THE EFFECTS OF PROJECT-BASED LEARNING IN THE MIDDLE SCHOOL SCIENCE CLASSROOM

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Effective problem solving is a vital 21st century skill leading to successful careers in academics and the work force. This study aims to improve middle school students' problem solving skills and increase their confidence. Project-Based Learning (PBL) was implemented in the earth science classroom with the intent to challenge students to solve real world problems through collaboration, critical thinking, and problem solving while learning to take initiative and build confidence. Units were taught in alternating phases of PBL and normal instruction. Students were assessed on their comprehension through the analysis of pre and post content tests and students' problem solving abilities were measured with a rubric to determine their individual success of applying appropriate problem solving strategies concluding each unit. Student confidence levels were determined with a survey, unit reflection, and interviews. The results indicated that the majority of the students preferred PBL instruction to normal instruction and were more effective problem-solvers concluding PBL units. The treatment of PBL instruction had a positive influence on students' confidence levels as students expressed more confidence, motivation and desire for collaboration following treatment.

INTRODUCTION AND BACKGROUND

Edgewood Campus School (ECS), a private school located in Madison, Wisconsin, is set on a shared 55-acre campus with Edgewood High School and Edgewood College. The Sinsinawa Dominican Sisters founded ECS in 1881. For the 2015-2016 school year, ECS enrolled 269 students in grades kindergarten through eighth. The school population was evenly dispersed with 51% female and 49% male students. Forty percent of these students were identified as being ethnically diverse, including students with visas from Brazil, Canada, China, Germany, Japan, Netherlands, Sierra Leonne, and Switzerland (edgewoodcampusschool.org). The sixth grade was comprised of 39 students divided into two classrooms. Twenty-four students were female and 15 students were male. One of the sixth graders came from China in the summer of 2015 and is an English Language Learner.

Sixth grade is known as a transition year at ECS. The students leave the elementary school building and take most of their classes in the middle school located in the bottom floor of the high school. During the sixth grade school year, students develop their independence as they rely less on their parents and take more responsibility for their actions and success in academics.

At the beginning of the 2015-2016 school year, I noticed that this particular class of sixth grade students were more reliant on my guidance and help when it came to dealing with everyday issues and solving a variety of academic problems. I recognized that most of their dilemmas could have been solved independently with more patience, by applying their knowledge, or by seeking help from another classmate. Some of the questions or comments my students had demonstrated that they lacked self-confidence and they were just looking for reassurance. It became my goal to build my students' confidence and problem-solving skills to help them have a successful academic career.

I decided to implement project-based learning (PBL) in my science classes as it is seen by many as an effective approach for emphasizing problem-solving skills through motivating and engaging questions or tasks, that require students to work in collaboration with each other to solve a problem (Bender, 2012). I saw PBL as a way to improve my students' problem-solving skills while relying on other classmates to help them reach a solution. This learning design is typically characterized by students having "a voice in some aspects of how the project might be undertaken and be encouraged to exercise choices throughout" (Bender, 2012, pg. 32). Additionally, PBL products are intended to be presented to an audience to build authenticity and real-world experiences. I hoped these factors of making and carrying out decisions along with presenting final projects would increase student confidence.

An essential part of building 21st century skills, such as problem solving, is the incorporation of technology. Grades six through eight at ECS has a one-to-one student-iPad ratio. My goal as a teacher was to become more familiar with this technology and enhance student learning by integrating technology with PBL instruction.

The following primary question was addressed during this research, *What are the effects of project-based learning in science on comprehension and problem-solving skills?* The following secondary questions were addressed in this project: 1) What are the effects of project-based learning in science on student confidence? and 2) What are students' attitudes towards using iPads to engage in project-based learning?

CONCEPTUAL FRAMEWORK

Since the early 1900's project-based learning (PBL) has played a role in education starting with the forward thinking of John Dewey supporting "learning by doing." Constructivism reflects this notion as students learn best when they are constructing meaningful products that deepen their engagement, which can be shared and reflected upon (Grant, 2002). The Next Generation Science Standards (NGSS) calls for a deeper understanding and application of knowledge of the big ideas in science, similar to the theme of PBL (Miller, 2013).

As an instructional model, PBL uses authentic, real-world projects, driven by inquiry that requires collaboration to design many aspects of an assignment and create solutions. Differing from a traditional project assignment, PBL is framed by a driving question, has a collaborative nature, a longer time frame, more depth of content and is publically presented (Bender, 2012). The Buck Institute for Education website provides a selection of PBL activities in a variety of content areas (bie.org/project_search). One sample interdisciplinary PBL project combines science and social studies content on the topic of global warming. In this project students are required to demonstrate their understanding of global warming by creating an advocacy presentation that includes specific descriptions of one effect and suggests actions to reduce that effect.

The NGSS learning structure emphasizes science and engineering practices that lead to three-dimensional learning. The three dimensions are scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. The NGSS highlight practices that meaningfully engage students and require them to formulate questions throughout their own investigations. Many concepts in the NGSS are cutting across content requiring students to discover patterns, cause and effects, proportions, and system modeling. Three-dimensional learning extends to disciplinary core ideas that students can relate to as they investigate complex problems across multiple disciplines (NGSS Lead States, 2013). Project-based learning is an instructional model that meets these three dimensions. The authentic projects of PBL produces opportunities for students to engage in multiple science and engineering practices while learning disciplinary core ideas and crosscutting concepts that can be used to make sense of phenomena and propose solutions to real-world problems (Metz, 2015).

