EFFECTS OF ONLINE PRELAB ACTIVITIES ON SUCCESS IN LABORATORY EXERCISES IN THE SCIENCE CLASSROOM

by

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Katherine Christina Koessler

July 2014
TABLE OF CONTENTS

INTRODUCTION AND BACKGROUND ................................................................. 1

CONCEPTUAL FRAMEWORK ........................................................................... 3

METHODOLOGY ............................................................................................. 10

DATA AND ANALYSIS .................................................................................... 15

INTERPRETATION AND CONCLUSION ............................................................ 27

VALUE ............................................................................................................ 31

REFERENCES CITED ...................................................................................... 34

APPENDICES ................................................................................................. 36

APPENDIX A: Saint Thomas Academy Research Approval ............................ 37
APPENDIX B: Attitudes of Science Learning Survey ...................................... 39
APPENDIX C: Attitudes of Science Labs Survey ............................................ 41
APPENDIX D: Use of Technology Survey ....................................................... 43
APPENDIX E: Student Interview Questions ................................................... 45
APPENDIX F: Teacher Journal Prompts ......................................................... 47
LIST OF TABLES

1. Data Triangulation Matrix ...................................................................................................................15

2. Dynamic Earth Unit Pre and Post Lab Quiz Results for Treatment and Non-treatment Groups .................................................................................................................................16

3. Dynamic Earth Unit Exam Results for Treatment and Non-treatment Groups ........18
LIST OF FIGURES

1. Percent Positive Pre-treatment and Post-Treatment Responses to Attitudes About Learning Science Survey .................................................................20

2. A Comparison of Positive Responses for Pre and Post Study Attitudes About Science Labs ........................................................................................................21

3. Percent Positive Responses by Students to Pre-lab level of Preparation Survey ........22

4. Percent of Positive Responses to Post-lab Survey Addressing Effectiveness of Lab in Learning Course Content .........................................................................................23

5. Comparison of Positive Results for Pre and Post Treatment Technology Survey .......27
ABSTRACT

This project, conducted with 8th grade Earth Science students, measured the effect of pre-laboratory exercises on student learning in science. Traditional laboratory exercises were conducted over a unit of study and comparisons of pre-laboratory and post-laboratory quizzes were analyzed between students who participated in the pre-laboratory activity and those who did not. iPad technology was utilized as a means of conducting pre-laboratory activities, pre- and post-laboratory quizzes, and student surveys. Data from student interviews, teacher journal, and end of unit assessment was also analyzed. While student performance on post-laboratory quizzes and end of unit assessment was not significantly affected by the pre-laboratory activities, students did report feeling more prepared for laboratory activities after participating in pre-laboratory activities. Benefits of pre-laboratory activities were noted in student organization and participation, and student support of technology use in science class was high.
INTRODUCTION AND BACKGROUND

For the past three years, I have been teaching 8th grade earth science and 9th grade physical science at Saint Thomas Academy in Mendota Heights, Minnesota. Saint Thomas Academy is a grade 7 – 12 school founded on four guiding pillars: all-male student body, Catholic education, Military leadership, and college preparation. The student body includes approximately 800 students and consists of predominately Caucasian, upper-middle class students of average or above average academic ability.

During my time at Saint Thomas Academy, there has been increasing discussion about the role of technology in teaching and learning at the school. Several committees were formed to investigate the possibility of the school moving to a one-to-one curriculum where all students are provided with an iPad for use in class work and at home. Within the science department, discussion of technology use has focused on effective communication with students and exploration of “flipped” or “blended” curriculum in teaching science to our students. As a college preparatory school, we recognize the increasing use of technology in collegiate settings and its use in building 21st century skills in our students. Through these conversations, I began to reflect on technology use in the classroom and how I might better use technology to improve my students’ learning experiences and outcomes. I have chosen to focus on the use of technology in helping students prepare for and connect with laboratory experiences. One of the prevalent struggles I see students having in science class is transferring their laboratory experiences to the course content and to a larger global context. It is the aim of this project to implement online pre-laboratory exercises to help prepare student thinking
about the laboratory and investigate whether this action improves students’ ability to transfer their experience to other areas of learning.

Focus Question

Concern about student performance with laboratory exercises led me to develop the focus question: What are the effects of pre-laboratory preparation on students’ ability to connect laboratory outcomes with course content and other real world scenarios? I am also interested in investigating the use of technology as an effective means of preparing students for in class laboratory experiences.

CONCEPTUAL FRAMEWORK

Laboratory experiences have traditionally been an essential component of any science class. Laboratory educates students in scientific skills and procedures and gives opportunities to experience scientific principles in practice. Research suggests, however, that laboratory experiences are often not designed or implemented in a manner that facilitates mastery of scientific concepts and are largely not meeting the goals of science teaching and learning (Singer, Hilton, & Scheingruber, 2005). As the 21st century progresses, both the roles and goals of laboratory experiences are changing in response to changing societal needs (Singer, et al. 2005). A greater emphasis is being placed on inquiry-based laboratory experiences that promote development of original questions, experimental design and implementation, collection and analysis of data, and critical thinking skills (Hofstein & Lunetta, 2003). Increased access and utilization of technology is also changing the methodology of science education. The use of “flipped” and “blended” classrooms, which require students to view class material electronically at home, is allowing science educators time in the curriculum to provide more in depth and
complex laboratory experiences in the classroom. A review of current research identifies the goals of laboratory experiences in science education, the challenges of meeting those goals, and methods utilized for providing meaningful lab experiences. Technology's role in creating a lab experience that meets the goals of science learning and teaching is also examined.

**The Role of Laboratory in Science Education**

Science laboratory experiences allow students to learn through doing by connecting tactile experiences and direct observation with the content of study (Hofstein & Lunetta, 2003). The Committee on High School Science Laboratories: Role and Vision, National Research Council has identified seven goals of laboratory experiences for science learning. These goals include: enhancing mastery of science material, developing practical skills, understanding the nature of science, cultivating interest in science and learning science, developing teamwork abilities, and understanding the complexity and ambiguity of empirical work (Singer, Hilton, & Scheingruber, 2005). The last goal, understanding the complexity and ambiguity of empirical work, is a new addition and reflects the unique nature of laboratory experiences which require students to question the outcome of their experiments, compare their outcomes to expected results and resolve disparities between observed results and expected outcomes. Through laboratory, students are given opportunities to be part of the scientific process by playing the role of scientist in their quest to discover and learn scientific principles.

