps support reading materials, perceptions of concept maps by both teachers and students, and the implementation of concept maps into the classroom.

The technique of concept mapping was created and designed by Joseph D. Novak at Cornell University in 1972 (Lee, 2013). Novak based concept maps on David Ausubel’s assimilation theory, which discusses how “the mind organizes information in a hierarchical top-down fashion” (Hilbert & Renkl, 2008, p. 53). Novak and Gowin (1984) discuss that learners need to build on their current knowledge structures to make learning more meaningful, which can be done through the use of concept maps.

Constructing Concept Maps

Concept maps are a visual tool that connect different concepts, usually depicted in circles, by showing their relationships to each other through the use of labeled links (Bentley, Kennedy, & Semsar, 2011; Daugherty, Custer, & Dixon, 2012; Lim et al., 2009; Martínez, Pérez,
Suero, & Pardo, 2013; Vanides et al., 2005). Labeled links within concept maps are used to explicitly show relationships between concepts and are often hierarchical, with the most important concept near the top with secondary and tertiary concepts building from this concept (Santiago, 2011; Uewellyn, 2007). Gericke and Wahlberg (2013) discuss how concept maps can have different levels of complexity in their structures. They discuss that the simplest kind of concept map consists of a main concept in the center of the map and then secondary concepts radiating from this center concept. Concept maps that are linear are slightly more complex because each concept has two concepts linked to it in a hierarchical structure. The most complex type of concept map described by Gericke and Wahlberg (2013) is one where the map forms a net due to multiple interconnections created between concepts. Concept maps that demonstrate this highest level of complexity also demonstrate a deeper understanding of the material by the student. How complex a student makes their concept map can then give teachers insight into the level of understanding a student has about a certain subject.

The Effects of Concept Maps on Learning

Concept maps are a tool that can be used in the classroom to connect prior knowledge to new knowledge, show relationships between concepts, show main ideas, summarize information, serve as a form of note taking, and show student misconceptions and misunderstandings within a subject (Blunt & Karpicke, 2014; Clariana & Koul, 2008; Henao-Cálad & Arango-Fonnegra, 2007; Wu, Hwang, Milrad, Ke, & Huang, 2012; Yang et al., 2013). The ability to be used in a variety of different ways makes concept maps a potentially valuable tool for teachers when used in the classroom, regardless of the academic subject in which it is being used. Concept maps can help teachers understand how students organize learned information and thus allow teachers to continue to help students while they are learning because teachers will now have insights into a
students’ knowledge structure. Studies about concept maps as a learning tool have shown that concept maps can increase academic success and improve students’ problem-solving skills within a subject, primarily due to students being actively involved in their education (Cheema & Mirza, 2013; Santiago, 2011).

Both the teacher and the student can use concept maps to identify misconceptions that can hinder learning. Teachers can use the information provided in student-constructed concept maps to address any misunderstandings and misconceptions students may have in their knowledge of a subject and then correct these misunderstandings (Cheema & Mirza, 2013; Karakuyu, 2011; Lee, 2013; Martínez et al., 2013; Vanides et al., 2005). Martínez et al. (2013), demonstrated that students who used concept maps in a university-level physics classroom scored higher on post-tests due to the use of concept maps during their lessons. This was because possible misconceptions within a subject were addressed, which allowed new knowledge to be placed in the students’ existing knowledge more easily.

Concept maps are tools that can also be used to determine how students organize information within a certain subject. Since teachers will be able to see how students organize concepts within a subject, they can use this information to help them in planning future lessons on a particular topic. These future lessons can be constructed to build upon what students already know or to address any misunderstanding and misconceptions that students may have (Daugherty et al., 2012; Gericke & Wahlberg, 2013; Lee, 2013; Santiago, 2011; Vanides et al., 2005; Wu et al., 2012). A benefit of concept maps is that they can be used before, during, and after a lesson to monitor student learning (Daugherty et al., 2012; Martínez et al., 2013). As discussed previously, concept maps are beneficial to teachers because they allow teachers to see how a student organizes content within a subject and because of their ability to be used throughout a lesson, but
they are also beneficial to students. According to Vanides et al. (2005), concept maps allow students to think about, organize, and reflect on relationships between concepts.

**Concept Maps as Support for Reading Materials**

Concept maps are an especially useful tool for helping students to organize information found in text materials. As a learning tool, concept maps have been described as a tool that makes learning more meaningful (Bentley et al., 2011; Cheema & Mirza, 2013; Hilbert & Renkl, 2008; Karakuyu, 2011; Lim et al., 2009; Novak & Gowin, 1984; Wu et al., 2012; Yang et al., 2013). After reading a section of text, concept maps can help students in connecting prior knowledge to new knowledge, showing relationships between ideas, identifying main ideas, and by identifying gaps in their current knowledge. To make learning from concept maps more meaningful, teachers need to show students how to plan the construction of their concept maps and how to accurately label the relationships between concepts. If students inaccurately label relationships on their concept maps, then they will not have learned the information correctly. Teachers need to show students how to determine what the correct relationships in the text are and then monitor that students are using these relationships to construct a meaningful concept map that increases learning (Hilbert & Renkl, 2008).

Blunt and Karpicke (2014) discuss how concept maps used as a retrieval method can be used to make leaning more meaningful. They concluded in their study that concept mapping and writing paragraphs are both effective at increasing learning after reading a text, but that learning was increased in students who recalled information without the use of the physical text after reading. This means that actively practicing recalling is more meaningful to learning than when using the text to create concept maps or to write a paragraph. Yang et al. (2013) looked at the use of concept maps that could be found online as a support to text material. These authors found
that the use of concept maps did support increased learning from text-based materials. These studies show that concept maps, whether used as support material or physically created by students after reading, can increase student learning of content found in text.

**Perceptions of Concept Maps**

For concept maps to be effectively implemented into the classroom, they need to be accepted by both the students and the teachers that will be using them. It was determined in a study by Karakuyu (2011) that both primary-level preservice and in-service teachers have positive attitudes towards the use of concept maps in the classroom. This was because both types of teachers believe that concept maps enhance learning and because they currently use concept maps to summarize and review certain concepts in the classroom.

Students also need to embrace the use of concept maps for them to have a positive effect on their learning. Bentley et al. (2011) looked at what factors contributed to the acceptance or rejection of a concept map as a learning tool amongst students in university-level science classrooms. The authors determined that students are more likely to embrace the use of concept maps if they know that it will provide them with the information needed to study for their assessments, if educators will provide feedback on student-constructed concept maps, and if concept maps fit into a students’ current study preferences. Wu et al. (2012) also discuss the importance of educator feedback on student attitudes towards concept maps. These authors discuss how instant feedback, provided by a specialized computer software tool, was found to increase the acceptance of a concept-map-based learning system in the classroom. This feedback allows students to review their concept maps and fix any mistakes, which will help the student while studying (Bentley et al., 2011; Wu et al., 2012). For concept maps to be beneficial to
student learning, students need to accept that they are using them to learn, but these maps may not be an ideal learning tool for every student.

**Implementation of Concept Maps**

The implementation of concept maps into the classroom can be done in numerous ways. Prior to utilizing concept maps in the classroom, an educator needs to show students how to create and interpret a concept map. Teachers need to show students how to draw concepts, connect concepts, and then label these connections to clarify relationships between concepts. Concept maps can either be created by paper and pencil or on the computer with specialized software packages, which is something a teacher has to consider when implementing concept maps into their classroom (Lee, 2013; Uewellyn, 2007; Vanides et al., 2005). Some schools, due to financing and other factors, may not be able to have students construct concept maps through software programs, which will force students to use the paper and pencil method to create concept maps. Certain teachers may also prefer software programs or paper and pencil concept maps over the alternate method, which will dictate what method teachers choose when implementing concept maps into their classrooms.

Teachers can present the structure of concept maps in various ways. Teachers can choose whether or not to provide students with key terms that will be used as concepts in the concept map. The phrases that show the relationships between concepts can also be provided or not provided by the teacher. Regardless of if the teacher provides the students with concept terms or relationship phrases, the teacher has to provide students with the main question or theme for students to be able to construct the concept map (Lee, 2013; Vanides et al., 2005). Daugherty et al. (2012) suggest that when students are presented with a concept mapping assignment that they first be presented with a context for the subject for students to be able to pull out key terms for
their concept maps. Students should then be provided clear instructions for the assignment, including the grading process of their concept map. Concept mapping activities need to focus on student learning and students should explain their concept maps to their teachers for the teachers to understand what the students thought processes within a subject were.