In science, PBL provides students with authentic science, technology, engineering, and mathematics (STEM) experiences in a student-centered learning environment. Project-based learning challenges and motivates students to think critically and creatively through collaboration. The interdisciplinary approach and self-directed learning of STEM project-based learning provides students with the opportunity to enhance 21st-century skills such as higher-order thinking, problem solving, and communication (Capraro, Capraro, & Morgan, 2013). Students take responsibility of their learning and produce tangible learning outcomes by creating and answering relevant and authentic research questions (Colley, 2008). Furthermore, STEM project-based learning uses real world problems with poorly defined answers. The nature of solving problems of this difficulty aims to highlight student expertise of various STEM concepts. The illdefined task allows for the development of original interpretations and solutions, resulting in various learning outcomes (Capraro et al., 2013).

According to the New York City Department of Education (2009), PBL has five characteristics that create effective learning experiences and result in in-depth understanding. First, PBL is an inquiry process that should lead to the exploration of important ideas and questions. It is important to differentiate PBL for students' interests and needs. Project-based learning should be a student-centered process rather than teachers providing direct information. The project should require the application of critical thinking, creativity, and skills to research, problem solve and draw conclusions. Finally, PBL most is effective if it applies to real-world problems and issues.

Teachers act more as mentors or facilitators during PBL guiding the learning process and supporting student questioning and reflecting (Capraro et al., 2013). As the design of PBL replaces unit-based instruction, teachers must carefully determine which instructional standards will be addressed exclusively through the PBL experience and design methods to support these standards throughout the process (Bender, 2012).

During the progression of PBL, students apply knowledge instead of solely consuming it and begin to make meaning of the information that is investigated. Through PBL students are active learners who plan, organize, develop, and carry out activities such as presentations, discussions, interviews, guest speaker events, and field trips (Fleming, 2000). Throughout the inquiry process students begin with their own questions, search for resources and discover answers, which leads to student generation of new questions, investigations, and drawing of their own conclusions (Larmer & Mergendoller, 2010). The final product is as realistic as possible for students, where communities and parents may be involved or present as the audience (Fleming, 2000).

The NGSS claims K-12 science instruction should build scientific understanding, incorporate technology, and relate to students experiences or address current issues (NGSS Lead States, 2013). The implementation of real world applications addresses the need for fostering a foundation in STEM fields and allows students to relate to their learning experiences. The theory of using real world applications in the classroom "is that if academic content is made more relevant, participatory and stimulating, students will respond more effectively" (Walter, 1992, p.1). Project-based learning provides students with an authentic opportunity to practice real learning and present this new proficiency. They become active learners as they translate information to real knowledge while connecting it to their own interests (NYC Department of Education, 2009). Technology can be used to engage students in various scientific projects and help carry out investigations. Digital tools can be used to collect real-time data on the web while expanding networks of communications (Krajcik, 2015).

The National Science Resource Center (1998) argues that middle school students learn more when they are actively involved in their learning, creating solutions to real life problems. Students engaged in real world problems develop skills and knowledge beyond the classroom creating connections to the outside world (Bransford, Brown, & Cocking, 2000). If PBL supports real world problems and projects that originate in a school environment, students' motivation to participate in the project will increase. Additionally, students' motivation will increase if they present their final product, performance, exhibition, or demonstration to people outside their typical social setting (Larmer & Mergendoller, 2010).

It is important to implement PBL in the early stages of students' education to help them develop lifelong skills. These skills are essential for inquiry, self-directed learning, critical thinking, creativity, and collaboration. When middle school students are continuously practicing PBL they can develop knowledge, skills and stamina for independent learning, preparing them for future academic and non-academic careers (Capraro et al., 2013).

METHODOLOGY

This study implemented project-based learning (PBL) units to build student confidence and problem solving skills. 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 (Appendix A).

Data collection began at the beginning of the second quarter in November 2015 prior to PBL treatment and ended in May 2016. Throughout the study, all 39 sixth grade students were exposed to eight units alternating between treatment and non-treatment methods, which implemented and correlated to the middle school earth and space science NGSS. During non-treatment units, regular classroom instruction took place following the 5E instructional model, a sequence of teaching and learning techniques: Engage, Explore, Explain, Elaborate, and Evaluate. Additionally, non-treatment units included hands-on activities, readings from texts, worksheets, and a final quiz. The treatment units contained the following components of PBL a driving question or problem, collaboration with peers, learning through inquiry, authenticity, student voice and choice, and a public product. The four treatment units were based on the planets, constellations, egg drop engineering, and earthquakes. The four non-treatment units focused on the Moon, the Sun, galaxies and the universe, and plate tectonics.

During treatment, students were exposed to new concepts through participation in an introductory lesson. For example, during the treatment unit on planets, students had two introductory lessons on the planets, one being on the order of the planets and the other being on the gravitational force of each of the planets. These initial lessons allowed students to acquire background knowledge before being presented with the project. Students were then placed in small groups of two to four during treatment units and were introduced to a driving questions or problem. To help outline and pace the inquiry process students were provided with guidelines and/or a graphic organizer to follow over the project period. For example, in the planet PBL unit, the Planet Project Guidelines clarified expectations and upcoming project deadlines (Appendix B). Each PBL unit also followed a similar Project Rubric format to measure student's success at completing their project effectively with their team members and as an individual (Appendix C). These rubrics were administered prior to the start of any project to further establish expectations. To complete the projects, students worked both individually and in small groups for two to three weeks during class time. During this time, I acted more as a facilitator and guide, reminding students of upcoming deadlines and expectations, while the students became responsible for their learning process. The final product of all PBL units was presented publically to an audience in a college classroom, uploaded to

YouTube, shared with family and friends, or presented to students from other local schools.

