Assessing the use of Concept Maps in the Science Classroom

Paige Russell
Louisiana State University and Agricultural and Mechanical College

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ASSESSING THE USE OF CONCEPT MAPS FOR LEARNING GAINS IN THE SCIENCE CLASSROOM

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agriculture and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Natural Sciences

in

The Interdepartmental Program of Natural Sciences

by

Paige D. Russell
B.S., Louisiana State University, 2000
August 2015
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ABSTRACT

Graphic organizers have been used in the classroom since the late 1960’s. Several studies have been published on the effects of graphic organizers on cognitive learning and yet the traditional method of teaching in the science classroom still remains strongly focused on traditional lecture and note taking. This study shows that relative to traditional methods graphic organizers maintain equivalent learning gains, but increase excitement and engagement among the students.

The purpose of this study was to assess traditional lecture vs. traditional lecture with the addition of concept maps to determine if concept maps affect learning gains in the high school science classroom. The study used 86 traditional Biology students. The students were given both a pre-test and post-test on two separate units in the Biology curriculum. The first unit covered Charles Darwin and the theory of natural selection, while the second unit covered the muscular and skeletal systems. Although there was a slight increase in learning gains when concept maps were used, statistical analysis determined that this small increase was not significant for this sample size. There was a statistically significant difference in learning gains between the two units however. An attitudinal survey given at the end of the course showed that students preferred using the concept maps in addition to traditional lecture over traditional lecture alone.
INTRODUCTION

Differentiated instruction is the practice of using multiple approaches to content and instruction. As part of the implementation of differentiated instruction at a Baton Rouge, Louisiana high school, this thesis examines the use of graphic organizers as a way to help students achieve success in high school biology. The use of graphic organizers was developed by Ausibel in 1968, (Griffin 2001) but at that time was called structural overview. Ausubel began promoting the use of advanced organizers as a method for teachers to enhance student cognitive function.

It is a common misconception that graphic organizers are only useful for visual learners. Everyone uses all three learning styles visual, auditory, and kinesthetic to some extent (Siraj 2014). This thesis compares dual presentation to traditional lecture alone. In the case of this study students received traditional lecture alone or received traditional lecture along with seeing and using concept maps.

Cognitive learning: The cognitive approach to learning seeks to understand how incoming information is processed and structured into memory (Dye 2000). According to cognitive theory, a student is bombarded with a great deal of information. The information enters a sensory register for only a few seconds where the information is either processed or forgotten. If processed, it moves from the sensory register to short term memory, and then it must be rehearsed or forgotten. The more it is used or rehearsed, the larger the chance of moving to long term memory (Dye 2000). Cognitive theory postulates that teachers need to find more ways to expose students to the same information in different formats. According to
cognitive theory, the more they see it in different formats, the better chance they have of retaining it (Dye 2000). This is where graphic organizers can be useful.

**Graphic Organizers:** Graphic organizers are communication flow charts that spatially depict the organization of concepts as well as the relationships between those concepts. Figure 1 shows an example of a simple graphic organizer. The visual or graphical arrangements of the information actually reduce the cognitive demands on the learner (Ellis and Ellis 2001). A well designed graphic organizer aims to help students understand what information is the most important. “Showing” in addition to “telling” the information to students aims to give them a better understanding of the content and its inter-relationships.

![Problem and Solution Map](image)

Figure 1. An example of a graphic organizer.
Also students are more likely to become strategic learners by learning how to organize information (De Simone and Gleason 2007). A strategic learner can evaluate what they are doing and make adjustments as opposed to just memorizing text. In theory, they will learn to recognize and organize information into patterns (De Simone and Gleason 2007). There are many different types of graphic organizers. The type of graphic organizer that this study is focused on is the concept map. Concept mapping is a learning strategy that has received considerable attention over the last 20 years (De Simone and Gleason 2007). It is particularly suited for identifying relationships between ideas.

**Constructing Concept Maps:** Concept maps are relatively easy to make, but one needs to be sure that all of the important information is included and that the connections or relations between information are presented correctly. One simple type of graphic organizer is called “mind mapping” (Novak 2010). With mind mapping the individual begins with a central idea in the center of a sheet of paper, and then draws links radiating out from this key idea to smaller related ideas.

![Figure 2. An example of a mind map.](image-url)
The simplicity of the mind map has made it popular in both businesses and schools (Novak 2010). Figure 2 shows an example of a mind map. This is a very basic sort of concept map that most people can use to help organize information.

There are four basic steps in creating and using a graphic organizer that need to be followed. 1) Select all the information that you want to present to the students on a particular concept or story. 2) Decide what key information they need to learn. 3) Create a graphic representation of all the key information. Your chart should both identify all key concepts and link the key elements of the concept. 4) Help the students to see the connections within the graphic organizer by explaining it to them (Dye 2000, pg.5).