Concept maps can also be used as an assessment tool in the classroom. As an assessment tool, concept maps can show an educator how students organize concepts within a subject, identify misunderstandings, allows a teacher to physically see how a student incorporates new knowledge into their current learning schema, and also to see how a student has progressed in learning over time (Bentley et al., 2011; Cheema & Mirza, 2013; Lee, 2013; Uewellyn, 2007; Vanides et al., 2005). When evaluating concept maps, teachers need to look at the complexity of the concept maps, the presence of relationships between concepts, and then the quality of these relationships (Vanides et al., 2005). Lee (2013) discusses the use of structural or rational grading methods that can be used when grading concept maps. The structural grading method analyzes the links between concepts, which creates the concept map structure. The relational grading method analyzes the relationships between different concepts in the concept map. The use of rubrics or a teacher master copy of a concept map for comparison can also be used as grading methods. A teacher does not need to use the same grading method for each concept mapping activity. The grading method used can be dependent on the type of concept map created or the content used in the concept map (Lee, 2013). The use of concept maps as an assessment tool can be both beneficial to the student and the teacher.

**Conclusion**

Concept maps are a learning tool that can be used to build new knowledge onto existing knowledge to make learning more meaningful for students. This learning tool can be used across
disciplines, but can be used within a science classroom to improve student understanding and organization of a particular subject. Concept maps allow educators to identify how students organize the concepts within a subject and determine any misconceptions and misunderstandings that students may have. This can help teachers to plan lessons and clarify concepts in future lessons to help students learn. Concept maps can also be used as a support material to a text. Concept maps will allow students to pull main ideas from a text and create a visual representation of these main ideas.

For concept maps to be successfully implemented into the classroom they need to be accepted by both the educators and the students. Teachers need to show students how to create and interpret concept maps to enable students to be able to use them effectively. Allowing students to then create concept maps either before, during, or after learning can give a teacher valuable insights into what a student has learned and any misunderstandings they may have.

In this literature review, concept maps have been shown to be beneficial to learning. They serve as material to support learning and to make learning more meaningful. When implemented into a classroom, regardless of subject area, they can provide insight into student learning for both students and teachers. This insight can help educators in continuing to improve student learning and finding ways to make learning more meaningful to students.
Chapter 3: Method

Introduction

The purpose of this study was to see whether students will benefit from the use of concept maps in their high school elective biology classroom. During two units of human anatomy, students used concept maps as an additional learning tool. Pre- and post-test scores for each unit were used to show student achievement and to compare the class using the concept maps to the class who did not. Pre- and post-unit surveys were also given to the students to see how students felt about concept maps and how they felt concept maps impacted their learning. Student-constructed concept maps were analyzed to see if there were common trends in how students constructed and organized concepts within their concept maps.

Participants

The participants in this research study included students in two elective biology classes at a rural high school in Southeast Ohio. Both of these classes were college-prep, studying the same material, and one class consisted of 13 students and the other consisted of 14 students. Most students in these classes were juniors and seniors, with one student being a sophomore. One class consisted of twelve girls and one boy, whereas the other class consisted of seven girls and seven boys.

Procedures

Two elective biology classes were used for this research study. This study took place over the course of two units, which were back-to-back, on human anatomy. During one unit, one class utilized concept maps as a learning tool and the other did not. The class that utilized concept maps were referred to as the treatment class, and the class that did not utilize concept
maps were referred to as the control class for that unit. During the second unit, the same procedures were followed, but the class utilizing and the class not utilizing concept maps as a learning tool were switched.

Before the content of the unit was presented to the students, the students of both classes were given a pre-test to determine prior knowledge. At the start of each unit, the class that utilized concept maps for that particular unit were given a pre-survey. Students in the treatment class for each unit created concept maps for that unit as an additional learning tool. These student-constructed concept maps were analyzed after each unit to determine common trends in how students constructed and organized concepts within their concept maps.

At the end of each unit, students in both classes were given a post-test. The post-test included all of the same questions as the pre-test, but also some additional questions to determine content mastery. Only the questions that were the same on both tests were analyzed for the research. The class averages of the pre- and post-test were compared to analyze knowledge gained during the course of the unit. The class averages between the control and treatment classes for each unit were also compared to see if there was a significant difference in knowledge gained from the control and treatment class due to the additional tool of concept maps during the unit.

After each unit, the class that utilized concept maps for that particular unit were given a post-survey. The statements on the post-survey were the same as those on the pre-survey, but also included open-ended questions. These survey statements were analyzed using a Likert scale system to determine student feelings towards concept maps and if they increased after utilizing concept maps as a learning tool for a unit. The open-ended questions were analyzed for common responses in what helps students learn in science and how they felt about concept maps.
Instrumentation

Test scores, surveys, and concept maps were used as instruments during this study. For each human anatomy unit used during this study, a pre- and post-test were used. The post-test contained the same questions as the pre-test, but also additional questions to show mastery of the unit concepts. Pre- and post-surveys were used before and after the unit where each class utilized concept maps. The pre- and post-surveys contained the same statements that were measured by a Likert scale system. The post-survey also contained some open-ended questions for students to respond to. Student-constructed concept maps were also analyzed to determine if there were common trends amongst organization of the concepts within the unit of study.

Pre- and Post-test

At the start of each unit that was used in this study, students were given a pre-test. This measured the amount of prior knowledge students had going into the unit of study. At the end of each unit used in this study students were given a post-test. The post-test showed student mastery of the concepts learned in each unit. The pre-test consisted of the same questions as the post-test, but the post-test also contained more questions to show student mastery of the unit. Only the questions that were the same on both the pre- and the post-test were compared in the data analysis. During this unit, one of the biology classes utilized concept maps as a learning tool, while the other class did not. The pre- and post-test class averages were compared to determine knowledge gained from each class, but also to compare the averages of the class who utilized concept maps to the class who did not, in order to see if there was a significant difference in learning between these two classes. In the unit immediately following this unit, the same procedure was followed, but the class who utilized the concept maps was switched. The researcher evaluated the pre- and post-tests in the same manner as during the first unit of the
study. See Appendix A, Part 1 and Appendix A, Part 2 for pre- and post-test questions used for analysis for the first and second unit, respectively.

**Pre- and Post-survey**

Prior to the start of the unit, the students in the class that utilized concept maps for that unit were given a pre-survey. At the end of the unit, that class was given a post-survey. The pre- and post-survey contained the same nine statements that was measured with a Likert scale system. These survey statements were intended to see how students felt about concept maps and their impact on the students’ learning. The scores for each statement were added up and averaged to determine the average response to each statement and if the average of these responses changed from before the unit to after the unit that utilized concept maps for each class.

The post-survey also contained six open-ended questions that were not on the pre-survey. These questions were used to gain insight into what helps students learn in science and how they felt about concept maps in their own words. These survey questions were analyzed to determine common trends amongst responses. See Appendix B, Part 1 and Appendix B, Part 2 for the pre- and post-survey, respectively.

**Student-constructed Concept Maps**

Student-constructed concept maps were also analyzed to see if there were common trends in how students constructed and organized concepts within their concept maps. Concept maps were analyzed by looking at concepts placed in circles, the relation of the concepts to each other, and the terms used to show the relationship of one concept to another.

To get students used to constructing and reading concept maps, students were given multiple concept maps per unit. One type of concept map given to students was a concept map
already outlined by the researcher with the relationship lines, terms to describe the relationships, and circles to show where the concepts would be placed. Some of the circles were already completed with concept terms written in, but students were asked to fill in the missing concepts in the circles left blank. For this concept map, the researcher did have a copy of the concept map that served as an answer key since specific concepts fit into each specific concept circle. Since this concept map was not created by students, it was not used as part of the analysis of student-constructed concept maps. See Appendix C, Part 1 and Appendix C, Part 2 for an example of this kind of concept from the first and second unit of this study, respectively.

Another type of concept map used was where students were given a list of terms and asked to create a concept map using these terms. For this concept map, concept maps were analyzed by looking at concepts placed in circles, the relation of the concepts to each other shown by lines, and the terms and/or phrases used to show the relationship of one concept to another.

A final type of concept map used was when students were asked to create a concept map for a given topic in the unit and were given a list of terms to include in their concept maps, but were also given distracter terms that did not have anything to do with the specific topic of the concept map. For this concept map, just like the second concept map, concept maps were analyzed by looking at concepts placed in circles, the relation of the concepts to each other shown by lines, and the terms and/or phrases used to show the relationship of one concept to another.
Chapter 4: Results

To analyze results, pre- and post-test score averages for the treatment and control class were compared for each unit. Pre-test scores were compared to post-test scores to show knowledge gained by each class. Post-test scores for the treatment and control class were compared and an independent t-test was used to show if there was a significant difference in learning between the two classes. Pre- and post-survey responses were also compared to each other by adding the student responses for each Likert scale statement and averaging these responses for each class. Open-ended responses on the post-survey were analyzed by looking at common trends in responses. This showed how students felt about concept maps before and after their implementation into the classroom. Finally, student-constructed concept maps were analyzed to find common trends in how students organized information within a subject. Concept maps were analyzed by looking at concepts placed in circles, the relation of the concepts to each other, and the terms used to show the relationship of one concept to another.