Prior to any treatment, students were administered an anonymous Self-Evaluation Survey asking for a reflection towards group work, projects, technology, and overall confidence levels in science (Appendix D). The survey used a Likert Scale to measure students' ratings from *1 – Strongly Disagree* to *5 – Strongly Agree*. After intervention of all treatments and non-treatment units, students were provided with the same Self-Evaluation Survey. The results from the survey were analyzed and compared using a stacked column chart. These results helped to indicate, after exposure to PBL, if students preferred to work in groups, do a project, and if confidence levels had increased.

During both treatment and non-treatment units, a Content Test was administered before and after each unit to measure comprehension of the material (Appendix E). This examination contained 10 multiple-choice questions and one short answer question. The Pre and Post Content Test were analyzed using normalized gains and organized through a Box and Whisker Plot to determine patterns while comparing progression between PBL and normal instructional units.

Upon completion of each treatment and non-treatment units, students were provided with a question that required the application of problem-solving skills. Their solution to the problem-solving question was measured using a Problem Solving Rubric (Appendix F). Data from the Problem Solving Rubric was organized in bar graphs and analyzed for comparisons between treatment and non-treatment units. This information allowed me to understand if individual problem-solving skills were improving and if there was any correlation with successful problem-solving skills after PBL units.

Concluding each unit, students were provided with a Unit Reflection Questionnaire (Appendix G). This questionnaire differentiated students' attitudes of post treatment and post non-treatment units. The four questions required students to assess their ability of problem solving, reflect on their individual confidence levels, and share any attitudes towards the design of the unit. These responses were analyzed for trends or patterns to characterize PBL and normal instructional units.

To gather additional qualitative data, 12 students were randomly selected to take part in a post intervention interview (Appendix H). These questions were designed to gather further insight concerning working in groups, projects, and technology. The questions emphasized expression regarding individual confidence levels. Data from the interview questions were recorded and analyzed for themes.

The variety of data collection tools used to answer the primary and secondary questions are outlined in Table 1.

Table 1
Data Triangulation Matrix

Data Source	Questions		
	Focus Question: What are the effects of project-based learning in science on comprehension and problem-solving skills?	*Secondary Question*: What are the effects of project-based learning in science on student confidence?	*Secondary Question:* What are students' attitudes towards using iPads to engage in project-based learning?
Pre and Post Self-Evaluation		X	X

Pre and Post Content Test	X		
Unit Reflection Questionnaire		X	X
Problem Solving Rubric	X		
PBL Rubric	X		
Interview Questions		X	X

DATA AND ANALYSIS

The results from the pre- and post- content assessments indicated that students' had a higher learning growth during the project-based learning (PBL) units (*N*=39). The average normalized gain for all PBL units was consistently medium-high from 0.63 to 0.77, whereas the average normalized gain for normal instructional units ranged from low-medium-high (Table 2). The non-treatment unit pre-content assessments had both the lowest class average gain of 0.37 for the first non-treatment unit and the highest gain of 0.81 during the second non-treatment unit. Both PBL treatment and non-treatment pre content assessments had a low class average score ranging from 40% to 48%.

Table 2
Class Average Normalized Gains From Pre- to Post- Content Tests

Unit	Pre Average (%)	Post Average (%)	Average Gain
Moon	43	65	0.37 low
Planets	47	84	0.66 medium-high
Sun	45	88	0.81 high
Stars and Constellations	47	79	0.63 medium-high
Galaxies and Universe	40	73	0.54 medium
Egg Drop Engineering	48	88	0.77 medium-high
Plate Tectonics	45	84	0.69 medium-high
Earthquakes	42	79	0.65 medium-high

Note. Grey rows are non-treatment and white rows are treatment, (*N*=39).

The average problem solving scores concluding each unit were slightly higher on all treatment PBL units compared to non-treatment units. The average score ranging from *0 - blank response* to *4 - problem solved accurately* for non-treatment units was a 2.85 whereas the average score for treatment PBL units was a 3.27 (Figure 1).