In examining the effectiveness of laboratory experience in science education, Singer, et al. (2005) determined that laboratory activities often do not meet the intended goals of science learning. Although the intended role of laboratory experience is to
provide hands on experiences that allow students to practice scientific skills and connect
with scientific principles, research has not definitively concluded that laboratory
experience alone leads to mastery of either skill or content (Hofstein & Lunetta, 2003).

Fischer, Harrions, Henderson, and Hofstein (1999) found that traditional lab
experiences, or “cookbook” labs, focus students’ attention on step-by-step procedures and
provide little opportunity for students to reflect on the purpose of the experience or
connect outcomes with scientific principles of study (as cited in Hofstein & Lunetta,
2003, p. 40). A study by Chang and Lenderman (1994) indicated that students are not
making the gains in scientific understanding that laboratory experiences are expected to
provide. Students are often unsure of the purpose or reason behind conducting
laboratories and see the main goal to be following a set of directions or simply arriving at
that due to the technical nature of traditional labs, students often suffer insufficient time
and opportunity to reflect on data collected from experimentation and lack the ability to
integrate that data with previous understandings of concepts (Hofstein & Lunetta, 2003).

Current understandings of science education suggest that lab experiences as stand
alone activities do not seem to be effective in promoting mastery of science knowledge.
However, when designed and implemented in thoughtful and structured ways, laboratory
experiences can be successful in attaining science education goals.

After having identified science laboratory goals and flaws of ineffective
laboratory experiences, researchers created an outline for effective laboratory practices.
In the Committee on High School Science Laboratories report on high school science
education, four guiding principles are outlined for providing laboratory experiences that
meet the intended goals. These principles include providing students with clearly communicated learning objectives, integrating labs into a greater context of science content and process skills, utilizing lab experiences at appropriate junctures of study, and providing ongoing opportunities for discussion and reflection of the material (Singer, et al., 2005).

After experiencing dissatisfaction with students’ enthusiasm for lab and the understandings gained from such experiences, Ende (2012) shifted his pedagogy to a more inquiry-based approach. Students were given objectives and guidelines for their work and asked to develop their own questions and procedures in a manner relevant to them. Ende (2012) found that students displayed a higher level of engagement with the material, formed a collaborative atmosphere with peers and related their experimental data to the scientific concepts of study. Similarly, Gunstone and Champagne (1990) found that laboratory experiences become increasingly meaningful in student learning when students are given time and opportunity to reflect on and interact with their work (as cited in Hofstein & Lunetta, 2003).

Baird (1990), Dupin and Joshua (1987), and White and Gunstone (1992) came to similar findings in their research on laboratory effectiveness. Results suggest that when students have opportunities for metacognitive activities in response to laboratory experiences, they are better able make connections between their direct observations and the content of study (as cited in Hofstein, Lunetta, 2003). In this environment, metacognition may involve students connecting scientific concepts in a concept map, applying knowledge to solve real world problems, extending experiences from lab into
other areas of science or society, and identifying flaws in one’s own thinking (Hofstein, Lunetta, 2003; Singer, et al., 2005).

As a method of following the four principles of effective laboratory experiences to meet its goals in science education, Singer, et al. (2005) reported on the use of Integrated Instructional Units. In this approach, labs are carefully selected based on the likelihood that they promote learning, challenge student ideas, provide opportunities for analysis and evaluation, and connect with other learning activities. Integrated Instructional Units provide laboratory experiences that are structured within a larger context of material, giving students more opportunities to revisit their experiences and knowledge as they move through the science content (Singer, et al., 2005).

In a study examining high school students’ perceptions of learning in a science classroom, Goldenberg (2012) found that students desire qualities of learning consistent with the goals and guiding principles outlined by Singer, et al (2005). Students in the study expressed a desire for science learning to include hands-on activities, opportunities to communicate and collaborate with peers, and to make learning relevant by connecting concepts with real-life examples and scenarios (Goldenberg, 2012). In pursuit of providing quality laboratory experiences that meet student-learning needs, new methods of utilizing technology are being developed and implemented in science classrooms.

**Role of Technology in Meeting the Goals of Laboratory in Science Education**

Over the last decade, two pedagogical strategies flipped classroom and Just in Time Teaching (JiTT), have gained momentum in science education. These strategies seek to meet the goals of science learning while utilizing the increased availability of online technology. In both strategies, students are asked to explore science content at
home by viewing online material. This frees up class time to review concepts, address student questions and misconceptions, and apply of content in the form of laboratory work and problem solving (Bergmann, Overmyer, Willie, 2011).

One of the goals of these strategies is to leverage class time for more in depth investigations or discussions of the material and increase student-teacher interaction. In a study by Lage, Platt, and Treglia (2000), students in a microeconomics course were asked to view lectures before coming to class and then spent class time reviewing concepts, asking questions, engaging in laboratory experiences, and collaborating with classmates. The authors found that students responded positively to this strategy and the class was able to integrate a much larger amount of collaborative group work and active learning strategies without giving up coverage of vital content (Lage, Platt, Treglia, 2000). In a similar analysis of a flipped classroom, Alvarez (2011) reports that a flipped strategy in a high school physical science course freed up significant class time that was used for application of content via projects and lab work.

Flipped and JiTT teaching strategies expose students to a host of learning techniques that include online videos and animations, reflective writing, frequent assessments and feedback, class discussions and problem solving, and hands-on laboratory experiences (Lage, et al., 2000; Zappe, Guertin, Kim, 2006). These teaching strategies allow teachers to gauge student understanding and misconceptions in a more timely fashion and address topics of concerns during the class session, while congruently serving as learning activities themselves (Zappe, et al., 2006). Through use of flipped classroom and JiTT strategies in science education, students are exposed to a wider range of learning styles, are able to work at a more individualized pace, and are able to dig
deeper into content material through hands-on laboratories and problem solving activities.