Pre- and Post-Test Results for the First Unit

During the first unit this research was conducted on, 4th period, with 13 students, was the treatment class that utilized concept maps as a learning tool and 5th period, with 14 students, was the control class that did not utilize concept maps as a learning tool. Prior to the start of this unit, students in both classes were given a pre-test. Once the pre-test was submitted, the researcher graded each pre-test for percent correct and calculated a class average percentage. For this first unit, the class average on the pre-test for 4th period was 37.69% and 5th period was 45.00%. These results show that 5th period’s average was 7.31% higher than 4th period’s average on the pre-test.
This unit was taught the same to both classes, except 4th period also utilized concept maps as a learning tool. After the unit was taught, students were given a post-test. The post-test had more questions than the pre-test to show student content mastery of the material, but only the questions that were the same on both the pre- and post-test were analyzed and averaged for this research. On the post-test, the class average for 4th period was 90.00% and 5th period was 87.50%, which shows that both classes gained knowledge about topics in this unit. There was a 52.31% increase in the average test score for 4th period, and a 42.50% increase for 5th period. On the post-test, 4th period’s average was 2.50% higher than 5th period’s average. See Table 1 for comparison of class average percentages on the pre- and post-tests.

An independent t-test was done to determine if the difference in class averages on the post-test was statistically significant. When comparing the post-test scores of 4th and 5th period, p=0.539 with the significance level being 0.05. Since the p-value of 0.539 is greater than 0.05, this data is shown to not be significant. For this unit, the use of concept maps as a learning tool in 4th period did not correlate to significantly higher post-test scores than 5th period, who did not utilize concept maps as a learning tool in this unit.
Table 1: Pre- and post-test averages for the first unit. The treatment class was 4th period and the control class was 5th period.

<table>
<thead>
<tr>
<th>Class Period and Test</th>
<th>Class Average Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th Pre-Test</td>
<td>37.69</td>
</tr>
<tr>
<td>4th Post-Test</td>
<td>90.00</td>
</tr>
<tr>
<td>5th Pre-Test</td>
<td>45.00</td>
</tr>
<tr>
<td>5th Post-Test</td>
<td>87.50</td>
</tr>
</tbody>
</table>

Pre- and Post-Test Results for the Second Unit

For the second unit, 4th period served as the control class and 5th period served as the treatment class. A pre-test was given prior to the start of this unit. Once the pre-test was submitted, the researcher graded each pre-test for percent correct and calculated a class average percentage. On the pre-test, 4th period had a class average of 26.72% and 5th period had a class average of 23.69%. This data shows that 4th period’s average was 3.03% higher than 5th period’s average on the pre-test.
During this unit, both classes were taught in the same manner, except 5\textsuperscript{th} period utilized concept maps as an additional learning tool. Students were given a test at the end of the unit that had all of the same questions as the pre-test, but also more for students to demonstrate content mastery. Only the questions that were the same as those on the pre-test were analyzed and averaged for comparison. On the post-test, the class average for 4\textsuperscript{th} period was 76.92\% and the class average for 5\textsuperscript{th} period was 67.29\%. This reveals that both classes learned material in this unit due to an increase in post-test results in comparison to the pre-test results. There was a 50.20\% increase in the average test score for 4\textsuperscript{th} period, and a 43.60\% increase for 5\textsuperscript{th} period. On the post-test, 4\textsuperscript{th} period’s average was 9.63\% higher than 5\textsuperscript{th} period’s average. See Table 2 for comparison of pre- and post-test class averages for 4\textsuperscript{th} and 5\textsuperscript{th} period during the second unit.

An independent t-test was used on the post-test results of 4\textsuperscript{th} and 5\textsuperscript{th} period to see if there was a significant difference in learning between 4\textsuperscript{th} period, who did not utilize concept maps, and 5\textsuperscript{th} period, who did utilize concept maps in the second unit. With p=0.172, which is greater than the significance level of 0.05, the difference in post-test results between 4\textsuperscript{th} and 5\textsuperscript{th} period was not significant.
Table 2: Pre- and post-test averages for the second unit. The control class was 4\textsuperscript{th} period and the treatment class was 5\textsuperscript{th} period.

![Class Averages for Pre- and Post-Tests - Second Unit](image)

Pre- and Post-Surveys for the First Unit

For the first unit, 4\textsuperscript{th} period was the treatment class that utilized concept maps as a learning tool. Prior to the start of this unit, students were given a pre-survey to see how students felt about concept maps and their impact on their learning prior to using them in the unit. There were nine statements on the survey, each to be rated from 1 (strongly disagree) to 5 (strongly agree) on a Likert scale. After the unit was taught, students were given a post-survey, which included the same nine statements as the pre-survey and six additional open-ended questions.
The post-survey was intended to see if students’ feelings about concept maps and their impact on their learning had changed.

The results for each statement on the nine Likert scale questions were totaled and averaged. The results are shown in Table 3 below. As can be seen in Table 3, averages to statement 1 through 4, and 6 decreased from the pre- to post survey. Averages for statements 5, and 7 through 9 increased from the pre- to post-survey.

*Table 3: Pre- and Post-survey results for 4th period during the first unit.*

<table>
<thead>
<tr>
<th>Statement</th>
<th>Pre-Survey</th>
<th>Post-Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) I am a visual learner.</td>
<td>4.00</td>
<td>3.77</td>
</tr>
<tr>
<td>2) Concept maps help me learn.</td>
<td>3.62</td>
<td>3.23</td>
</tr>
<tr>
<td>3) Concept maps help me visualize concepts within a unit.</td>
<td>3.62</td>
<td>3.23</td>
</tr>
<tr>
<td>4) Concept maps help me visualize the relationships between concepts within a unit.</td>
<td>3.77</td>
<td>3.69</td>
</tr>
<tr>
<td>5) I like utilizing concept maps as a study tool.</td>
<td>3.23</td>
<td>3.31</td>
</tr>
<tr>
<td>6) I like creating concept maps.</td>
<td>3.23</td>
<td>3.00</td>
</tr>
<tr>
<td>7) I like reading concept maps.</td>
<td>3.15</td>
<td>3.46</td>
</tr>
<tr>
<td>8) I currently like biology 2.</td>
<td>4.00</td>
<td>4.08</td>
</tr>
<tr>
<td>9) I like learning about anatomy.</td>
<td>3.54</td>
<td>4.15</td>
</tr>
</tbody>
</table>

On the post-survey there was also six open-ended questions that students were to respond to. These questions were on the post-survey after the nine Likert scale statements. Responses to each question from the 13 students in 4th period are recorded and/or summarized below. Similar responses to each question were listed near each other.
Question 10) *How do you believe you learn best in the classroom?*

Responses:

- Hands on through labs + explanation.
- Hands on learning.
- Hands on.
- I learn best by hands on or visually.
- Through a visual representation and repetition.
- Visually.
- I learn best when given visual examples. Using Kahoot also helped because it’s a little hard to study alone.
- Reading + writing the notes. Visually + also interacting with the project.
- By taking notes that have examples. (Like we currently do).
- I like notes, with lots of review and interaction.
- Powerpoints.
- Experiments.
- Being able to listen to the teacher instead of writing, given 2 days to study, Kahoot, and given something to compare the example to. Ex. The movement of cells like dancing.

Question 11) *What has been done so far this school year in biology 2 that has helped you learn?*

Responses:

- Actually doing labs hands on ourselves.
- Any labs or hands on stuff.
- Labs and hands on stuff.
- Study guides, labs.
- Labs, call teacher, study guides, and Kahoot.
- The notes and labs.
- Notes-I learn better by writing them because I grasp information better.
- Dissecting stuff.
- The concept maps have helped a lot because I can see how things are related in an easy way.
- Concept maps.
- Concept maps, notes, worksheets.
- The teacher went over what he/she was talking about more than once.
- One student did not write an answer.