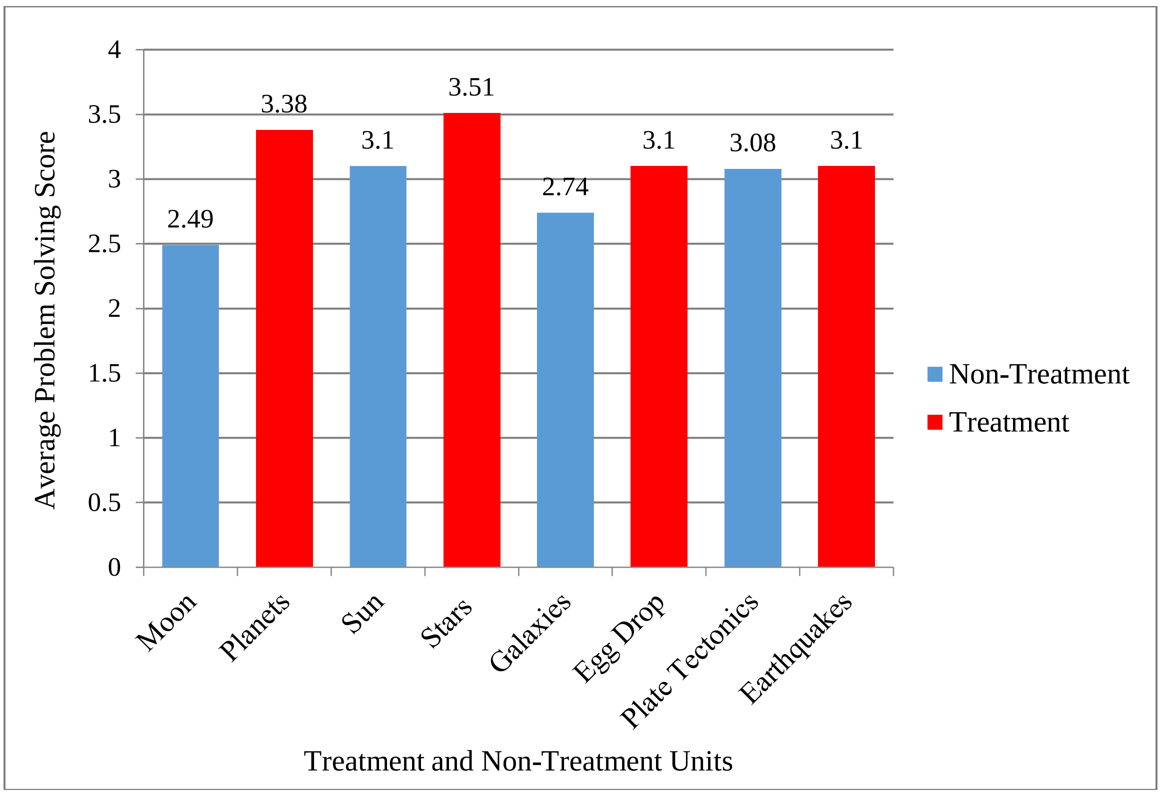

Figure 1. Average problem solving score concluding each unit, (*N*=39).
Note: Problem solving scores: 4 = problem solved accurately, 3 = appropriate strategies were used but solution is not entirely correct, 2 = appropriate strategies were used but solution is not correct, 1 = incomplete and/or incorrect response, 0 = blank response.

Correlating pre-and post- content test normalized gains with problem solving skills revealed a coherent relationship between performance on each unit's content tests and ability to successfully problem solve concluding the unit (Figure 2). For example, if students had a gain over 0.6 for a unit then they were likely to have a positive problem solving score of *3- appropriate strategies were used but solution is not entirely correct* or *4 – problem solved accurately*.

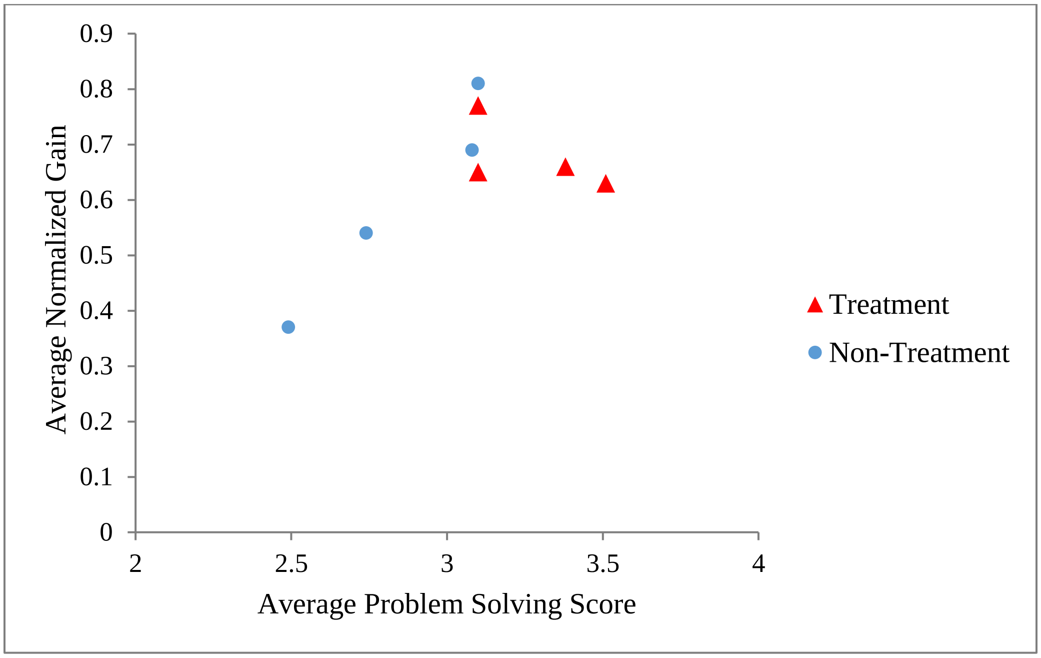

Figure 2. Comparison of average problem-solving scores to average normalized gains, (*N*=39).
Note: Problem solving scores: 4 = problem solved accurately, 3 = appropriate strategies were used but solution is not entirely correct, 2 = appropriate strategies were used but solution is not correct, 1 = incomplete and/or incorrect response, 0 = blank response.