By providing multiple avenues for learning success, technology based pedagogy has helped improve student achievement and attitude toward science learning. In a study of a geoscience course that used JiTT online exercises to assess student understanding of material before class, 89.8% of students reported the exercises helped them learn the material and increase critical thinking skills. In the same study 69.4% of students reported the exercises helped them learn and remember the material better than traditional methods of learning (Zappe, et al., 2006).

Flipped and JiTT pedagogy strategies have shown to be useful in providing time in the classroom for more in depth laboratory experiences. They can also be utilized as a means of preparing students for laboratory experiences, thus facilitating a greater sense of meaning and purpose in the activity. In a study of high school chemistry students, Bhatti, Ghias, and Zaman (2012) examined the effectiveness of pre-lab exercises on students’ performance as measured by post-lab analysis. Their study found a significant difference in achievement of post-lab scores by students who completed the pre-lab material than the control group who did not. In addition, this study analyzed pre-lab and post-lab results by gender and found that boys showed a significant difference in achievement between their pre-lab and post-lab scores (Bhatti, Ghias, Zaman, 2012).

In a study on the effects on preparedness on student performance in laboratory setting, Sadaghiani (2012) had students view Multimedia Learning Modules (MLM) before coming to class lecture. In a survey of students, Sadaghiani(2012) found that only about 20% of students read the text before coming to class, but once MLM was
implemented, 78% of students viewed the content and participated in the online quizzes.

Sadaghiani’s (2012) study emphasizes the role of JiTT in engaging students in course material prior to class time and incorporating assessment with online learning experiences to help teachers address questions and misconceptions during class sessions.

Having also studied the role of technology in the classroom, Pettenati and Cigognini (2007) proposed a model of how a class sequence might be structured when using a flipped classroom approach. This model includes three component parts where students participate in pre-class, in-class, and post-class activities. Pre-class activities are designed to prepare students and utilize techniques previously described. In-class, instructor-led activities build on student preparation or address misconceptions. Post-class activities give students a chance to produce examples of their understanding while instructors are able to give feedback on student learning. Pre-lab and pre-lecture activities are considered pre-class activities and, when utilized to prepare students for laboratory experiences, can be effective tools in promoting connection to content and metacognitive skills.

Through use of web based teaching practices, students are able to access learning tools independent of the classroom setting. Content can be delivered through online and video mediums that allow students to view content at home and at their own pace. Because students can access content material outside of the classroom, class time can be better utilized for guided practice, authentic assessment, application of learning, and in depth laboratory experience. Laboratory experiences are a staple of science education, however, the effectiveness of labs on student learning can only be realized when planned thoughtfully within the scope of content delivery and when students are given the
opportunity to prepare and reflect on their work. When the guiding principles of effective laboratory experiences are implemented, students can attain content mastery, explore and develop interests in science, and transfer learning to real-life applications of science.

METHODOLOGY

This action research project focuses on using pre-laboratory exercises to enhance students’ understanding of laboratory activities and their connection to course content. As Gunstone and Champagne suggest in their 1990 study, students who are given increased time to reflect on their work are better able to connect data collected in laboratory to targeted concepts and apply those ideas to different scenarios. The goal of this study is to provide students with more exposure and reflective practice prior to application of concepts in lab, thereby improving student understanding and transference of concepts.

This project will be conducted with 8th grade Earth and Space science students at Saint Thomas Academy, located in Mendota Heights, Minnesota. Earth and Space science is the required 8th grade science course and is designed as an introduction to Earth systems and processes. Three sections of Earth science classes ranging from 16 to 20 students will be utilized for this study.

The research methodology for this project received an exemption by Montana State University’s Institutional Review Board and compliance for working with human subjects was maintained. Saint Thomas Academy Assistant Headmaster Mike Sjoberg approved the research project without the need for parental consent (Appendix A).

Preparation for Intervention

Prior to the intervention, students participated in three surveys. The first survey was an Attitudes About Science Learning Survey, modified from the original CLASS
(Colorado Learning Attitudes about Science) survey, which aimed to gauge student’s beliefs and attitudes regarding their ability and motivation for science learning. This survey was modified from its original form to better fit an 8th grade Earth and Space science audience. The second survey addressed student’s attitudes and perceptions about the role of laboratory in science learning. The third survey was given in conjunction with the technology department as part of the 1:1 iPad initiative that began with all middle school students at the beginning of second semester. The technology survey was used to gauge student’s comfort level with and attitude toward technology resources utilized throughout the study. Students were trained to effectively access and utilize iPad technology prior to the intervention.

The pre-laboratory intervention was conducted during the Dynamic Earth unit in February and March. This unit was chosen both for the nature of the content and laboratory exercises involved as well as for its scheduled time in the semester. The Dynamic Earth unit includes topics such as continental drift theory, seafloor spreading, and plate tectonic theory. Several themes present in this unit, and are reinforced throughout the year, include change over time, thermal energy transfer, and density.

The study investigation was implemented using three lab activities performed during the Dynamic Earth Unit. These lab activities included: 1) Continental Drift Puzzle Lab, 2) Seafloor Spreading Modeling Lab and 3) Modeling Plate Tectonic Lab. These labs have been used in past years as part of this unit and have been adapted for the classroom from various sources. Laboratory exercises used in this unit were selected based on the guiding principles of effective laboratory, as laid out by the Committee on High School Science Laboratories report (Singer, et al., 2005).
Intervention: Preparation for Laboratory

As outlined by Pettenati and Cigognini (2007), the treatment consisted of pre-class, in-class, and post-class components. Prior to each laboratory exercise in the Dynamic Earth unit, students in the treatment group utilized the Schoology website to access pre-lab material. Two days prior to lab, pre-lab materials were posted to the site for students to access. Pre-lab exercises consisted of content introduction or review presented as text or video, a preview of the goals and procedures of the lab activity, and a pre-lab quiz or preflight. Students were expected to use the pre-lab information to set up their science notebooks with a purpose statement, required data tables and answers to pre-lab questions. A Google form survey was used for the pre-lab quiz and embedded into the assignment accessed on Schoology. Students responded to questions designed to evaluate their level of understanding of the intended purpose and methods of the lab activity as well as gauge their progress with the content being addressed. Students indicated on a Likert scale how well prepared they felt for the lab activity and were given an opportunity to ask any questions that came up during the pre lab activity. Through the use of the pre-lab quiz, students began to process their understanding of the material, and identify and address misconceptions before the start of the lab activity. The completion of the pre-lab material acted as students’ ticket into lab for the in-class portion of the treatment. Students who came unprepared for class had to complete the pre-lab materials in their seats before joining their partners for the lab activity.