Question 12) *How do you feel about concept maps?*

Responses:

- They are a good tool to show relationships in a system.
- Kinda hard, but they help me.
- They are okay.
- Looking at them helps me see what goes together.
- See 11 (Response to 11: “The concept maps have helped a lot because I can see how things are related in an easy way.”)
- I feel like they help me visually see where the layers of skin were and the functions of the skin.
- They can be a good study guide.
- They’re a useful study tool.
- I complain about them, but they aren’t that bad
- Me-emotions felt-despair, frustration, hopelessness (just kidding).
- I honestly think that they are a waste of time. I can’t really learn from them.
- Strongly dislike them
- One student did not write an answer.

Question 13) Do you feel that concept maps can help you learn in biology?

Responses:

- Seven students responded: Yes/Yup.
- Yes, I like that they make you see the terms as a whole idea, look at them in a new way.
- Yes-see 11 (Response to 11: “The concept maps have helped a lot because I can see how things are related in an easy way.”)
- Somewhat.
- I believe they won’t help at all.
- Maybe for other people but not me.
- One student did not write an answer.

Question 14) Do you feel that concept maps helped you to better understand some of the concepts learned in this unit?

Responses:

- Two students responded: No
- Seven students responded: Yes/Yup
- I definitely better understood the chapters we did with concept maps.
- Yes, I like that they make you see the terms as a whole idea, look at them in a new way.
- Somewhat.
- One student did not write an answer.

Question 15) *Do you feel that concept maps helped you organize some of the concepts learned in this unit?*

Responses:

- Nine students responded: Yes/Yup.
- A little.
- Somewhat.
- Not really.
- One student did not write an answer.

**Pre- and Post-Surveys for the Second Unit**

For the second unit, 5th period was the treatment class that utilized concept maps as a learning tool. Prior to the start of this unit, students were given a pre-survey to see how students felt about concept maps and their impact on their learning prior to using them in the unit. There were nine statements on the survey, each to be rated from 1 (strongly disagree) to 5 (strongly agree) on a Likert scale. After the unit was taught, students were given a post-survey, which included the same nine statements as the pre-survey, but also six open-ended questions. The post-survey was intended to see if students’ feelings about concept maps and their impact on their learning had changed.
The results for each statement on the nine Likert scale questions were totaled and averaged. The results are shown in Table 4 below. As can be seen in Table 4, the average response to all statements, except statement 6, increased. The average response for statement 6 did not change at all.

Table 4: Pre- and Post-survey results for 5th period during the second unit.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Pre-Survey</th>
<th>Post- Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) I am a visual learner.</td>
<td>4.36</td>
<td>4.43</td>
</tr>
<tr>
<td>2) Concept maps help me learn.</td>
<td>3.21</td>
<td>3.57</td>
</tr>
<tr>
<td>3) Concept maps help me visualize concepts within a unit.</td>
<td>3.36</td>
<td>3.71</td>
</tr>
<tr>
<td>4) Concept maps help me visualize the relationships between concepts within a unit.</td>
<td>3.43</td>
<td>3.86</td>
</tr>
<tr>
<td>5) I like utilizing concept maps as a study tool.</td>
<td>3.07</td>
<td>3.21</td>
</tr>
<tr>
<td>6) I like creating concept maps.</td>
<td>3.14</td>
<td>3.14</td>
</tr>
<tr>
<td>7) I like reading concept maps.</td>
<td>2.57</td>
<td>3.36</td>
</tr>
<tr>
<td>8) I currently like biology 2.</td>
<td>4.14</td>
<td>4.43</td>
</tr>
<tr>
<td>9) I like learning about anatomy.</td>
<td>4.00</td>
<td>4.14</td>
</tr>
</tbody>
</table>

On the post-survey there was also six open-ended questions that students were to respond to. These questions were on the post survey after the nine Likert scale statements. Responses to each question from the 14 students in 5th period are recorded and/or summarized below. Similar responses to each question were listed near each other.

Question 10) How do you believe you learn best in the classroom?

Responses:

- Usually (This is all the student wrote.)
- By listening and being involved in discussions.
- With doing projects and getting hands on.
- By hands on activities.
- Hands on experience and study games
- Two students responded: Hands on.
- Notes and visually/hands on.
- Hands on, visually.
- Visual.
- Visually.
- Depends on what we are learning about.
- Worksheets.
- Going over it in class over and over.

Question 11) *What has been done so far this school year in biology 2 that has helped you learn?*

Responses:

- Kahoot helps me review, but visual things are better.
- Kahoot!
- Same answer for #10 (Response to 10: “By listening and being involved in discussions.”)
- Student teaching lady.
- Dissections, class discussion, etc.
- Dissections.
- Study guide.
- Creating test review sheets.
- Study guides and hands on activities.
- Asking a lot of questions.
- Student teacher’s study guides and Kahoot.it.
- The notes.
- Notes.
- One student did not respond to this question.

Question 12) How do you feel about concept maps?

Responses:

- Don’t like them.
- Not sure.
- I feel they are confusing.
- They are helpful, but confusing to make.
- I like them but sometimes are confusing to make.
- They’re alright.
- They’re OK.
- They’re okay. Not the best learning tool but they help.
- They can be helpful.
- They help me.
- Great.
- Easy to make and help you remember stuff in a unit.
- They are easy to read, I just don’t understand the info enough to put it into a concept map.
- They are acceptable for certain uses.
Question 13) *Do you feel that concept maps can help you learn in biology?*

Responses:

- Six students responded: Yes.
- Yes, if I understand the stuff we are learning better.
- They show the breakdown of large systems.
- It depends on the topic in which we are discussing.
- In certain chapters.
- Somewhat.
- I think they do.
- Undecided.
- No.

Question 14) *Do you feel that concept maps helped you to better understand some of the concepts learned in this unit?*

Responses:

- Five students responded: Yes.
- Six students responded: Kinda/Somewhat.
- Two students responded: No.
- I don’t think so.

Question 15) *Do you feel that concept maps helped you organize some of the concepts learned in this unit?*

Responses:
- Three students responded: No.
- Seven students responded: Yes.
- Three students responded: Kinda/Somewhat.
- A little bit

**Concept Maps Created During the First Unit**

During the first unit, 4th period was the class that utilized concept maps as a learning tool. This class worked with three concept maps during this unit. During this unit, the first section taught to the students was about the human skeletal system. The first concept map given to students, asked students to fill in missing concepts in a concept map created by the researcher. This concept map served as a way to get students used to reading and filling in concepts in a concept map. The researcher looked at the concept maps students turned in and compared it to a concept map that served as an answer key, but did not analyze this as part of the research since the concept map itself was not created by the students.

The second section in this unit was about the muscular system. In this section students were asked to create a concept map after being given a list of seven key concepts to use as concepts for this section. The concepts were *smooth muscle, skeletal muscle, the muscular system, cardiac muscle, bones, internal organs,* and *heart.* For this concept map, all 12 students who created concept maps constructed their maps showing the same relationships. One student did not complete the assignment. *Picture 1* shows how all students in 4th period represented concepts in circles and connected the concepts with lines. The only difference between students’ concept maps was the physical location of the concepts on the page. As can be seen in *Picture 1,* all students identified *the muscular system* as the main concept of the section, which can be broken down to the *cardiac muscle, smooth muscle,* and *skeletal muscle.* Seven students had one
line coming from the muscular system concept that branched into three lines to cardiac muscle, smooth muscle, and skeletal muscle. The five remaining students had three individual lines emerging from the muscular system concept to attach to the cardiac muscle, smooth muscle, and skeletal muscle. All students then connected cardiac muscle to the heart, smooth muscle to internal organs, and skeletal muscle to bones.

Picture 1: General representation of concept map created by 12 students in 4th period.
Four students verbalized the relationships between concepts by using terms and/or phrases to connect the lines between concepts. *Picture 2* shows how three students verbalized the relationship between different concepts. The fourth student did not write “consists of” after *the muscular system* concept circle, wrote “located” after the *cardiac muscle, smooth muscle*, and *skeletal muscle* concept circles on the line, and wrote “around” in the concept circles that said *heart, internal organs, and bones.*

*Picture 2*: Concept map similar to that created by three students in 4th period that verbalizes the relationships between concepts.
For the third section in this unit, which was about the integumentary system, students were given a list of concepts and asked to create a concept map of the third section of the unit. Students were given the following concepts: skin, barrier to infection, epidermis, smooth muscle, osteocytes, remover of waste products, dermis, skeletal muscle, outer layer, osteoblasts, inner layer, protects against UV radiation, cardiac muscle, regulator of body temperature, and osteoclasts. In this list of concepts there are concepts that served as distracter concepts and did not have anything to do with the third section of the unit. The distracter concepts are: smooth muscle, osteocytes, skeletal muscle, osteoblasts, cardiac muscle, and osteoclasts. Twelve students created concept maps and one did not. There was a greater variation of how students arranged their concept maps for this section.