The results from the unit reflections indicated that the majority of students preferred PBL instruction to normal instruction. At least 77% of students *agreed* or *strongly agreed* that they enjoyed each PBL unit (Figure 3). One student shared they *strongly agreed* with enjoying a PBL unit because “I loved working with a partner and having freedom on what we could do.” During normal instructional units, 62% to 74% of students enjoyed the unit. Students conveyed enjoying hands on activities during normal instruction units but expressed that they did not like having tests or worksheets. In one non-treatment unit, 46% of the students mentioned their least favorite part of the unit was taking a quiz or completing worksheets.

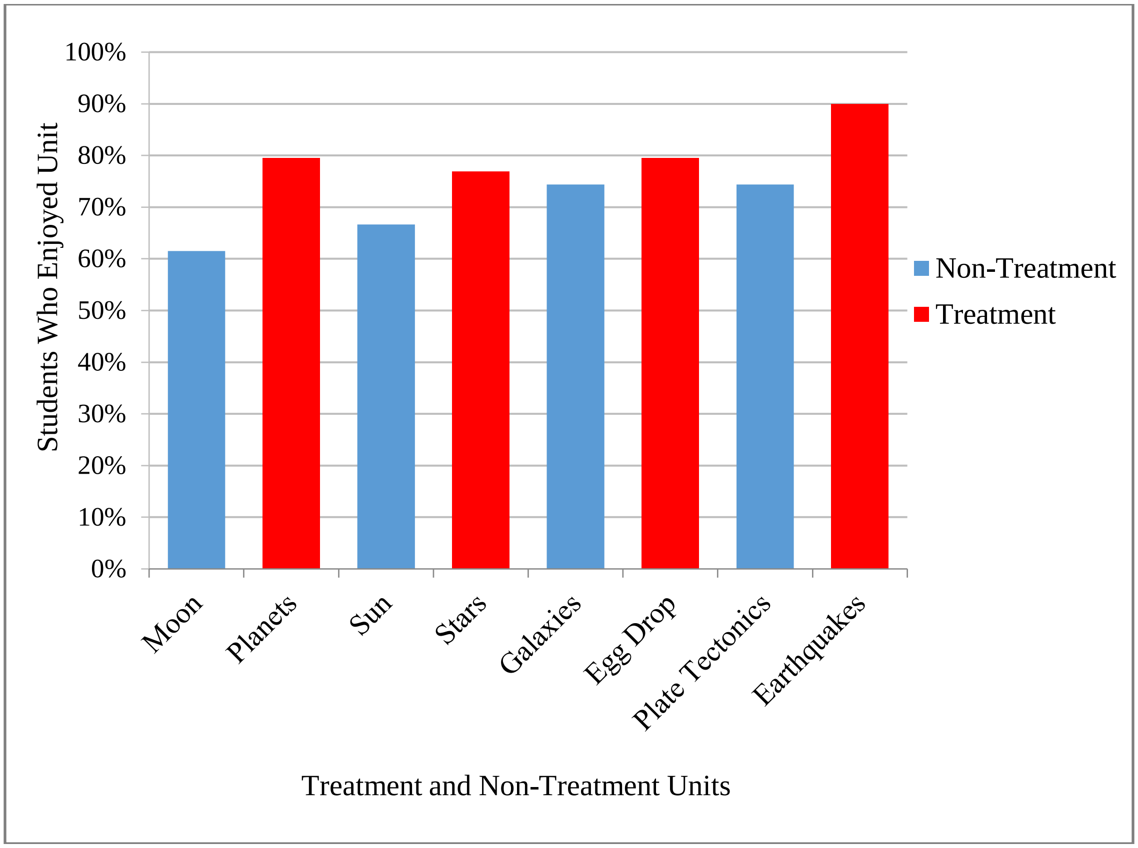

Figure 3. Students enjoying treatment and non-treatment units, (*N*=39).

The unit reflections also indicated that students felt more confident explaining learned information concluding PBL units compared to non-treatment units. At least 69% of students agreed or strongly agreed that they were confident explaining the information from PBL units whereas confidence concluding non-treatment units ranged from 53% to 69% (Figure 4). One student who *strongly agreed* with feeling confident concluding a PBL unit explained their rating selection by sharing that, “When I did this project I was proud of myself and I felt like I was smart.”