Students in the non-treatment group for the designated lab also conducted the pre-lab quiz on the day of the lab but had not been exposed to the pre-lab assignment. After students completed the pre-lab quiz they were then able to begin work in lab with their
partners. The first components of the lab that the non-treatment students completed included the work that the treatment students came prepared to class with.

**Intervention: During Laboratory**

During the in-class portion of the treatment, students conducted a lab activity, recorded data, and completed data analysis in their science notebooks. Lab write-ups were assessed for quality of data and communication of results using a laboratory rubric. Students had an opportunity to work with a partner or small group to discuss their ideas on data analysis and post lab questions. During the laboratory activity, student progress was monitored and any questions that arose were addressed. Notes were taken on these interactions and incorporated into a journal entry for each day.

**Intervention: After Laboratory**

Upon completion of lab work, students participated in a post lab quiz. The assessment helped determine improvement in student understanding over the course of the lab activity and to see how well students could integrate their experience in lab with conceptual content. Students also responded to a Likert question on the post lab quiz to gauge how they thought the lab had helped them learn the content. Both treatment and non-treatment groups participated in the post lab quiz. Students were also assessed in the end of chapter summative assessment to indicate student’s ability to apply their knowledge to different situations or problems and integrate lab experiences with the broader content. This may also give an indication of how well students retain their understanding of content linked to lab experiences.
Intervention Analysis

In order to analyze the impact of this treatment on student lab performance, the three sections of earth science were given the treatment in a staggered format. The section 1 earth science class was given the treatment for the Continental Drift Puzzle Lab (1) and the Modeling Plate Tectonics Lab (3). Section 2 was given the treatment for the Continental Drift Puzzle Lab (1) and the Seafloor Spreading Lab (2). Finally, section 3 was given the treatment for the Seafloor Spreading Lab (2) and the Modeling Plate Tectonics Lab (3). Students in all three sections conducted all lab exercises outlined for the unit, but only treatment groups in each case prepared for the lab experience with pre-lab activities. All students conducted the same in-class activities and were administered the post-lab quiz. Comparisons were made between treatment and non-treatment groups in terms of how well students were able to connect course content to laboratory exercises.

Data was collected throughout the intervention on student performance and progress. Student results on pre-lab and post-lab quizzes was cataloged and lab write-ups analyzed using a lab report rubric. A teacher journal was kept to record observations and assist in organization of thoughts and questions that arose through the treatment. Student interviews were conducted after each lab activity with both treatment and non-treatment groups to ascertain perceptions of the experience and to help identify areas for improvement.

Table 1 summarizes the data collection approaches used in this study.
Table 1

*Triangulation Matrix*

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Source</th>
<th>Data Source</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How do pre-laboratory preparation activities affect student’s ability to connect laboratory outcomes with course content and apply data to new scenarios?</td>
<td>Pre-lab quiz responses</td>
<td>Post-lab quiz responses</td>
<td>End of unit summative assessment</td>
</tr>
<tr>
<td>2. How does the use of pre-laboratory preparation activities impact student achievement in lab assignments and content mastery?</td>
<td>Post-lab quiz responses</td>
<td>Student lab samples and scores</td>
<td></td>
</tr>
<tr>
<td>3. How do pre-laboratory activities impact student’s attitude toward learning science?</td>
<td>Attitudes of Learning Science Survey and Attitudes about Labs in Science Survey</td>
<td>Student interview</td>
<td>Teacher Journal</td>
</tr>
<tr>
<td>4. Does the use of technology for pre-laboratory activities help engage students in science learning?</td>
<td>Technology Survey</td>
<td>Student interviews</td>
<td>Teacher Journal</td>
</tr>
</tbody>
</table>

**DATA AND ANALYSIS**

Over a four-week period, during the Dynamic Earth Unit, data was collected on a group of 54 eighth grade Earth Science students to address the questions outlined in Table 1. Data was analyzed to determine whether the treatment group performed better in a number of assessments than the non-treatment group using statistical tools such as mean, standard deviation, and difference of mean t-test analysis. Data analysis was interpreted to determine if significant ($\alpha = 0.05$) evidence existed to support the claim that the treatment group performs better than the non-treatment group.

*Connecting Laboratory Outcomes with Course Content and New Scenarios*
To address the effect of pre-laboratory activities on students’ ability to connect laboratory outcomes with course content pre-lab quizzes were compared to post-lab quizzes in both treatment and non-treatment groups. Table 2 summarizes the results of these tests.