Within these four basic steps there are several additional guidelines that one should follow (Novak and Canas 2006). First, arrange the key concepts in a hierarchical fashion with the most general concepts at the top and more specific concepts at the bottom. A second important structural characteristic of a concept map is cross-linking. Cross-links represent relationships between concepts from different areas of study. The final guideline is to include specific examples that can help clarify the meaning of a concept (Novak and Canas 2006). Concept maps can be used at all grade levels and with many different types of information. Figure 3 shows one of the concept maps used in this study. Several other examples of concept maps are shown in the Appendix.
Figure 3: An example of a concept map linking ideas and information together about evolution. Students use the word bank to fill in the blank spaces in the concept map. This is one of the concept maps used in this study (see Appendix A).

**Purpose and Approach:** In this thesis I examine whether using these concept maps can help raise student test scores. Instructing students to take notes and review them later would seem to allow students to benefit from encoding and external storage functions. Most students take less than half of the notes from a lecture according to the study by Robinson (Robinson 2006). Also many students with learning disabilities have trouble extracting relationships from
expository texts. Since teachers often have students with special needs there is a need to find ways to work with all students to learn and retain knowledge (DiCecco and Gleason 2002). One purpose of this study is to help identify alternative methods teachers can use to help students learn and retain information. According to Ellis and Ellis concept maps are the way of the future in education (Ellis and Ellis 2001). The hypothesis of this thesis is that when students use concept maps they are actually learning relationships between information as opposed to just memorizing text and this will lead to higher learning gains.

This study used a sample size of 86 traditional Biology students in a tenth grade classroom from a school that serves students predominantly from a lower socioeconomic status. This study used teacher made concept maps. By first focusing on only one type of graphic organizer we can start to determine which ones might be the most effective in science education.

This study used Biology sections on 1) Darwin and natural selection and 2) The muscular and skeletal systems, both with and without the use of concept maps. These two units were chosen because many of the concepts are interrelated, and based on teacher experience the information in these units is difficult for students to understand. The study of Darwin includes many related ideas that helped him formulate his theory of evolution. For example, Hutton and Lyell’s theory that the Earth is very old is a key requirement for his theory of evolution to be plausible. Thus, this topic provides a good opportunity for the use of a concept map to show the relationships among all these ideas. The skeletal and muscular systems work together and are interrelated. Based on experience it is difficult for many students to understand how all of
these parts are inter-related. The concept map should not only provide differentiated instruction, and more exposure to the information, but also provide a way to visualize and link the information together.

I expected that the results of this study would show that the students who receive concept maps in addition to their traditional lecture would be able to retain information much more efficiently than students receiving traditional lecture only based on previous literature by Masterminds Publishing (Ellis and Ellis 2001). What was found with this study group however, was that concept maps increase student interest and enjoyment but do not significantly increase student learning gains, which is consistent with several other controlled studies (Griffin, et al. 2001, Stull and Mayer 2007, Snead and Young 2003). Due to this increase in student interest alone, as shown in this thesis, concept maps do have a place in the classroom.
METHODS AND PROCEDURES

Before using graphic organizers, the teacher had been lecturing in a traditional fashion and following the normal curriculum for the State of Louisiana (Pastorek 2008). The test students were primarily in the tenth grade. Students had been exposed to a variety of topics prior to this point in the course, including the scientific method and how to perform an experiment. The course was divided into three units over the duration of the semester. Each unit covered approximately three to four chapters and lasted approximately six weeks. At the end of unit one, students were briefly introduced to concept maps and how they are used to organize information. At the end of unit one, the teacher and students worked together on a concept map regarding the scientific method, and also used this concept map in a class discussion. Students discussed how and why we organized the map the way we did, and also argued their point if they thought that something should be changed. Thus, at this point all students had some understanding of concept maps. At this point the classes were ready to start on unit two which included Darwin and the theory of natural selection where we began testing the effects of using concept maps.

Study Population and Settings: The students in the classes are traditional students primarily from lower socioeconomic backgrounds. The school population is approximately 1248 students total with 921 (73.8%) receiving free or reduced lunch. The racial make-up of the school population is 86.38% African American, 10.82% Caucasian, 2.56% Asian, and .24% other. This study included four classes composed of approximately twenty-five students each. Not all students were included in this study due to consistent absences or being removed from the
class at some point. The range of Biology background knowledge within each class was fairly large and some of the students are considered “special needs” students that have accommodations for various learning disabilities. Accommodations can range from extended time on tests to having someone read the information out loud to them. In this test study there were a total of fifteen special needs students. The students are taught in a regular science classroom with individual desks. The teacher has a table in the front of the class that is used primarily for demonstrations. The classroom has a projector for traditional power point presentations or videos to accompany lectures. There is only one computer in the classroom so any computer lab work has to be done in the library or the teacher can bring in a mobile laptop lab that has thirty additional laptops for student use.