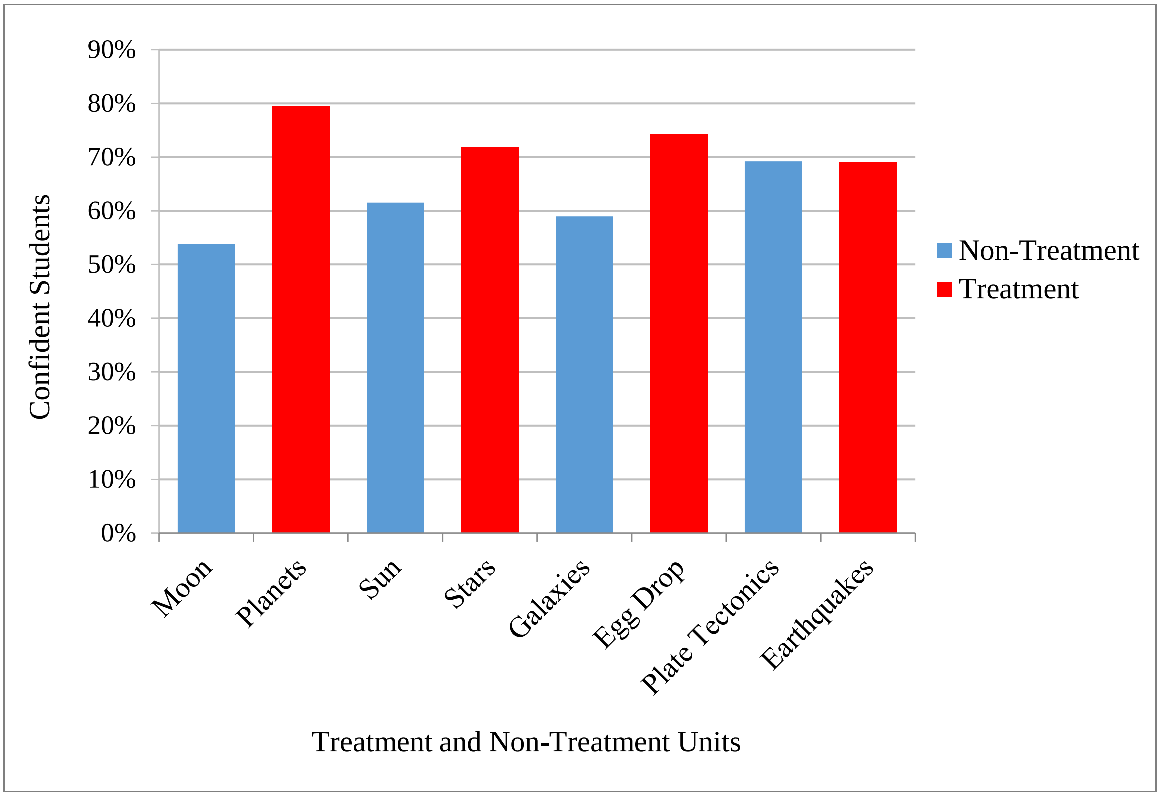

Figure 4. Students expressing confidence concluding treatment and non-treatment units, (*N*=39).

Student confidence ratings from the unit reflections compared to students' normalized gains from the pre- and post-content tests indicated that if students were confident in the material, then they were more likely to have a higher gain on the content test (Figure 5). For example, when 62% of students or more felt confident concluding each unit there was at least a medium-high class average normalized gain of 0.63. The units that indicated students were not as confident in explaining the learned material demonstrated a correlation of medium-low class average normalized gains.

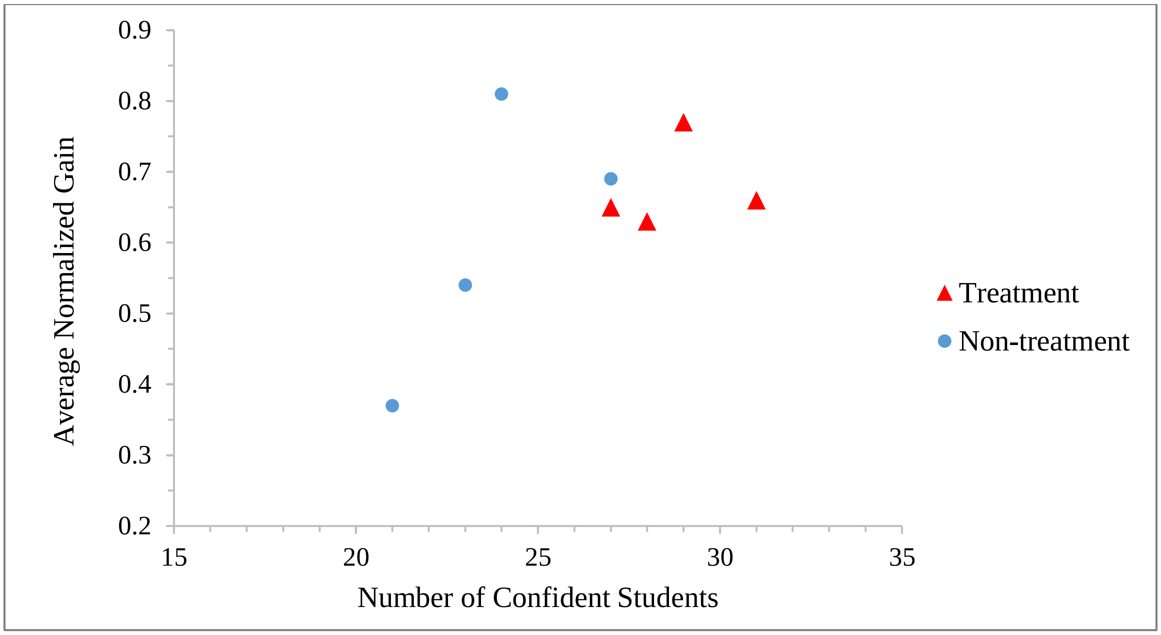

Figure 5. Relationship between total number of confident students and average normalized gain score per unit, (*N*=39).

Comparing the results from the unit reflections to the problem solving scores showed a positive relationship between confidence and problem solving ability. The greater the amount of students that felt confident concluding each unit, the more likely they were able to effectively solve a problem. Figure 6 reflects the units in which the class average problem solving score was a 3 or higher, students' confidence was also higher. Concluding PBL units, student confidence was higher and reflected their positive performance on the problem solving questions.