Table 2
*Dynamic Earth Unit Pre and Post Lab Quiz Results for Treatment and Non-treatment Groups*

<table>
<thead>
<tr>
<th>Lab</th>
<th>Time</th>
<th>Group</th>
<th>Sample (N)</th>
<th>Mean</th>
<th>SD</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continental Drift Puzzle Lab</td>
<td>Pre Lab</td>
<td>Treatment</td>
<td>35</td>
<td>4.088</td>
<td>1.29</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-treatment</td>
<td>18</td>
<td>4.5</td>
<td>0.86</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Post Lab</td>
<td>Treatment</td>
<td>35</td>
<td>5.628</td>
<td>0.87</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-treatment</td>
<td>18</td>
<td>5.611</td>
<td>1.09</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td>Seafloor Spreading Lab</td>
<td>Pre Lab</td>
<td>Treatment</td>
<td>35</td>
<td>6.94</td>
<td>1.79</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-treatment</td>
<td>18</td>
<td>6.27</td>
<td>1.87</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Post Lab</td>
<td>Treatment</td>
<td>35</td>
<td>7.08</td>
<td>1.57</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-treatment</td>
<td>18</td>
<td>6.74</td>
<td>1.76</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td>Modeling Plate Tectonics Lab</td>
<td>Pre Lab</td>
<td>Treatment</td>
<td>33</td>
<td>3.03</td>
<td>0.98</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-treatment</td>
<td>18</td>
<td>1.83</td>
<td>0.99</td>
<td>P&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Post Lab</td>
<td>Treatment</td>
<td>28</td>
<td>4.21</td>
<td>0.96</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-treatment</td>
<td>14</td>
<td>2.71</td>
<td>0.91</td>
<td>P&lt;0.05</td>
</tr>
</tbody>
</table>

For both the Continental Drift Lab and the Seafloor Spreading Labs there was not a significant difference in pre-lab assessment scores between the treatment and the non-treatment groups. Although both groups did show improvement in content knowledge in the post-lab assessment the difference between treatment and non-treatment group here was also insignificant. Several contributing factors may account for this data. At the time of both the Continental Drift Puzzle Lab and the Seafloor Spreading Lab, curriculum had been interrupted several times due to weather related school closures. Although students
had sufficient time to complete the pre-lab assignment, time gaps between instruction and lab may have influenced results by creating too large of a gap between the completion of pre-lab assignment and lab activity. A more continuous and fluid approach to presenting pre-lab assignment expectations, conducting the pre-lab quiz, and completing the lab activity in class may influence the effects the pre-lab activity has on student learning.

Students in the non-treatment group who did not participate in the pre-lab activity were assigned a reading from the textbook that introduced to the concepts in the lab. This may have provided a sufficient introduction of the content to prepare students for the lab activity, yielding results that were not considerably different than the treatment group.

Data from the last lab activity, Modeling Plate Tectonics, did indicate that the treatment group performed better than the non-treatment group in both pre-lab and post-lab assessments. Students noted in the interview that the terminology in this lab was more difficult and that the pre-lab assignment was “helpful in understanding the three types of plate boundaries”. The difference in results for this lab may be attributed to the difficulty level of the content suggesting that the pre-lab activity was more helpful for this level of content. It may also be true that students in the treatment group were better equipped to access this information and would preform better regardless of pre-lab activity.

The end of unit assessment, Dynamic Earth Test, was analyzed to determine how students applied the lab material to new situations and generally retained the content. Three question sets were analyzed; each question set addressed a particular lab from the unit and asked students to apply their knowledge in a new way. Scores were categorized into treatment groups and non-treatment groups depending on if the student had participated in the treatment for that lab. For each of the three question sets the null
hypothesis failed to be rejected by the data suggesting that the treatment group performed equally as well as the non-treatment group. The results from the Dynamic Earth Test are summarized in Table 3.

Table 3: Dynamic Earth unit Exam Results for Treatment and Non-treatment Groups

<table>
<thead>
<tr>
<th>Question Set</th>
<th>Group</th>
<th>Sample (N)</th>
<th>Mean</th>
<th>SD</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continental Drift</td>
<td>Treatment</td>
<td>28</td>
<td>4.67</td>
<td>1.64</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Non-treatment</td>
<td>14</td>
<td>5.21</td>
<td>1.18</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td>Seafloor Spreading Lab</td>
<td>Treatment</td>
<td>28</td>
<td>6.33</td>
<td>1.9</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Non-treatment</td>
<td>14</td>
<td>6.14</td>
<td>1.35</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td>Modeling Plate Tectonics Lab</td>
<td>Treatment</td>
<td>27</td>
<td>2.23</td>
<td>0.79</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td></td>
<td>Non-treatment</td>
<td>13</td>
<td>2.69</td>
<td>1.11</td>
<td>p&gt;0.05</td>
</tr>
</tbody>
</table>

Results from the Dynamic Earth Test suggest that participation in the pre-lab assignment did not necessarily indicate success on the end of unit exam. The lab activity itself may have contributed to overall understanding of the topic, along with other class activities such as lecture, guided practice, discussion and review. However, additional time with the material before the lab activity was not an indicator of later success on the exam.

Impacts of Treatment on Student Attitudes of Science Learning

Data was collected through survey to determine students’ attitudes about learning science as well as the use of lab activities as a means to learning science content. Two surveys were administered to all students (n=54). The Learning Attitudes about Science Survey (modified CLASS survey) (Appendix B) was used to determine general attitudes about science learning, and the Attitudes about Labs in Science Survey (Appendix C) was used to determine students’ attitudes regarding lab activities in the science class. Surveys were administered once before the study began and again at the end of the study period.
Results from the Attitudes About Science Learning Survey (Figure 1) indicate a strong level of interest in science as students responded with a majority in agreement to the statements “I enjoy figuring out answers to scientific questions” and “Learning science changes my ideas about how the natural world works”. Student responses also indicated attitudes about how they learn science with a majority of students pre-treatment in agreement that “A significant problem in learning science is being able to memorize all the information I need to know”, trending to a more neutral attitude post-treatment. Student responses reflected a level of confidence in their abilities in science with a majority of students responding negatively to the statements “After I study a topic in science and feel that I understand it, I have difficulty applying that information to answer questions on the same topic”; “When I am answering a science question, I find it difficult to put what I know into my own words”; and “Knowledge in science consists of many disconnected topics”. The nature of these responses may be due to the particular population of students who participated in the study. An all male student body may show greater interest in and perceived understanding of science topics. In this private school setting, a high value is placed on education and academic success by the students and their families. Students attend tutoring sessions regularly to clarify understandings and complete course work. This population may be more motivated to do well and think highly of a rigorous science education.
Figure 1. Percent Positive Pre-treatment and Post-treatment Responses to Attitudes About Learning Science Survey, \((N=52)\).