**Materials:** Student materials consist of a Pearson Biology textbook and a Pearson Biology workbook (Miller and Levine 2010) that are used in the traditional lecture. Teacher materials include the teacher’s manual for the classroom textbook, and the teacher also had premade concept maps for each chapter in each unit. There were a total of nine concept maps, four were used in the unit on Darwin and the theory of natural selection, and five were used in the muscular and skeletal systems unit. The pre-test and post-test are Pearson Biology tests from the textbook (Miller and Levine 2010) as required by the East Baton Rouge Parish school district (Pastorek 2008).

**Procedure:** All concept maps used in this study were prepared in advance by the teacher. The experimental groups were led through a concept map at the beginning of each chapter in addition to traditional lecture that conforms to the curriculum set by the Louisiana
Department of Education (Pastorek 2008). The time in the experimental group was divided between 50% concept maps and 50% lecture. At the end of each lecture, the class went over the concept map as a whole (led by the teacher) and participated in a discussion. Any questions that the students had were discussed by the class and answered by the class while the teacher provided assistance as needed. The control group was given only the traditional lecture that conforms to the curriculum set by the Louisiana Department of Education (Pastorek 2008). 100% of the time in the control group was spent on lecture. At the beginning of each chapter all students were given the Pearson Biology pretest (Miller, Levine 2010) for that specific unit. After the students had completed the unit and the experimental group were exposed to the graphic organizers all students took the Pearson Biology post-test (Miller, Levine 2010) on that unit to determine any learning gains. Students not using the graphic organizers take the same Pearson Biology post-test (Miller, Levine 2010) to determine learning gains. At the end of each unit the results of the pretest and post-test were compared among the two groups to see if any difference in learning gains occurred. The formula used for calculating normalized learning gains (G) was $G = \frac{\text{post-test} \%- \text{pre-test} \%}{100- \text{pre-test} \%}$ (see Table 1). At the end of unit 1 the experimental group became the control group for unit 2 and vice versa.

**Consent Forms and IRB:** Participants in this study were under the age of eighteen so consent forms were given to all students to request parental permission for the students to participate in the study. (See Appendix B) Also permission was granted by the principal of McKinley High School to perform the study and collect data. All of the participants’ information was kept confidential and individual test scores were not available for anyone to see except for
the individual participant. The study design was approved by the Louisiana State University Institutional Review Board IRB# E8917 (see Appendix C).

**Data Analysis:** After all data were gathered from both the experimental and control groups the two were compared to see if any difference in learning gains were observed. Statistical analysis was performed using the program Instat from GraphPad (GraphPad Software, Inc.). The mean learning gains, standard deviation, and standard error of the mean were calculated. Each of these formulas is listed in Table 1.

Table 1. Formulas for statistical analysis.

<table>
<thead>
<tr>
<th>Normalized Learning Gains</th>
<th>( G = \frac{\text{postscore} %- \text{prescore} %}{100- \text{prescore}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Deviation (( \sigma ))</td>
<td>( \sigma = \sqrt{\frac{\sum (x - \bar{x})^2}{n}} )</td>
</tr>
<tr>
<td>( \sigma ) = standard deviation</td>
<td>( \Sigma ) = sum of</td>
</tr>
<tr>
<td>( x ) = each value in the data set</td>
<td>( \bar{x} ) = mean of all values in the data set</td>
</tr>
<tr>
<td>( n ) = number of value in the data set</td>
<td></td>
</tr>
<tr>
<td>Standard Error of the Mean (SE)</td>
<td>( SE = \sigma/\sqrt{n} )</td>
</tr>
</tbody>
</table>

An unpaired t test was used to compare data from different groups and determine differences in learning gains. An unpaired t test was used because the data consisted of two independent groups with a continuous dependent variable. A two tailed p-value then used to determine if the two groups were statistically significantly different. The two tailed p-value was
selected to test for statistical significance in both directions. No assumptions were made that the distribution would scatter in one specific direction alone. To determine a p value you must have a null hypothesis, then determine the normal range of values being observed which is usually .05. Then determine your experiments observed results and calculate the degrees of freedom. Compare the expected results to the observed results with chi square. Then use a chi square distribution table to approximate your p value. Some of the groups failed the normality test due to non-normal distribution, so a non-parametric Mann-Whitney U test was performed on these groups to determine a p-value. The Mann-Whitney U test is a non-parametric alternative to the unpaired t test is used when data fails the assumptions necessary for the unpaired t test.
RESULTS

Overall: Concept Maps vs. Lecture Alone: The overall learning gains comparing students who used concept maps in conjunction with traditional lecture vs. students using traditional lecture only are reported in Table 2 and shown in Figure 4. Statistics shown are mean learning gains, standard deviation, and standard error of the mean. An unpaired t test, a two tailed P value and an assumption test were run. All statistical analysis was conducted using Instat Graphpad software. A total of 86 students were pre-tested and post-tested over the course of two units using either a combination of concept maps and traditional lecture or traditional lecture alone.