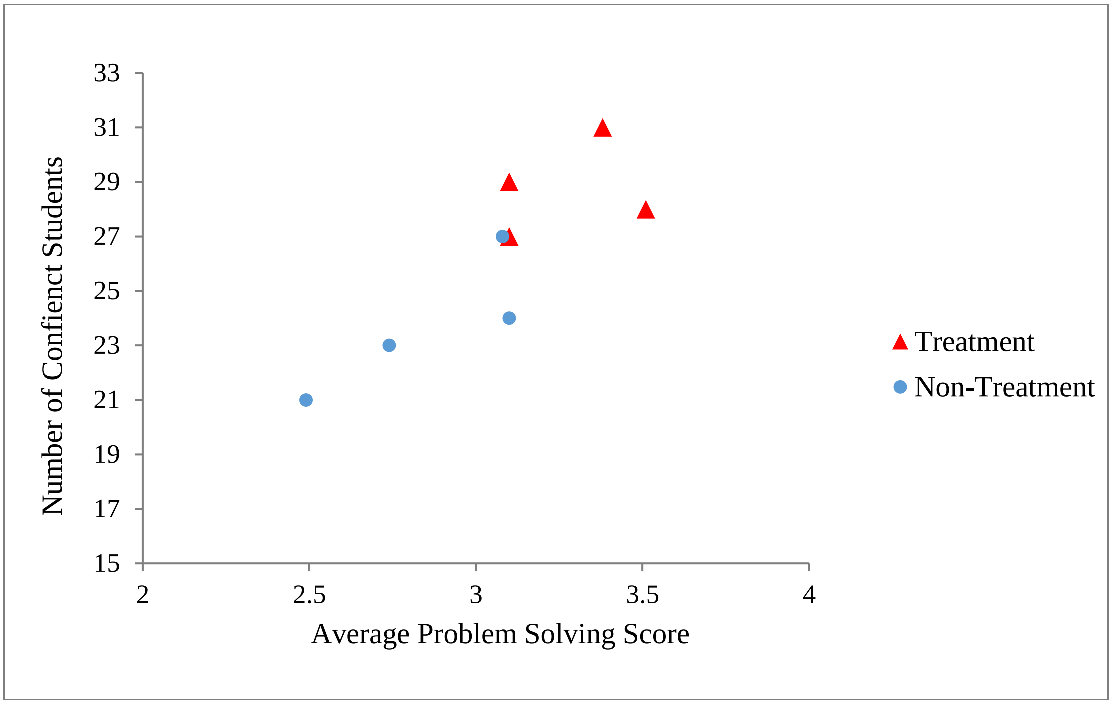

Figure 6. Relationship between total number of confident students and average problem solving scores per unit, (*N*=39).
Note: Problem solving scores: 4 = problem solved accurately, 3 = appropriate strategies were used but solution is not entirely correct, 2 = appropriate strategies were used but solution is not correct, 1 = incomplete and/or incorrect response, 0 = blank response.

The pre-treatment self-evaluation survey compared to the post-treatment survey indicated increased positive attitudes towards confidence, motivation, group work and the use of technology during science class. Pre-treatment, 72% of students *agreed* or *strongly agreed* that they were confident in their ability to explain learned science concepts to others, 21% of students *strongly disagreed* or *disagreed* with this statement, as the rest indicated neutral feelings (Table 3). Post treatment, an additional 15% of the students were confident in explaining learned science concepts and the students that *disagreed* or *strongly disagreed* with this statement reduced by 11%. Seven percent more students indicated that they did not feel discouraged during science if they did not know an answer. Confidence in test taking during science class rose by 8% from pre-treatment to post-treatment.

Table 3
Pre- and Post- Self-evaluation Survey Confidence Results

	Pre Treatment (%)	Post Treatment (%)
Confident in ability to explain learned science concepts to others	72	87
Confident when answering a question in science class	69	72
Does not get discouraged if they don't know an answer	67	74
Does not have a fear of looking dumb when answering a question incorrectly	72	74
Confident during science tests	54	62

Note. Confident students = strongly agreed or agreed with the statement. (*N*=39).

Prior to treatment, 56% of students *agreed* or *strongly agreed* that they liked to share what they had learned in science with their parents and family, 23% of students *strongly disagreed* or *disagreed* with this statement, and 21% of students expressed neutral feelings (Table 4). Prior to treatment, 13% more students liked sharing what they had learned in science, the students that expressed neutral feelings decreased by 13%, while the amount of students that did not like sharing what they learned in science with family stayed the same. Upon completion of treatment, 92% of students felt motivated to work hard and achieve success during science class, an increase of 10% from the pre-self-evaluation survey.

Table 4

Pre- and Post- Self-evaluation Survey Motivation Results

	Pre Treatment (%)	Post Treatment (%)
Likes to share what they have learned in science class with family	56	69
Feel motivated to work hard and achieve success	82	92

Note. Motivated students = strongly agree or agree with the statement. (*N*=39).

Attitudes towards group work remained positive from the pre- to post-self-evaluation survey, however only two questions reflected a positive increase. Pre-treatment, 51% of students agreed or strongly agreed that they would rather complete a project or make a presentation than take a test in science class. This number increased by 13% upon completion of treatment (Figure 7). Seven percent more students indicated that they learn better when working in groups, resulting in 79% of students preferring group work. The number of students that felt motivated during group activities reduced by 2%, remaining at a positive 85% of students expressing motivation when working with others and 13% *disagreed* or *strongly disagreed*.