Three students created their concept maps similarly to the one depicted in Picture 3. As seen in Picture 3, these students identified skin and the main concept. From the concept of skin the students have one line emerging that divides into two pathways. One pathway is verbalized with the term “function” which leads to the concepts barrier to infection, remover of waste, protects against UV radiation, and regulates body temperature. The second pathway is verbalized with the phrase “divides into” and leads to the concepts dermis and epidermis. A line emerges from the concept dermis and leads to the concept inner layer. A line also emerges from the concept epidermis and leads to the concept outer layer.
Four other students also created their concept maps in a similar manner to that shown in Picture 3, but with some variations. The difference on two of the four concept maps are seen on the line leading to the concepts *dermis*, *epidermis*, *inner layer*, and *outer layer*. In these concept maps, the line leading to these concepts says “layers” and creates two branches into the terms “outer” and “inner.” The term “outer” leads to *epidermis* and the term “inner” leads to *dermis*. None of the words or phrases are circled in these concept maps. The difference on the other two concept maps are that they do not use words or phrases to verbalize the relationships between concepts and instead of putting *epidermis* and *dermis* before *inner layer* and *outer layer*, they
constructed it with the layers of skin (inner layer and outer layer) before the name of the layer (dermis and epidermis).

One student created a concept map with the concept skin as the main concept with one line emerging from it, which divides into six lines. These six lines lead to the following concepts: barrier to infection, remover of waste, protects against UV radiation, regulates body temperature, epidermis, and dermis. A line emerges from both epidermis and dermis, which leads to the concepts outer layer and inner layer, respectively.

Two other students created concept maps with the concept skin as the main concept with three lines emerging from this concept. One line leads to epidermis, which connects to outer layer, a second line leads to dermis, which leads to inner layer, and the third line leads to the term “functions”, which was placed in a circle. This circle has four lines emerging from it to lead to the concepts barrier to infection, remover of waste, protects against UV radiation, and regulates body temperature.

Two students constructed their concept maps in a manner that was more varied than the previous concept maps. One student created her concept map similar to the one depicted in Picture 4. As seen in Picture 4, skin is identified as the main concept, with one line emerging from this concept and verbalized with the term “layers.” This line branches into two concepts, epidermis and dermis. Unlike previously analyzed concept maps, epidermis has one line emerging from its’ circle, verbalized with the term “function”, which branches into regulator of body temperature and protects against UV radiation. The concept dermis also has one line emerging from it verbalized with the term “function”, which branches and leads to the concepts barrier to infection and regulator of body temperature.
Picture 4: Concept map created by one student in 4th period.

The second student, also identified skin as the main concept, but has two lines emerging from it. One line leads to the concept *inner layer* and the other to the concept *outer layer*. The *inner layer* concept has a line emerging from it, leading to the concept *dermis*, which has a line emerging from it leading to the concept *regulator of body temperature*. The *outer layer* concept has a line emerging from it, leading to the concept *epidermis*. The *epidermis* concept has three
lines emerging from it, with one line leading to the concept *remover of waste products*, the second to *protects against UV radiation*, and the third leading to *barrier to infection*.

**Concept Maps Created During the Second Unit**

During the second unit, 5th period was the class that utilized concept maps as a learning tool. This class interacted with two concept maps during this unit. During this unit, the first section taught to the students was about the human circulatory system. The first concept map given to students asked students to fill in missing concepts in a concept map created by the researcher. This concept map served as a way to get students used to reading and filling in concepts in a concept map. The researcher looked at the concept maps students turned in and compared it to a concept map that served as an answer key, but did not analyze this as part of the research since the concept map itself was not created by the students.

The second section in this unit was about the human blood system. Students were given a list of concepts and asked to create a concept map. The concepts were: *red blood cells, enzymes, blood clot, plasma, infection, white blood cells, blood cells, water, plasma proteins, oxygen, blood*, and *platelets*. There was a variety of different concept maps created by students in this class. Five out of 14 students created a concept map similar to that shown in Picture 5. As seen in Picture 5, students identified *blood* as the main concept. From the concept *blood*, two lines emerge with one line leading to the concept *plasma* and the other to the concept *blood cells*. From the concept *plasma*, three lines emerge leading to the terms *enzymes, plasma proteins*, and *water*. Three lines also emerge from the concept *blood cells* leading to the terms *platelets, white blood cells*, and *red blood cells*. From each of these concepts emerges a line. The line from *platelets* leads to the concept *blood clot*, the line from *white blood cells* leads to the concept *infections*, and the line from *red blood cells* leads to the concept *oxygen*. Only one student put a
shape around the concepts, which were rectangles. One student put rectangles around all concepts except *blood*, while another student put a rectangle around the concept *blood* and none of the rest. Two students did not circle any concepts. Out of the five students who created a concept map similar to that depicted in *Picture 5*, only one put the terms seen in the photo to verbalize the relationship lines between the different concepts. One other student created a concept map similar to the one depicted in *Picture 5*, without terms describing the relationships between concepts, except this student connected the concept *enzymes* to the concept *water*, instead of to the concept *plasma*.

*Picture 5*: Concept map similar to that created by five students in 5th period.
Two students identified \textit{blood} as the main concept and had four lines emerging from this concept leading to the concepts \textit{red blood cells}, \textit{platelets}, \textit{white blood cells}, and \textit{plasma}. \textit{Red blood cells} in then connected to a circle that says “transports oxygen”, and \textit{platelets} is linked to \textit{blood clots} on one map and “promoting blood clotting” on the other. On one map, \textit{white blood cells} in connected to “helps fight infection, parasites, and bacteria” and “performs a variety of protective functions.” In this map, the concept \textit{platelets} is connected to rectangles containing “fluid in blood”, “90% water”, “10% enzymes along with other stuff”, and \textit{plasma proteins}, which is connected to rectangles containing “albumin”, “globulins”, and “fibrinogen.”

On the other concept map, which does not use rectangles or circles around concepts, \textit{white blood cells} is connected to “protects against infection, parasites, bacteria.” \textit{Plasma} is connected to “fluid in blood”, which is linked to “90% water, 10% nutrients, enzymes, etc.” The concept \textit{plasma} is also linked to the concept \textit{plasma proteins}, which is linked to “albumins”, “globulins”, and “fibrinogen.” The term “albumins” is liked to “regulate osmotic pressure”, “fibrinogen” to “makes blood clot”, and “globulins” to “transport.”

One student identified \textit{blood} as the main concept, which was linked to \textit{blood cells} and \textit{platelets}. \textit{Blood cells} was further linked to \textit{red blood cells} and \textit{white blood cells}, which was further linked to \textit{oxygen} and \textit{blood clot}, respectively. No terms were used to verbalize connections in this concept map.

One student identified \textit{blood} as the main concept, which was linked to \textit{red blood cells}, \textit{platelets}, and \textit{white blood cells}. \textit{Red blood cells} was linked to \textit{oxygen} and \textit{blood cells}. \textit{White blood cells} was linked to \textit{infection} and \textit{blood cells}. \textit{Platelets} was linked to \textit{plasma proteins}, \textit{blood cells}, \textit{blood clots}, and \textit{enzymes}. \textit{Plasma proteins} was further connected to \textit{water}. No terms were used to verbalize connections in this concept map.
Two students identified *blood* as the main concept, which was linked to *blood cells* and *plasma*. *Blood cells* was then linked to *red blood cells* and *white blood cells*, which were linked to *oxygen* and *infection*, respectively. *Plasma* was linked to *water*, *enzymes*, and *plasma proteins*, which was further linked to *blood clot* and *platelets*. One student did use the terms “carry” to show the relationship between *red blood cells* and *oxygen*. This same student used the term “fights” to verbalize the relationship between *white blood cells* and *infection*, while the other student wrote “fight” in the concept circle. The same initial student also used the term “90%” to verbalize the relationship between *plasma* and *enzymes*, while the other student wrote “90%” in the concept circle.