Table 2: Mean Learning Gains, Standard Deviation, Standard Error of the Mean, and Sample size for Concept Maps vs. Lecture Alone

<table>
<thead>
<tr>
<th></th>
<th>Concept Maps</th>
<th>No Concept Maps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Learning Gains</td>
<td>0.35</td>
<td>0.32</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.27</td>
<td>0.33</td>
</tr>
<tr>
<td>Standard Error of the Mean</td>
<td>0.03</td>
<td>0.04</td>
</tr>
<tr>
<td>Sample size (n)</td>
<td>86</td>
<td>86</td>
</tr>
</tbody>
</table>

The assumption test showed no significant difference in standard deviations between the experimental and test groups. Although the mean learning gain for students using concept maps was slightly higher than for students using lecture alone, there was no statistically significant difference between the mean for the two groups (+.348, +.315) (P value=0.470). The
differences were not considered significant because the two tailed P value was greater than 0.05.

Figure 4. Mean Learning gains and standard error of the mean for the experimental (concept maps) and control (no concept maps) groups. There is a slight increase in learning gains when students use concept maps (10.6%), but within this test sample the difference does not exhibit statistical significance.

**Gender: Males** The mean learning gains for males (n=41) using concept maps was 0.0335 vs. lecture alone at 0.250. The learning gains, standard deviation, and standard error of the mean are reported in Table 3 and Figure 5.
Table 3: A comparison of learning gains for males using concept maps with traditional lecture vs. traditional lecture alone.

<table>
<thead>
<tr>
<th></th>
<th>Concept Maps</th>
<th>No Concept Maps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Learning Gains</td>
<td>0.34</td>
<td>0.25</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.31</td>
<td>0.35</td>
</tr>
<tr>
<td>Standard Error of the Mean</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Sample Size (n)</td>
<td>41</td>
<td>41</td>
</tr>
</tbody>
</table>

The assumption test on the “males only” analysis showed no significant difference in standard deviations. Again although the mean learning gains were higher when concept maps were used, no statistically significant difference was found between the two groups (P value=0.2322). The P value was not considered significant because it was over .05. The possible improvements due to the use of concept maps appear even greater for males alone (36%) but the smaller sample size (n=41) increases the standard error of the mean and again means that the differences are not significantly different.
Figure 5. Mean learning gains and standard error of the mean for the experimental (males with concept maps) and control (males without concept maps) groups. Again there is an increase in learning gains when students use concept maps (36%), but when statistical analysis was run there was no statistically significant difference.

**Gender: Females** Statistical analysis was also performed for females only (n=45) using concept maps with traditional lecture vs. traditional lecture alone. The mean learning gains using concept maps was 0.357 compared to 0.374 for the traditional lecture only group. The learning gains, standard deviation, and standard error of the mean are reported in Table 4 and Figure 6.
Table 4: A comparison of learning gains for females using concept maps with traditional lecture vs. traditional lecture alone.

<table>
<thead>
<tr>
<th></th>
<th>Concept Maps</th>
<th>No Concept Maps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Learner Gains</td>
<td>0.36</td>
<td>0.37</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.24</td>
<td>0.30</td>
</tr>
<tr>
<td>Standard Error of the Mean</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Sample Size (n)</td>
<td>45</td>
<td>45</td>
</tr>
</tbody>
</table>

The assumption test showed no significant difference in standard deviations. Here the learning gains for students not using concept maps were slightly higher, but again no significant
difference was found between the two groups (P value=.0760). The P value was not considered significant because it was over .05.

Figure 6. Results showing learning gains for females using concept maps vs. traditional lecture alone.

**Special Needs: 504/ ESS** Statistical analysis was also performed for students designated as special needs students (504=learning disabled and ESS=exceptional student services) to determine if there was any significant difference in learning gains. The mean learning gains for special needs students (n=15) with concept maps was .289 compared to .354 for special needs
students without the use of concept maps. Again standard deviation, standard error of the mean, an unpaired t-test, a two tailed P value, and an assumption test were run.

Table 5: A comparison of learning gains for special needs students using concept maps vs. lecture alone.