In the Attitudes about Science Labs survey (Figure 2), students expressed a high level of interest in doing hands-on lab activities as a means of learning science. Students responded with a majority in agreement with the following statements, “I enjoy doing hands on activities, such as labs, in science class”; “Lab activities help me better understand scientific concepts”; and “I learn about scientific concepts best by doing hands on science”. In response to the negative statement “I don't understand how lab activities relate to what we are learning in science class” the majority of students expressed disagreement. It is likely that the all male study group contributed to the high percentage of positive responses in this survey. The survey supports the teaching philosophy of the school to provide engaging, relevant learning opportunities that are centered on best practices in educating boys.
During the study, students answered a question on each pre-lab quiz to determine how prepared they felt for the lab activity (Figure 3) and again on the post-lab quiz to determine how they felt the lab had helped them learn the content (Figure 4). Students were selected at random from each section after each lab activity and interviewed about their lab experience and their level of understanding of lab material (Appendix E).
Before the Continental Drift Lab, students in the treatment group reported feeling more prepared for the lab activity than their non-treatment classmates. In the student interviews, students in the treatment group reported that the online activity was “really helpful in knowing what we’re going to be learning about” and had a generally high level of confidence. Although pre-lab quiz scores did not show a significant difference between treatment and non-treatment groups in terms of understanding the content, the survey showed a difference in how students felt about what they were going to be doing in class and what they were going to be learning.

A lower number of students in both the treatment and non-treatment groups felt a high level of preparedness before the Seafloor Spreading Lab. It is noted that a high percentage of students, 33% and 47% respectively, responded neutrally to this question indicating uncertainty about their level of preparedness for this lab. Teacher reflection from this lab notes that due to shortened class periods before and during the scheduled lab, as well as a missed day due to weather made preparation for the lab feel disconnected.
and rushed at times. A future attempt at this lab during normal conditions may yield different results.

Students in the treatment group reported a much greater level of preparedness before the Modeling Plate Tectonic Lab than the non-treatment group. Students in the non-treatment group had a much higher incidence of uncertainty or feelings of unpreparedness for this activity. In post-lab interview, students in both groups revealed a sense of ambiguity in their level of preparedness for this lab stating that “the vocabulary was unclear” and that they were “unsure about the different types of plate movement”.

For the pre-lab activity, the treatment group watched animations of the various plate movements and participated in an online activity whereas the non-treatment group read the section in their textbook. Students may have been able to engage more fully with the online activity and animation allowing them to feel a greater sense of comfort with the material from the start.

![Figure 4](image.png)

**Figure 4.** Percent of Positive Responses to Post-lab Survey Addressing Effectiveness of Lab in Learning Course Content ($N = 53, N=53, N=52$).
Students were surveyed again during the post-lab quiz to assess how well they thought the lab had helped them learn the concepts highlighted in each lab activity. The percent of positive responses for each lab activity is outlined in Figure 4.

Both treatment and non-treatment groups consistently reported a high percentage of positive responses to post-lab surveys that asked how well the lab had helped them learn course content. It is interesting to note that in two of the three labs, Continental Drift Puzzle and Seafloor Spreading Lab, the non-treatment group reported a higher percentage of positive responses to this question. Five of the six students interviewed after the Continental Drift Puzzle Lab stated that the lab was helpful in understanding the concepts and preparing for the quiz, whereas one of the six students expressed that notes alone were more helpful than the lab.

An overwhelming number of students (83%) from the non-treatment group reported that the lab was helpful in learning the concept of Seafloor Spreading, while the treatment group reported a smaller majority of students (50%) who found the lab helpful in learning the concept. Student interviews confirmed these findings as all students interviewed stated that the lab was helpful in preparing for the quiz and that “the model we used helped me see what it (seafloor spreading) would look like for real”. Because of some of the timing issues that surrounded this lab, students in the treatment group may have felt more confused by the pre-lab activity than helped, whereas the non-treatment group approached the lab without any prior complications. This may have contributed to the treatment group reporting to a lesser degree that the lab was helpful in their learning.
Results for the post-lab survey from the first two lab activities may indicate that either the non-treatment group was better able to access the material through hands-on discovery compared to the treatment groups, or that because the treatment group had been prepared with an introduction to the lab ahead of time, the amount of new learning that took place through the lab activity was less than with the non-treatment group.

This pattern, however, did not hold true in the last lab, Modeling Plate Tectonics. In this lab the treatment group reported a much higher percentage of students who felt the lab had helped their learning than the non-treatment group. Some students in the interview expressed that the “lab was really fun” but “the results did not always match what was expected”. Other students reflected that the lab “showed how the different plates move” and that doing the lab “helped me see the whole process”. The disparity seen in attitude between the treatment and non-treatment groups for this lab may be due to the more technical nature of the material addressed in this lab and the amount of new vocabulary used. Students in the treatment group may have found the lab to be helpful only after participating in the pre-lab activity, which introduced the concepts and vocabulary.

**Impacts of Technology Use on Students’ Attitudes of Science Learning**

This study also explored the use of technology as a medium for pre-lab activities and its effectiveness in engaging students in science learning. To address this question, students took a Technology Survey both at the beginning of the study and again at the end (Appendix D). Students were also asked to describe the role technology played in the lab setting during student interviews. Student responses were largely positive in the pre-treatment survey with some change in attitude reported in the post-treatment survey.
(Figure 5). Students responded particularly positively to questions regarding the impact of technology on student motivation, such as “I can apply my learning in new ways using technology”; “Classes are more interesting when I use technology”; and “Classes are more engaging when using the iPad”. These results indicate that students are generally receptive to the use of technology in classroom learning. Technology applications can be used to engage students in the learning process and participation in the current topic of study.

Students showed a lower level of positive agreement to questions that addressed the affects of technology on student learning in the pre-treatment survey, but responded more positively to these questions in the post treatment survey. Questions that addressed student learning included “I understand more of what I am taught when using technology in school”; “Using technology helps me be better prepared for learning; and “I am more prepared for class when I use the iPad as part of my homework”. The trend to more positive results in the post-treatment survey is encouraging as students had little experience with iPad use in the learning process prior to the treatment. This trend suggests that iPad use in preparation for class and in aiding understanding of content material was at least as helpful as expected if not more by students.