One student created a concept map like the one shown in Picture 6. As shown in Picture 6, the student wrote “blood system” as the main topic of the concept map, which is linked to *blood cells*, *platelets*, and *plasma*. *Blood cells* is linked to *white blood cells* and *red blood cells*, with the phrase “consists of” verbalizing this relationship. *White blood cells* is linked to *infection* with the term “fight.” *Red blood cells* is linked to *oxygen* with the term “carry.” *Platelets* is linked to *blood clots* with the term “form” and *blood clots* is linked to the term *blood* with the phrase “to stop the flow of.” *Plasma* is linked to *water* and *enzymes* with the phrase “consists of.” In the *water* concept circle, “90%” is written in parenthesis, and in the *enzymes* concept circle, “other stuff” is written in parenthesis. Both *water* and *enzymes* is connected to *plasma proteins* with the phrase “divides into.”
One student created two smaller concept maps for this material. In the first concept map, this student identified *blood* as the main concept, which is linked to *blood cells* by the term “different.” *Blood cells* is connected to *red blood cells, platelets,* and *white blood cells.* *Red blood cells* is linked to *oxygen* with the term “has”, *platelets to blood clot* with the term “causes”, and *white blood cells to infection* with the term “fights.” The second concept map created by this student has the term *plasma* as the main concept, which is linked to *water, plasma proteins,* and *enzymes* with the phrase “made up from.”
Chapter 5: Discussion, Conclusions, Recommendations and Implications for Practice

Discussion

The purpose of this study was to see if the use of concept maps improved student understanding and organization of a subject. There were four research questions that this research study aimed to answer.

Research question one. The first question was: Does the use of concept maps as a learning tool significantly increase test scores? The answer to this question was revealed in the analysis of the pre- and post-test scores of each unit. During the first unit of this study, 4th period was the treatment class that utilized concept maps as a learning tool and 5th period was the control class. For this unit, the class average on the pre-test for 4th period was 37.69% and 5th period was 45.00%. The class average on the post-test for 4th period was 90.00% and 5th period was 87.50%. Both classes showed an increase in average percentage from the pre-test to the post-test, showing content knowledge was gained. An independent t-test was performed on the post-test averages between the 4th and 5th period classes, which revealed that the difference in percentages is not statistically significant with the p-value being 0.539 at a significance level of 0.05.

During the second unit of this study, 5th period was the treatment class that utilized concept maps as a learning tool and 4th period was the control class. For this unit, the class average on the pre-test for 4th period was 26.72% and 5th period was 23.69%. The class average on the post-test for 4th period was 76.92% and 5th period was 67.29%. Again, both classes showed an increase in average percentage from the pre-test to the post-test, showing content knowledge was gained. An independent t-test was performed on the post-test average between
the 4th and 5th period classes, which revealed that the difference in percentages is not statistically significant with the p-value being 0.172 at a significance level of 0.05. Also, the class average percentage on the post-test for 5th period, which utilized concept maps during this unit, was lower than 4th period’s. Overall, this data reveals that the use of concept maps as a learning tool did not significantly increase test scores.

As stated above, these data reveal that the use of concept maps as a learning tool did not significantly increase test scores, but it does reveal that 4th period had a higher amount of gain than 5th period from the pre- to post-test during the first unit. On the pre-test, 4th period’s class average was 37.69% and the average on the post-test was 90.00%. From the pre- to post-test, 4th period, serving as the treatment class for the first unit, had a 52.31% gain. On the pre-test, 5th period’s class average was 45.00% and the average on the post-test was 87.50%. From the pre-to post-test, 5th period had a 42.50% gain. Overall, 4th period had a 9.81% higher gain than 5th period. This percent gain did not hold true in the second unit, where 5th period was the treatment class, because the class average percentage on the post-test was lower than 4th period’s. Though, the use of concept maps as a learning tool did not significantly increase test scores, the percent gain from the pre- to post-test demonstrated in the first unit shows that the use of concept maps do have benefits to learning that may be validated through further studies.

The reason that test scores were not significantly increased may be due to various reasons. Concept maps were used with both classes when they were the treatment class, but maybe not enough were used. Both classes were provided with a concept map where they had to fill in missing concepts in circles and then were asked to create a concept map using a list of terms. Only one class was given the opportunity to create a concept map about a specific subject when given a list of concepts with distractor concepts embedded into the list. Other concept
maps should have been provided to students in examples, on assignments, on homework, and in the direct instruction. This would provide students with more opportunities to interact with the concept maps.

Also, while teaching the units, the material presented in the first unit, where 4th period was the treatment class, seemed to be easier for students to understand than the material presented in the second unit. The material covered in the second section seemed more complex for students to understand in both classes, which may have contributed to the reason why in the second unit, the treatment class scored lower than the control class on the post-test. Also, 4th period had six students who were seniors working towards scholarships, whereas 5th period only had three seniors. This may have led to increased motivation amongst 4th period students to earn high grades for their scholarship attempts. Generally, 4th period does score higher as a class on unit exams than 5th period.

Research question two. The second question this research study aimed to answer was:

Did students' feelings about the use of concept maps as a learning tool change after using them?

The answer to this question was revealed in the analysis of the scores of the first nine statements on the pre- and post-surveys. These nine statements were rated from 1 (strongly disagree) to 5 (strongly agree) on a Likert scale. The scores for each statement on the pre- and post-survey were averaged for comparison. Statements 2 through 7 specifically asked about concept maps.

For the first unit of this study, 4th period was the treatment class that utilized concept maps as a learning tool. The average score for statements 2, 3, 4, and 6 decreased from the pre- to the post-survey, while the average score for statements 5 and 7 increased. These results reveal, on average, that students did not feel the concept maps helped them learn (statement 2), visualize concepts within a unit (statement 3), visualize the relationships between concepts within a unit
(statement 4), or like creating concept maps (statement 6). The results of the surveys also revealed that students, on average, liked utilizing concept maps as a study tool (statement 5) and did like reading concept maps (statement 7).

The reason that many of the averages for the survey statements decreased may be because students were not comfortable with concept maps. When first presented with concept maps, many of the students knew what they were once they saw them, but did not seem to have had much interaction with them in the past. This may have led to students feeling uncomfortable with their ability to create and see the relations within concept maps. Also, students may have viewed this as an extra assignment more than a tool designed to help them in this unit and in their future learning.

For the second unit of this study, 5th period was the treatment class that utilized concept maps as a learning tool. The average score for statements 2, 3, 4, 5, and 7 increased from the pre- to the post-survey, while the average score for statement 6 stayed the same. These results reveal that, on average, students felt that concept maps helped them learn (statement 2), visualize concepts within a unit (statement 3), visualize the relationships between concepts within a unit (statement 4), liked utilizing concept maps as a study tool (statement 5), and liked reading concept maps (statement 7). The results of the surveys also revealed that students’ feelings towards creating concept maps did not change (statement 6).

The reason that the averages for these statements, except statement 6, may have slightly increased is possibly because students somewhat liked concept maps and what they were intended for, but still found them challenging. Some students in 5th period liked concept maps, but a lot of students initially struggled with them, probably because they were uncomfortable with them. If students had more interaction with concept maps in the past then they may not have
struggled as much with them during the research study. Also, the material presented in this unit was more complex than the previous unit, which may have led to students struggling to create concept maps with this information.

**Research question three.** The third question this research study aimed to answer was: _How do students feel about concept maps and do students feel that concept maps help them learn?_ This question was answered by the results of questions 12, 13, 14, and 15 on the post-survey. Question 12 was used to see how students feel about concept maps, whereas questions 13, 14, and 15 were used to see if students feel that concept maps helped them learn.

In response to question 12 during the first unit, it is revealed that a majority of students in 4th period found concept maps useful for various reasons, such as seeing relationships in a unit or to use them as a study tool. Three students revealed that they do not like concept maps, but do not thoroughly explain why. One student did not respond to this question. Overall, a majority of students in 4th period had positive feelings in regards to concept maps.

In response to question 13 during the first unit, it is revealed that 10 students, on some level, felt that concept maps can help them learn and two students felt that concept maps cannot help them learn. One student did not respond to this question. In response to question 14, it is revealed that 10 students, on some level, felt that concept maps helped them to better understand some of the concepts learned in the unit, whereas two students did not. One student did not respond to this question. Finally, in response to question 15, it is revealed that 11 students, on some level, felt that concept maps helped them organize some of the concepts learned in this unit, while one student did not feel so. One student did not respond to this question. Upon analysis of the responses to questions 13, 14, and 15, it is revealed that a majority of students in 4th period did feel that concept maps helped them learn.
In response to question 12 during the second unit, it is revealed that 11 students in 5th period felt that concept maps were okay or somewhat helpful, with multiple students revealing that they also felt they were confusing to make. Three students revealed that they did not like them, were not sure about their feelings towards concept maps, or thought they were confusing. Overall, these responses show that a majority of students had positive feelings towards concept maps, but also felt that they were sometimes confusing to make.