<table>
<thead>
<tr>
<th></th>
<th>Concept Maps</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Gains</td>
<td>0.29</td>
<td>0.35</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.21</td>
<td>0.32</td>
</tr>
<tr>
<td>Standard Error of the Mean</td>
<td>0.05</td>
<td>0.08</td>
</tr>
<tr>
<td>Sample Size (n)</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>
The assumption test showed no significant difference in standard deviations. There was no significant difference between the two groups. (P value=0.5135) The differences were not significant because the two tailed P value was greater than .05.

Figure 7. Mean learning gains for special needs students with and without the use of concept maps. Although here the performance after lecture alone had a 20% higher learning gain, again the difference was not statistically significant.

Statistical analysis was performed on the traditional students alone (n=71) without the special needs students. Although learning gains were greater with the traditional only students using concept maps (20%), the difference was not statistically significant (P=.299). (data not shown)

**Unit Differences:** Statistical analysis was also performed separately for unit 1 vs. unit 2 to determine if any significant difference between the two units existed. Unit 1 covered Darwin and the theory of natural selection, and unit 2 covered the skeletal and muscular systems. The overall mean learning gain for unit 1 (n=86) was .216 compared to unit 2 (n=86) at .452.
Learning gains, standard deviation and standard error of the mean are reported in Table 6. The Mann-Whitney U test a non-parametric test was run in place of the unpaired t test due to the fact that unit 2 did not pass the normality test, i.e. there was a non-normal distribution of data. This test determined a p-value to determine if there was a statistically significant difference between the two units.

Table 6: Mean learning gains, standard deviation, standard error of the mean and sample size of Unit 1 vs. Unit 2.

<table>
<thead>
<tr>
<th></th>
<th>Unit 1</th>
<th>Unit 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Learning Gains</td>
<td>0.22</td>
<td>0.45</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.24</td>
<td>0.30</td>
</tr>
<tr>
<td>Standard Error of the Mean</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Sample Size (n)</td>
<td>86</td>
<td>86</td>
</tr>
</tbody>
</table>

A significant difference was found between the two groups (P value <0.0001). The P value is considered extremely significant. Such a large difference in learning gains between Units 1 and 2 may influence overall data analysis (Table 1, Figure 4) so each unit was individually analyzed further below.

Table 7 shows that the large increase in learning gains between units 1 and 2 is independent of whether students used concept maps or not. In both units 1 and 2, when
analyzed individually, the results parallel those found in the overall analysis (Table 2) with small increases in learning gains with concept maps which were not statistically significant.

Table 7. Compares individual units both with concept maps (C), both without concept maps (N), and each unit with (C) and without (N) concept maps. A significant difference was found between the two units. (P<.05), but not between the presence or absence of concept maps in either unit when analyzed alone.

<table>
<thead>
<tr>
<th>Units Compared</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error of the Mean</th>
<th>Sample Size (n)</th>
<th>Two Tailed P value</th>
<th>Significant?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darwin C</td>
<td>0.23</td>
<td>0.23</td>
<td>0.04</td>
<td>42</td>
<td>.506</td>
<td>N</td>
</tr>
<tr>
<td>Darwin N</td>
<td>0.19</td>
<td>0.27</td>
<td>0.04</td>
<td>44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscular C</td>
<td>0.46</td>
<td>0.27</td>
<td>0.04</td>
<td>44</td>
<td>.766</td>
<td>N</td>
</tr>
<tr>
<td>Muscular N</td>
<td>0.44</td>
<td>0.34</td>
<td>0.05</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Darwin C</td>
<td>0.23</td>
<td>0.23</td>
<td>0.04</td>
<td>42</td>
<td>&lt;.0001</td>
<td>Y</td>
</tr>
<tr>
<td>Muscular C</td>
<td>0.46</td>
<td>0.27</td>
<td>0.04</td>
<td>44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Darwin N</td>
<td>0.19</td>
<td>0.27</td>
<td>0.04</td>
<td>44</td>
<td>.0003</td>
<td>Y</td>
</tr>
<tr>
<td>Muscular N</td>
<td>0.44</td>
<td>0.34</td>
<td>0.05</td>
<td>42</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Survey Results:** A survey (see Appendix D) examining student attitudes toward the use of concept maps was given to test whether the students enjoyed using the concept maps. Statistical Analysis was then run on the Likert scale student survey. For each survey question the possible Likert scale answers were Strongly Agree-5, Agree-4, Neutral-3, Disagree-2,
Strongly Disagree-1. The survey questions and results, along with the mean, standard deviation, and standard error of the mean are reported in Table 8.