Responses from student interviews post-lab activity expressed positive attitudes regarding their iPad use in laboratory preparation. One student reported after participating in the Seafloor Spreading Lab, “We used iPads to do the pre-lab questions and watch the video. I thought it helped a lot. It was better than reading and gave more perspectives. I am a more auditory learner than visual”, while another student said about the Continental Drift Lab “It (iPad use) helped a lot. The video was very helpful – both the lecture notes
and the NOVA video. I thought it was better than reading the textbook”. Interestingly, during some of the lab activities where students used their iPads to access the pre-lab activity and pre-lab quiz, students reported having used no technology for that lab. When asked to think a little deeper, students were able to come up with the technology applications used, indicating that the use of technology was an easily integrated addition to the lab setting.

**Figure 5. Comparison of Positive Results for Pre and Post Treatment Technology Survey (N= 51)**

**INTERPRETATION AND CONCLUSION**

The goals of this project centered on whether providing students with pre-lab activities to complete prior to the classroom lab activity would improve their ability to connect the experience in lab with the content of study. This study looked at students’ attitudes about learning science and the use of labs in the learning of science. This study used iPad technology as a way to facilitate these pre-lab activities, which corresponded to
the role out of the 1:1 iPad program with Middle School students at the school. Students were surveyed to assess how the use of technology impacted motivation for science learning and preparation for lab activities in science learning.

Data analysis revealed that the pre-lab activities had no significant influence on content understanding prior to the lab activity. Students scored about the same in the pre-lab assessments regardless of having participated in the pre-lab activity or having read their textbook. Several factors may have contributed to these results. Students in the study population are highly motivated students and the rate at which students had their work completed when they came to class was similar regardless of it being assigned on their iPad or in their textbook. The design of the pre-lab assignments and assessments may not have been formatted in a way that promoted optimal learning and preparation for the lab activity. Future use of the pre-lab activity may focus more on vocabulary use and development. Activities could also include introductory videos of lab set-ups or examples of possible lab outcomes to further prepare students to think about the upcoming activity. Also, with more practice with this technique, both teacher and students will become more proficient in utilizing the pre-lab activity as a reflective activity that more effectively builds connections between lab outcomes and course content.

While pre-lab activities may not have significantly impacted content learning, benefits were observed in student’s level of preparedness for lab. Pre-lab surveys indicated that students who participated in the pre-lab activity felt more prepared when they came to class for the lab than students who did not participated in the activity. Teacher journal entries also note that students who participated in the pre-lab activity
were more prepared with questions regarding the lab, and generally got to work in lab more quickly and were more focused than the non-treatment group.

Notes from the teacher journal throughout the study reveal that the pre-lab activity was helpful to both students and teacher in helping to organize and present material. Formatting the labs into pre-lab, lab, and post-lab segments as suggested by Pettenati and Cigognini (2007) gave students more exposure to the upcoming activity both through in-class introductions and reminders and through completion of the pre-lab activity itself. Materials had to be prepared and available for students in advance of the in-class activity, which required thoughtful preparation by the teacher as well. Teacher notes also reveal that as students were more prepared for the lab experience, they typically required less class time to complete the lab activity than students who had not participated in the lab activity. In future applications of this methodology, added time could be used for more in-depth lab experiences, additional learning extensions, or exposure to additional content.

Student motivation for science learning, and learning through hands-on lab activities was high throughout the study. Eighth grade students at Saint Thomas Academy reported enjoying learning science, and finding value in learning science through lab activities. These findings were consistent with studies such as Goldenberg’s 2012 study that reported student’s desire for relevant hands-on learning experiences in the science classroom.

Integration of the iPad technology throughout the study was both well received by students and smoothly implemented. Because of repeated school closures during the winter months, the introduction of the iPad was simultaneous with the beginning of the
study. Additional time was given in class to acclimate students with the pre-lab activity procedures and location on Schoology. All students, both treatment and non-treatment completed their pre and post-lab assessments in class to ensure that all students were able to access and complete them. In the future, the assessments could be done by the students at home as part of their pre-lab activity. Students were observed throughout the study viewing and reviewing online videos provided as part of the pre-lab activities as a way to review what they had learned. The teacher journal notes an overall increase in student engagement in the material during this unit and independent parent comments suggest that the material made available to students was valuable at home as a learning and review tool.

Students reported enjoying the pre-lab activities that included watching short video segments or completing interactives on the lab concepts. Students also utilized the iPads in unexpected ways during the labs. Particularly during the Continental Drift Puzzle Lab, students took pictures of uncompleted work as a reminder for the next day of where they had left off, shared notes through Google Docs with lab partners, and looked up information about Pangaea to confirm their predictions. Although the study limited the pre- and post-lab assessment opportunities to basic multiple choice and short answer responses, future use of the iPads for lab assessments could be used for a wider variety of assessment tasks such as identifying proper lab procedures and measurements, practicing content vocabulary, making predictions, and connecting content through concept mapping and diagramming.
Participating in this action research project has been incredibly valuable on both a personal and professional level. Through this project I have gained skills and knowledge that has been transformative to my teaching and hopefully impactful to my students’ learning. I was excited when the school announced the roll-out of the 1:1 iPad program for middle school students as I had been interested in the concept of flipped or blended learning but did not feel confident in implementing it into my class because I lacked both technological skills and I was concerned that not all students would be able to fully participate. With all students receiving personal iPad devices for use at school and at home I was encouraged to complete a project that integrated this technology into my teaching.

Having students experience science in a hands-on, minds-on way is an important part of my teaching practice, but one that I have never felt that I have masterfully executed. Through this project I wanted to become a better facilitator of lab experiences as well as make them more meaningful to my students. This project challenged me to think deeply about how I approach lab activities. Using the principles laid out by the Committee on High School Science Laboratories gave me a concrete, mental check-list to use when planning the lab activities to help ensure that they would provide meaningful learning experiences to students that would assist in mastery of content.