In response to question 13 during the second unit, it is revealed that 12 students in 5th period, on some level, felt that concept maps can help them learn in biology or at least in certain subject matter, whereas one student was undecided, and another student felt that concept maps cannot not help him/her learn in biology. In response to question 14, it is revealed that 11 students, on some level, felt that concept maps helped them to better understand some of the concepts learned in the unit. Three students did not feel this way about concept maps. In response to question 15, it is revealed that 11 students, on some level, felt that concept maps helped them to organize some of the concepts learned in the unit, but three students did not think so. Overall, responses to questions 13, 14, and 15 reveal that most students did feel that concept maps could help them learn.

These data show that a majority of students in these two classes felt positively about concept maps, but also found them a bit challenging to make. This may be due to students not being very comfortable with creating or reading concept maps or due to the material, which could sometimes be complex for students. Students could see the potential benefit of using concept maps, but were also not comfortable in creating and using them. Also, majority of students did feel that concept maps did help them learn, though these scores might have been higher on
the post-survey for both classes if students had more experience with and felt more comfortable using concept maps.

**Research question four.** The fourth question this research study aimed to answer was: *Are there common themes amongst how students organize concepts within a unit?* This question was answered by analyzing student-constructed concept maps. During the first unit of this study, 4th period worked with three concept maps. Students constructed two of these maps. The first student-constructed map was for the second section of the unit of study. In this section, all 12 students who created concept maps constructed theirs in a similar way, as shown in *Picture 1* above, with *the muscular system* as the main concept leading to the types of muscles, leading to the locations of these muscles. Three of these students also verbalized the relationships between concepts as shown in *Picture 2* above.

The second student-constructed concept map was for the third section of the unit. All 12 students who created concept maps identified *skin* as the main concept. Three students had a line emerging from the concept *skin* leading to its functions and another line leading to the layers of skin. This is shown in *Picture 3* above. Four other students also created their concept maps in a similar manner to that shown in *Picture 3* above, but with some variations. These variations mostly consisted of the absence and presence of terms/phrases to describe relationships between concepts and the order of concepts in relation to each other. One student had one line emerging from the concept *skin*, which divides into six lines leading to the functions and layers of skin. Two students had three lines emerging from the concept *skin*, with two of the lines leading to layers of skin and the other to its functions. One students’ concept map was similar to that shown in *Picture 4* above. Another student has two lines emerging from the concept *skin* leading to the layers of skin, their names, and then various functions.
In the first student-constructed concept map, all students had similar concept maps that showed correct relation of concepts to each other. There was more variations amongst the second student-constructed concept map. Common similarities included grouping the four functions together and then the name of a layer of skin and which layer it was (outer or inner layer). Most concept maps were consistent with how the material was taught to the students. Students were taught about the functions of skin and then about the layers of skin, though they were not taught which layer carries out which specific function. The two concept maps who connected the functions to the specific layer of skin were the most unique because students were not taught this relationship in biology 2.

During the second unit of this study, 5th period worked with two concept maps and constructed one of these maps. In this class, all 14 students created concept maps for the second section of the unit, with 12 students identifying blood as the main concept, one student creating two smaller concept maps and identifying blood as the main concept for one and plasma for the other, and another student identifying “blood system” as the main concept. Five of the students created concept maps similar to Picture 5 above. In this concept map, students had one line emerging from blood leading to plasma and its derivatives and another line leading to blood cells and the three different types and their functions. A sixth student created a concept map very similar to Picture 5 except this student connected the concept enzymes to the concept water, instead of to the concept plasma. Two students identified blood as the main concept and had four lines emerging from this concept leading to the concepts red blood cells, platelets, white blood cells, and plasma. These two concept maps varied slightly from each other, as described above, but had very descriptive connections between concepts and also some concepts not given in the concept term bank, but provided in class notes.
One student connected blood to blood cells and platelets. Blood cells was further linked to red blood cells and white blood cells, which was further linked to oxygen and blood clot, respectively. This student did not include all terms and the connection to white blood cells to blood clot is incorrect. One student linked blood to red blood cells, platelets, and white blood cells. These terms were further linked to their correct functions or derivatives, but also each was individually linked to the concept blood cells. Two students linked blood to blood cells and plasma. Blood cells was then linked to red blood cells and white blood cells, which were linked to oxygen and infection, respectively. Plasma was linked to water, enzymes, and plasma proteins, which was further linked to blood clot and platelets. Where these students differed were terms used to describe the relationships between concepts. One student created a concept map like the one shown in Picture 6 where “blood system” as the main topic of the concept map, which is linked to blood cells, platelets, and plasma. Blood cells are connected to red blood cells and white blood cells and their respective functions, whereas platelets is connected to its function and the concept blood. Plasma is connected to water and enzymes, which are both connected to plasma proteins. One student created two smaller concept maps for this material. One concept map starts with the concept blood, leads to the concept blood cells, and then leads to the three types of blood cells and their respective functions. The second concept map starts with the concept plasma and leads to its derivatives.

There were more variations in the concept maps created in 5th period than there were in 4th period when they were the treatment class. Most students did accurately connect all of the blood cells to their correct function and plasma to its derivatives. Most students struggled with where to put the concept blood cells and sometimes would separate the term platelets from blood
cells, but it is considered a blood cell. Most students did well with creating concept maps and some students even used excess materials from their notes in their concept maps.

**Other data.** The pre- and post-surveys revealed other information not related to concept maps. Statements 1, 8, and 9 on the surveys were used to determine if students felt they are visual learners and their feelings towards the course. The results for statement 1 decreased from the pre- to post-test for 4th period, indicating that more students felt that they were not visual learners after the use of concept maps in their class or had a decreased agreement with the statement. The results for statements 8 and 9 increased from the pre- to post-survey, indicating that feelings to towards the course (statement 8) and the study of anatomy (statement 9) increased after the first unit.

All of the results for 5th period increased from the pre- to post-survey on statements 1, 8, and 9. These results reveal that more students felt that they were visual learners or had an increased agreement with the statement. Also, students felt more strongly towards the course (statement 8) and the topic of anatomy (statement 9).

Questions 10 and 11 on the post-survey were also used to see how students felt they best learn and what has been used thus far this school year that has helped them learn, respectively. For 4th period, in response to question 10 about what students feel help them learn, students said with hands-on activities, visually, by taking notes, PowerPoints, experiments, by listening, having more study time, and through being given relatable examples. In response to statement 11, in 4th period, students felt that labs, notes, study guides, dissection projects, and concept maps have helped them learn in biology 2 thus far this year.
In response to question 10, students in 5th period felt that they best learn by being hands-on, visually, worksheets, discussions, and through repetition. In response to statement 11, students in 5th period felt that Kahoot.it (an online review game), dissection projects, study guides, and notes are what has been used to help students learn in biology 2 thus far this year.

Conclusions

The use of concept maps as a learning tool did not significantly increase test scores in a secondary anatomy classroom. Further studies should be done to determine the benefits of concept maps as a learning tool and if they significantly increase learning. Possibly, through the implementation of more concept maps in a unit and providing students with more practice with using concept maps to make students more comfortable with them, concept maps can be more effective. Some students felt positively towards the use of concept maps, while other students did not, just as some students felt that concepts maps helped them in an anatomy unit while others did not.

The use of concept maps as a learning tool does help students organize information provided in notes and direct instruction. It allows students to see how concepts and/or ideas are related to each other. This can help some students, who are visual learners, better organize concepts and information. To better utilize concept maps, students need to have more practice in using and creating them to become more comfortable in using them as a learning tool to benefit their education.

Implications

There are multiple implications in this study. First, this study was done in only two units and with only two classes. Both these classes contained less than 15 students. It would be ideal
that a future study be done with more classes, a larger population of students, and across more than two units. This would provide the researcher with more reliable data.

The surveys also had limitations. The survey was given to students to respond to anonymously. All students completed the survey, but on the post-survey one student in 4th period left all of the open-responses blank except question 10. This is probably due to this student not seeing the back page, which questions 11 through 15 were on. Ensuring that all students are aware of a back page is critical if giving a two page survey. Also, most students responded to the open-ended questions on the post-survey with very brief responses. This might be due to students being given the post-survey after the post-test. It would be ideal to give a post-survey a day after the post-test if it has open-ended questions, which may motivate students to be more descriptive in open-ended questions.