Table 8. Survey questions 1-10 given to students after the units. Included in the table are the mean, standard deviation, and standard error of the mean for each individual question. A value of 3.0 indicates a neutral response. A value above 3.0 indicates agreement with the statement while below 3.0 indicates disagreement. The survey answers are also graphically depicted in Figure 8.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: I like traditional lecture from my teacher.</td>
<td>3.76</td>
<td>1.06</td>
<td>0.13</td>
</tr>
<tr>
<td>Q2: I like learning from traditional lecture alone, without graphic organizers.</td>
<td>2.84</td>
<td>1.12</td>
<td>0.14</td>
</tr>
<tr>
<td>Q3: Using graphic organizers helps me to understand information better.</td>
<td>3.29</td>
<td>1.11</td>
<td>0.14</td>
</tr>
<tr>
<td>Q4: I like using graphic organizers.</td>
<td>3.45</td>
<td>1.02</td>
<td>0.13</td>
</tr>
<tr>
<td>Q5: I like using both traditional lecture and graphic organizers together.</td>
<td>3.87</td>
<td>0.91</td>
<td>0.12</td>
</tr>
<tr>
<td>Q6: I like learning about Darwin and natural selection.</td>
<td>2.65</td>
<td>1.16</td>
<td>0.15</td>
</tr>
<tr>
<td>Q7: I like learning about the skeletal and muscular system.</td>
<td>3.61</td>
<td>1.08</td>
<td>0.14</td>
</tr>
<tr>
<td>Q8: Information about Darwin and natural selection is easier for me to understand than the skeletal and muscular systems.</td>
<td>3.27</td>
<td>1.12</td>
<td>0.14</td>
</tr>
<tr>
<td>Q9: Information about the skeletal and muscular system are easier for me to understand than Darwin.</td>
<td>3.53</td>
<td>1.04</td>
<td>0.13</td>
</tr>
<tr>
<td>Q10: I use graphic organizers in my other classes.</td>
<td>2.68</td>
<td>1.14</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Question 5 had the highest mean, (3.87) while Question 6 had the lowest, with a mean of 2.65. This shows that students do prefer using concept maps with traditional lecture (Q5) as opposed to traditional lecture alone (Q2). Question 6 and Question 7 reflect the difference between learning gains in those two units. An unpaired t test was run on Question 5 and Question 2 and returned a p-value of <.0001 but failed the normality test. Then a Mann-Whitney U test was run to determine a p-value of <.0001 which showed a statistically significant difference. This shows that students did prefer using concept maps with the traditional lecture (Q5) as opposed to traditional lecture alone (Q2).

Figure 8. Graphic representation of survey answers with mean and standard error of the mean.
DISCUSSION

When comparing the learning gains of students using concept maps in addition to traditional lecture relative to traditional lecture alone, students using concept maps did perform slightly better overall, (.348, relative to .315), however, after performing statistical analysis no significant differences were upheld. When looking at potential gender differences no significant differences were found for males or females alone using concept maps vs. lecture alone. Special Needs students also showed no significant differences in learning gains with or without concept maps. This data confirms that using concept maps in no way detracts from student learner gains. Students did seem more engaged when using the concept maps and also asked more questions as opposed to during traditional lecture and the student survey results confirm that the students enjoyed using the combination of both methods significantly better than using lecture alone. The fact that there was more interest in the concept maps made class time more exciting for the students and the teacher.

Results from Previous Studies. Griffin and associates (Griffin, et al. 2001) performed similar studies with normal achieving fifth grade students to address several questions: Does graphic organizer instruction facilitate comprehension, recall, and/or transfer of information? Also, to what degree is explicit instruction necessary for independent generation and use of graphic organizers by students? Five classrooms totaling 99 participants were randomly assigned to one of five treatment conditions: 1) explicit graphic organizer instruction (students received detailed instruction on key ideas and structure of information), 2) explicit instruction with no graphic organizers (students received detailed instructions on key ideas and structure
of information without graphic organizers), 3) implicit graphic organizer instruction (instructor did not point out key ideas and just moved through the text), 4) implicit instruction with no graphic organizers (instructor did not point out any key ideas and no graphic organizers were used), and 5) traditional basal instruction (as outlined in their text, which included students writing vocabulary and sentences with the information, etc.). The students were given a basic pre-test at the beginning of the study. Students were then given instruction on the topic of Canada over a ten week period. They were given immediate and delayed post-tests. Participants in all 5 groups performed comparatively on both immediate recall and delayed recall post-tests with no significant differences. These results are similar to the results found in this thesis. The researchers then wanted to determine if the students could transfer the information they had learned about using graphic organizers to recall key ideas. When testing for the transfer of information, students were required to read and recall novel social studies content about South America to which they had not previously been exposed. Participants receiving the graphic organizers and explicit instruction recalled more key ideas than participants that received traditional instruction (Griffin, et al., 2001). This showed an increase in the transfer of information.