I also found a lot of value in research that described the use of reflection and metacognitive activities as part of the lab experience. One aspect of lab activities that I have struggled with as a teacher is “fitting it all in” and having time to really digest and explore the lab activity with students before moving on to the next topic. In this project, I
purposefully built in time for students to engage with the material and report on their understandings of the concepts. Through the use of Google Forms I was able to access data quickly and use it to inform instructional decisions. I also found that students, having time before and after the lab to reflect on the experience were engaged and thoughtful and referred to the lab experience when discuss the concepts later in class. I look forward to refining and improving my approach with the pre and post-lab activities in order to foster an environment of reflective practice in science learning.

Integrating the iPads into my teaching was challenging and enjoyable. I appreciated that the students and I were learning how to best use this technology together. Students were very helpful and honest about their experience, which helped me refine how I delivered the pre-lab activities to them throughout the study. Before the study, many students were still not using their Schoology account to check for homework or access assignments. Because they had a clear reason to access Schoology for the pre-lab assignments, participation in the use of Schoology increased and by the end of the study all students were proficient in accessing their accounts. Because students can download assignments off of their Schoology accounts onto their iPads, including copies of the lab activities done in class, more students are completing and submitting quality, thoughtful work. My knowledge of and abilities with the iPad are in their infancy, but I have gained confidence in implementing activities that use the iPads for both in and out of class assignments and I look forward to learning and exploring more about what they can do for my teaching and for student learning.

Finally, I have enjoyed participating in my own scientific inquiry through this action research project. I am pleased with the question that I chose to answer and took
meaning out of every step of the process. I really liked engaging my students in my research and eliciting feedback from them through student interviews. This is a practice that I would like to continue informally both through periodic surveys and conversations with students. It is helpful for both students and teacher to practice reflecting on our experiences and striving for improvement. Although my data did not suggest big gains in content mastery through the use of pre-lab activities, I did experience other benefits of the practice that I believe warrant further investigation and implementation. I will continue to utilize the skills that I have gained through this process to be reflective in my teaching practice, and stay current with best practices of teaching science.
REFERENCES CITED


APPENDICES
APPENDIX A

SAINT THOMAS ACADEMY APPROVAL OF RESEARCH PROJECT
Cheryl Johnson, Administrator
Montana State University Institutional Review Board
Bozeman, MT  59717
Dear Ms. Johnson:
MSSE candidate Katherine Koessler has the permission of Saint Thomas Academy to conduct interviews and surveys of her students for her MSSE capstone project. She has agreed that no identifying information of any student will be included in any document she writes as part of this research. As long as this condition is met, it will not be necessary for her to get written assent from students or consent from student parents for their participation. Refusal to participate in the research activities will not impact the students’ grades in any way.

Please let me know if I can be of assistance.

Mike Sjoberg
Assistant Headmaster
APPENDIX B

ATTITUDES OF SCIENCE LEARNING SURVEY (MODIFIED CLASS SURVEY)
ATTITUDES OF SCIENCE LEARNING SURVEY

1. A significant problem in learning science is being able to memorize all the information I need to know.

   Strongly Disagree  1  2  3  4  5  Strongly Agree

2. I find that reading the text in detail is a good way for me to learn science.

   Strongly Disagree  1  2  3  4  5  Strongly Agree

3. After I study a topic in science and feel that I understand it, I have difficulty applying that information to answer questions on the same topic.

   Strongly Disagree  1  2  3  4  5  Strongly Agree

4. Knowledge in science consists of many disconnected topics.

   Strongly Disagree  1  2  3  4  5  Strongly Agree

5. When I am answering a science question, I find it difficult to put what I know into my own words.

   Strongly Disagree  1  2  3  4  5  Strongly Agree

6. I enjoy figuring out answers to scientific questions.

   Strongly Disagree  1  2  3  4  5  Strongly Agree

7. Learning science changes my ideas about how the natural world works.

   Strongly Disagree  1  2  3  4  5  Strongly Agree
APPENDIX C

ATTITUDES OF SCIENCE LABS SURVEY
## ATTITUDES OF SCIENCE LABS SURVEY

1. I enjoy doing hands on activities, such as labs, in science class.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

2. Lab activities help me better understand scientific concepts.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

3. I learn about scientific concepts best by doing hands on science.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

4. Lab activities let me put scientific concepts into practice.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

5. I don't understand how lab activities relate to what we are learning in science class.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>
APPENDIX D

TECHNOLOGY SURVEY
## TECHNOLOGY SURVEY

1. Technology is very important to my learning.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

2. I communicate through technology weekly in school.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

3. I can apply my learning in new ways when using technology in school.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

4. I understand more of what I am taught when using the technology in school.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

5. Classes are more interesting when I use technology.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

6. Classes are more engaging when using the iPad.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

7. I understand more of what I am taught when using the technology in school.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

8. Using technology helps me be better prepared for learning.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

9. I am more prepared for class when I use the iPad as part of my homework.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>
APPENDIX E

STUDENT INTERVIEW QUESTIONS
STUDENT INTERVIEW QUESTIONS

These questions will be asked of a select group of students after each lab activity performed throughout the treatment. Both treatment and non-treatment students will be interviewed. Student participation in the interview process is completely voluntary and will, in no way, influence the students’ grade in class.

1. What was the purpose or goal of the lab we just conducted?
2. How well prepared did you feel for the lab before you began?
3. How well did you understand what you were supposed to do in this lab?
4. How did this lab help you understand the concepts we are discussing in class?
5. If you could change something about your experience in lab what would it be?
APPENDIX F

TEACHER JOURNAL PROMPTS
TEACHER JOURNAL PROMPTS

These prompts will be answered through teacher journal responses during each treatment episode.

1. How many students came prepared to lab with the pre-lab activity completed?
2. What misconceptions were addressed before the lab began?
3. What questions did students ask before the lab began?
4. How engaged did students appear to be while in lab?
5. What questions did students ask while in lab?
6. How long did it take students to complete this lab?