The concept maps also had implications. Most students knew what concept maps were after seeing them, but most students did not feel comfortable using, reading, and creating them. This might be because students did not have a great deal of experience with concept maps in prior classes. Norton (2015) discusses that the use of concept maps should be introduced to students in their middle years of learning and maintained through the rest of their schooling because this helps students to “develop confidence in the intellectual processing required within more complex and sophisticated subject areas” (p. 27). Though it cannot be guaranteed in most school districts for students to continually use concept maps from middle school on, it can be used more within a certain course taught by one teacher. For students to really experience the benefits of concept maps as a learning tool in just one course, it would be best if students had more interaction with them prior to the start of a study and with using them more in the unit of study itself, such as seeing them in notes, on assignments, and while doing homework. Vanides
et al. (2005) provides a step-by-step technique of how concept maps can be implemented into a classroom. This technique includes letting students practice at making concept maps in a topic they are very familiar with, then having students make individual concept maps, discussing these individual maps with students in small groups, and then as a whole class (p. 29). This is an example of technique that can be used by a teacher or a researcher to implement concept maps into the classroom prior to the start of a study to hopefully improve student confidence in using and creating concept maps.

**Recommendations**

This study would need some revisions if used for future studies on the use and benefits of concept maps as a learning tool. First, students need to be more comfortable in creating, using, and reading concept maps prior to a study being conducted. This will help students feel more comfortable and less confused when using concept maps. Using more students and performing this study in more than two units would gather more evidence to add to the data.

To see if test scores do increase due to the use of concept maps, it is recommended that more concept maps be used in the unit of study. Students should not only create concept maps on their own, but also see and interact with them in their notes, on various assignments, and on homework. This would give students more time with concept maps and also strengthen the study to see if concept maps are indeed the source to increased test scores and learning.
References


Appendix A, Part 1

Assessment Questions for First Unit

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

1. Which of the following is NOT part of the axial skeleton?
   a. skull
   b. vertebral column
   c. pelvis
   d. rib cage

2. Which of the following is NOT a function of bones in the human skeletal system?
   a. store minerals
   b. regulate body temperature
   c. move body parts
   d. protect organs

3. What body part has a joint that works in a manner similar to a door?
   a. wrist
   b. thumb
   c. skull
   d. knee

Figure 36–2

4. In Figure 36–2, B is an example of
   a. cardiac muscle.
   b. skeletal muscle.
   c. smooth muscle.
   d. heart muscle.

5. In addition to myosin, what other protein is involved in skeletal muscle contraction?
   a. collagen
   b. actin
   c. ATP
   d. chitin

6. What tough connective tissues join skeletal muscles to bones?
   a. joints
   b. ligaments
   c. periosteum
   d. tendons

7. What two layers make up skin?
   a. keratin and dermis
   b. epidermis and melanin
   c. epidermis and dermis
   d. melanin and keratin

8. Which of the following is NOT a function of skin?
   a. helps regulate body temperature
   b. removes body wastes
   c. contracts and relaxes muscles
   d. helps prevent infection

9. Which of the following is NOT part of the integumentary system?
   a. skin
   b. cartilage
   c. nails
   d. hair

Completion
*Complete each sentence or statement.*

10. Hair and nails are part of the ____________________ system.

11. The process by which cartilage is replaced by bone is ____________________.

12. The point of contact between a motor neuron and a skeletal muscular cell is called a(an) ____________________.

Short Answer

13. What are three functions of the human skeleton?

14. What are the three different types of muscle?

15. What are two functions of the integumentary system?
Appendix A, Part 2
Assessment Questions for Second Unit

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

1. Which of the following is NOT a part of the circulatory system?
   a. heart
   b. air passageway
   c. blood vessels
   d. blood

2. How much blood does the human body contain?
   a. 1–2 liters
   b. 4–6 liters
   c. 8–10 liters
   d. 12–14 liters

3. In Figure 37-1, what does step B show?

a. clot forming
b. capillary wall breaking
c. clumping of platelets
d. conversion of fibrinogen into fibrin

4. Air is forced into the lungs by the contraction of the

a. alveoli.
b. bronchioles.
c. diaphragm.
d. heart.

5. In the walls of the heart, there are two thin layers that form a sandwich around a thick layer of muscle called the
   a. epithelial tissue layer.
   b. pericardium.
   c. connective tissue layer.
   d. myocardium.

6. Which of the following are the smallest of the blood vessels?
   a. arteries
   b. veins
   c. lymphatic cells
   d. capillaries

7. Which of the following blood cells contain hemoglobin?
   a. red blood cells
   b. white blood cells
   c. platelets
   d. all of the above

8. The process by which oxygen and carbon dioxide are exchanged between cells, the blood, and air in the lungs is one type of
   a. systemic circulation.
   b. respiration.
   c. emphysema.
   d. cellular respiration.

9. What structure serves as a passageway for both air and food?
   a. pharynx
   b. trachea
   c. larynx
   d. bronchus

**Completion**
*Complete each sentence or statement.*

10. Fatty deposits called plaque build up on the inner walls of arteries, causing a condition known as ____________________.

11. Plasma consists mostly of ____________________.

12. Inhaled air passes from the trachea to one of the two ____________________.

**Short Answer**

13. Are the ribs raised or lowered after you exhale?

14. List the main functions of the three types of blood cells.

15. What are the three structures of the circulatory system?
Appendix B, Part 1

Pre-Survey

Period (circle one): 4th or 5th

This survey is intended to see how you feel about the use of concept maps in class. Please use the following scale to rate each statement below by putting the appropriate letter in the space provided.

1. Strongly disagree
2. Somewhat disagree
3. Undecided
4. Somewhat agree
5. Strongly agree

1) _____ I am a visual learner.
2) _____ Concept maps help me learn.
3) _____ Concept maps help me visualize concepts within a unit.
4) _____ Concept maps help me visualize the relationships between concepts within a unit.
5) _____ I like utilizing concept maps as a study tool.
6) _____ I like creating concept maps.
7) _____ I like reading concept maps.
8) _____ I currently like biology 2.
9) _____ I like learning about anatomy.
Appendix B, Part 2

Post-Survey

Period (circle one): 4th or 5th

This survey is intended to see how you feel about the use of concept maps in class. Please use the following scale to rate each statement below by putting the appropriate letter in the space provided.

1. Strongly disagree
2. Somewhat disagree
3. Undecided
4. Somewhat agree
5. Strongly agree

1) _____ I am a visual learner.
2) _____ Concept maps help me learn.
3) _____ Concept maps help me visualize concepts within a unit.
4) _____ Concept maps help me visualize the relationships between concepts within a unit.
5) _____ I like utilizing concept maps as a study tool.
6) _____ I like creating concept maps.
7) _____ I like reading concept maps.
8) _____ I currently like biology 2.
9) _____ I like learning about anatomy.
Answer the following questions.

10) How do you believe that you learn best in the classroom?

11) What has been done so far this school year in biology 2 that has helped you learn?

12) How do you feel about concept maps?

13) Do you feel that concept maps can help you learn in biology?

14) Do you feel that concept maps helped you to better understand some of the concepts learned in this unit?

15) Do you feel that concept maps helped you organize some of the concepts learned in this unit?
Appendix C, Part 1

Concept Map from First Unit

The Skeletal System

Has joints

Immovable Joints

Freely Movable Joints

Such as

Ball-and-Socket Joint

Such as

Saddle Joint

Such as

Knee

Lower Arm Bones
Appendix C, Part 2

Concept Map from Second Unit

The Circulatory System

Consists of

Heart

Includes

Pulmonary Circulation

Pumps blood to

Body

Blood

Includes

Veins

Takes blood to

Body

Capillaries

Takes blood to
A determination has been made that the following research study is exempt from IRB review because it involves:

Category 1. research conducted in established or commonly accepted educational settings, involving normal educational practices

Project Title: Concept Maps as a Way to Improve Understanding and Organization of Concepts Within a Subject

Primary Investigator: Michelle Patricia Waers

Co-Investigator(s):

Advisor: Ralph Martin

Department: Education

Date: 2/3/15

Rebecca Cale, AAB, CIP
Office of Research Compliance

The approval remains in effect provided the study is conducted exactly as described in your application for review. Any additions or modifications to the project must be approved (as an amendment) prior to implementation.
this unit, was lower than 4th period’s. Overall, this data reveals that the use of concept maps as a learning tool did not significantly increase test scores. As stated above, this data reveals that the use of concept maps as a learning tool did not significantly increase test scores, but it does reveal that 5th period had a higher amount of gain than 4th period from the pre- to post-test. On the pre-test, 4th period’s class average was 37.69% and the average on the post-test was 60.00%. From the pre- to post-test, 4th period, serving as the treatment class for the first unit, had a 22.31% gain. On the pre-test, 5th period’s class average was 45.00% and the average on the post-test was 61.50%. From the pre- to post-test, 5th period had a 16.50% gain. Overall, 4th period had a 9.31% higher gain than 5th period. This percent gain did not hold true in the second unit, where 5th period was the treatment class, because the class average percentage on the post-test was less than 4th period’s. Though...