A 2007 study performed by Stull and Mayer aimed to determine if students would have a deeper understanding of content if they constructed their own graphic organizers as opposed to being given teacher constructed ones. Three experiments were done, with different cognitive loads (amounts of information), where students were tested on how much information was retained (specific knowledge) and on how much information students were able to transfer after reading a passage with author provided graphic organizers or after being
asked to construct their own graphic organizer. In the first experiment (high cognitive load) students were divided into different groups. One group received 27 author-provided graphic organizers with the text for the unit. The other group was given margin space to construct their own graphic organizers for the material within the text. In the 2nd experiment (moderate cognitive load) either 18 author provided graphic organizers were given to students or 18 graphic organizer templates. In the third experiment (low cognitive load) participants were given 10 author-provided graphic organizers or 10 templates. This study found that for transfer of information the students with the author-provided graphic organizers performed better in the moderate and low cognitive load experiments, and showed no statistically significant difference in the high cognitive load experiment. However for retention (specific knowledge of that subject) no significant differences between the groups were found in any of the experiments (Stull and Mayer 2007). The results for retention were thus, again, consistent with the results of this thesis.

Another study performed by Snead and Young in 2003 with 182 African American middle school science students examined the effects of concept mapping on science achievement in the middle school classroom. The students were sorted into eight separate classes of earth science based on their ability levels. Students were tested over a nine week period on the weather with six performance assessment items and one final objective weather test. The report does not specifically define the six performance assessments. Overall there was no statistically significant difference found in student achievement on the final objective weather test for students using concept maps versus those that did not use concept maps. However, Snead and Young did report a significant difference among the “average ability”
students on two of the six performance assessments. This study showed that average ability African American students may benefit from the use of concept mapping, but the overall results of this study were, again, similar to the results of this thesis (Snead and Young 2003).

A thesis performed by Kristen Antoine at Louisiana State University showed significant gains during her study using graphic organizers. However, all of the published studies she referenced in her thesis had no significant learning gains for students using graphic organizers as opposed to traditional lecture alone.

**Concluding Remarks:** Concept maps make the class more enjoyable for all, and student surveys support this assertion. When comparing Question 2 (Table 8) and Question 5 (Table 8) from the student survey used in this study there was a statistically significant difference (p-value<.0001) between the two questions. The students got excited and participated more during use of the concept maps and also kept trying to guess what we were going to put in the next space. This study, along with previous studies from Griffin et. al (2001), Stull and Mayer (2007), and Snead and Young (2003), indicate that using graphic organizers in the classroom generally retains the same level of student learning gains as using traditional lecture alone. While claims of significantly enhanced student achievement made by some commercial entities (Ellis and Ellis 2007) are not upheld by any of the controlled studies, all of the studies do report solid maintenance of learning gains when graphic organizers are used.

The study in this thesis was performed with a sample size of 86 students. Although there was an increase in learning gains overall (3.3%) no statistically significant difference was found. A larger sample size might increase the possibility of establishing a statistically significant
difference. An increased sample size (n) would decrease both the standard deviation and standard error of the mean if the distributions around the mean did not significantly expand.

This thesis did demonstrate, however, a significant increase in student reported enjoyment of the use of graphic organizers in addition to traditional lecture. Together these two findings (maintenance of learning gains with increased student enjoyment) indicate that concept maps are certainly worthy of inclusion in the differentiated instruction toolbox in the high school science classroom.
REFERENCES


APPENDIX A/ EXAMPLES OF CONCEPT MAPS USED

Examples of Concept Maps Used:

Concept map for evidence of evolution

- **Fossils**
- **Biogeography Patterns**
  - Living Species
  - Fossils
- **Evidence of Evolution**
- **Age of Earth**
  - 4.5 Billion Years
- **Comparing DNA**
- **Anatomy**
  - Homologous Structures
  - Vestigal Structures
Concept map overview of the muscular system.
Skeletal system overview concept map.
Appendix B /Consent Form

Consent Form:

Parental Permission

Project Title: Effects of Graphic Organizers on Student Learning Gains in the Science Classroom

Performance Site: McKinley High School
800 E. McKinley Street
Baton Rouge, Louisiana 70808

Inquiries: The following investigators are available for questions about this study,

Monday – Friday 9:00 am – 3:00 p.m.
Mr. Paige D. Russell (225)287-3479

Purpose of this Study: The purpose of this study is to determine whether there are greater learning gains in the science classroom at McKinley High School when implementing graphic organizers.

Inclusion Criteria: Students in science classes taught by Mr. Paige D. Russell

Description of Study: Over the course of the 2014-2015 school year, the investigator will introduce students to graphic organizers. The teacher will implement the strategies to enhance student achievement in the science classroom over numerous units. The teacher will provide feedback and instruction on how to successfully use the strategies. The instructor will help students reflect and improve their learning using the graphic organizer techniques. At the end of each unit, students will take a post-test and student survey.

Benefits: It is anticipated that all subjects will notice improved academic performance pertaining to students’ abilities to grasp content knowledge and students’ abilities to retain content presented. This study will also enhance behavior patterns within students, social capacity with teachers and peers, and an overall confidence of scientific knowledge by participating in this study.

Risks: There are no risks associated with participation within this study.

Right to Refuse: While participation in this study is highly suggested and recommended, it is not mandatory that a student subject chose to participate. At any time, either the subject may withdraw from the study of the subject’s parent may withdraw the subject from the study. Non-participation in this study will leave no impact on the student’s final grades or assessments throughout the duration of the school year.
PRIVACY: The records of participants in this study include, but are not limited to test scores and attendance, which may be reviewed by investigators. Also, results of the study may be published, but no names or other identifying information will be disclosed in publication. All subjects’ identities will be kept confidential unless otherwise advised by law.

FINANCIAL INFORMATION: There is no cost for participation in this study, nor is there any compensation to the student subjects and/or their representatives for participation.

SIGNATURES: This study has been discussed with me and all of my questions have been answered. I may direct any additional questions regarding study specifics to the primary and/or co-investigator. If I have any questions about subjects’ rights or other concerns I can contact Dr. Dennis Landin, Chairman of the Institutional Review Board at 225-578-8692, irb@lsu.edu I LSU.edu/irb. I will allow my child to participate in the study described above and acknowledge the investigator’s obligation to provide me with a signed copy of this consent form.

Parent Signature___________________________________________________Date________________

IF APPLICABLE: The parent/guardian has indicated to me that he/she is non-English speaking/reading, or unable to read. I certify that I have read and/or translated this consent form to the parent/guardian and explained that by completing the signature above, he/she has given permission for the child to participate in the study.

Signature Reader____________________________________________________Date________________
TO: Paige Russell Biology  
FROM: Dennis Landin  
Chair, Institutional Review Board  
DATE: September 12, 2014  
RE: IRB# E8917  
TITLE: Graphic Organizers in the Science Classroom  
Institutional Review Board  
Dr. Dennis Landin, Chair  
130 David Boyd Hall  
Baton Rouge, LA 70803  
P: 225.578.8692  
F: 225.578.5983  
irb@lsu.edu | lsu.edu/irb  
Review Date: 9/11/2014  
Approved X Disapproved  
Approval Date: 9/11/2014  
Approval Expiration Date: 9/10/2017  
Exemption Category/Paragraph: 1, 2a
Signed Consent Waived?: No

Re-review frequency: (three years unless otherwise stated)

LSU Proposal Number (if applicable): __________

Protocol Matches Scope of Work in Grant proposal: (if applicable) __________

By: Dennis Landin, Chairman ________________________________

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –

Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
8. SPECIAL NOTE:

*All investigators and support staff have access to copies of the Belmont Report, LSU’s Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb
### Student Survey:

<table>
<thead>
<tr>
<th>STUDENT SURVEY QUESTIONS</th>
<th>Strongly Agree (5)</th>
<th>Agree (4)</th>
<th>Neutral (3)</th>
<th>Disagree (2)</th>
<th>Strongly Disagree (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I like traditional lecture from my teacher.</td>
<td></td>
<td></td>
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<tr>
<td>2. I like learning from traditional lecture alone, without graphic organizers.</td>
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<tr>
<td>3. Using graphic organizers helps me to understand information better.</td>
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<tr>
<td>4. I like using graphic organizers.</td>
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</tr>
<tr>
<td>5. I like using both traditional lecture and graphic organizers better than lecture alone.</td>
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</tr>
<tr>
<td>6. I like learning about Darwin and natural selection.</td>
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<tr>
<td>7. I like learning about the skeletal and muscular system.</td>
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</tr>
<tr>
<td>8. Information about Darwin and natural selection is easier for me to understand than the skeletal and muscular systems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Information about the skeletal and muscular system is easier for me to understand than Darwin.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>10. I use graphic organizers in my other classes.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
VITA

Paige Russell was born in Baton Rouge, Louisiana in 1975. After graduating from Belaire High School in 1993, he attended Louisiana State University. He received a Bachelor of Science in Secondary Education with a concentration in Biology from Louisiana State University in August 2000 and is expected to receive his Master of Science in Natural Sciences from Louisiana State University in August 2015. He would like to thank his committee chair Dr. Vince LiCata for his assistance with his thesis. This work was supported by NSF grant 098847.