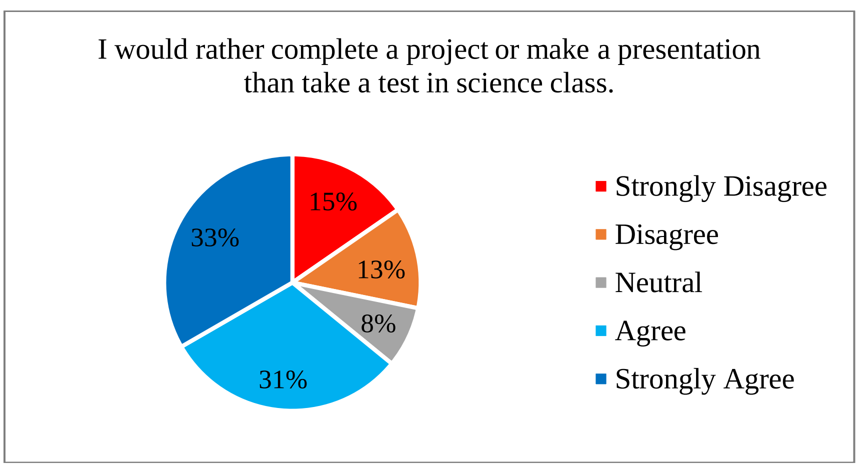

Figure 7. Student post-treatment attitudes of projects versus tests, (*N*=39).

Attitudes towards using technology in science class increased by 8%, as 84% of students *agreed* or *strongly agreed* with this statement during the pre-survey and 92% of students *agreed* or *strongly agreed* during the post-survey (Figure 8). Pre-treatment, 8% of students indicated they *strongly disagreed* or *disagreed* with the beneficial use of technology during science class and 8% of students had neutral feelings. Post-treatment, only 5% of students *strongly disagreed* or *disagreed* and 3% felt neutral about technology making learning science easier.

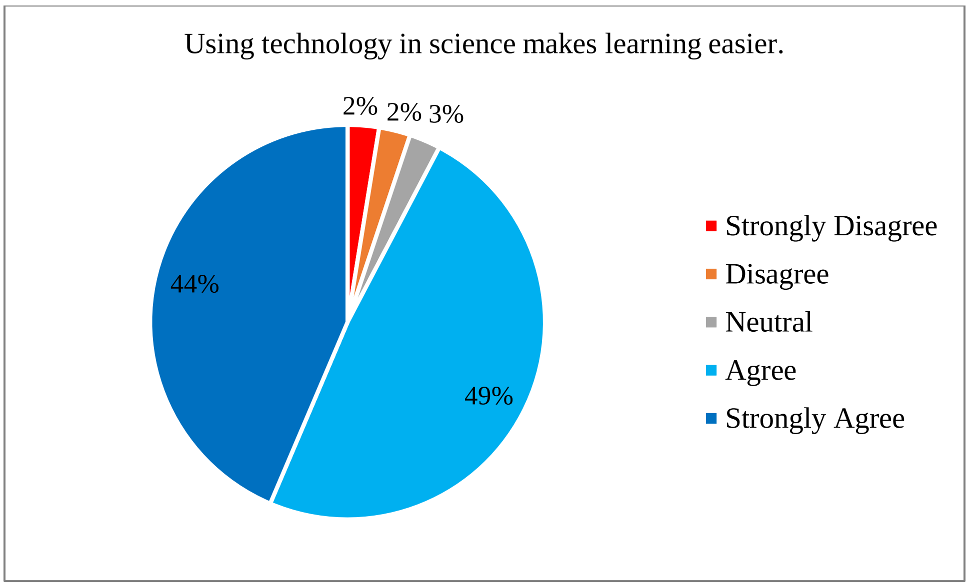

Figure 8. Student post-treatment attitudes of technology in science, (*N*=39).

Seventy-five percent of the students interviewed after the treatment of PBL, said they would rather do a project than take a test in science class (*N*=12). Of the students that would rather do a project in science class, 44% mentioned feeling nervous or stressed when it came to test taking. One student said, “I like projects because I don’t like studying and I get nervous for tests and I end up getting things wrong that I really knew the answer to.” When asked if they prefer to work in groups or individually, 58% of the students said it depends on what they were working on and 33% preferred group work. One student said, “I prefer group work because there is more than one idea that gets put together and it make a different mashup of ideas.” One student explained, “It depends. I like group work because I don’t have to do all of the work by myself, but working individually there is no arguing.” When asked about their favorite activity in science class so far, 92% of students mentioned an activity or project from a PBL unit. One student said, “I liked the Shake-A-Thon because we had variety of choices [of topics], the egg drop because I could design my own contraption, and planet project because I liked that we got to choose our own planet and do a skit.” When asked what the least favorite activity was during science class, 50% of students mentioned test taking or homework and 33% of students said they liked everything. When asked about confidence while learning a new concept in science, 50% of the students felt confident and 33% said it depends on the topic being learned. One very confident student said, “On a scale of one to ten, I would be about a nine and a half because I may forget a few things from the beginning of the year.” Eighty-three percent of the interviewed students felt confident explaining learned science concepts to others. One student who did not feel confident expressed they “do not like being on the spot.” Unanimously, all students enjoyed using their iPads during science class. Students said it helps with research, presentations, finding quick answers, iPads are more fun than reading a book, and they liked making the iMovies with their iPads. When asked if there is anything else you would like me to know, one student took the opportunity to share, “I like science class this year because at my old school it was hard for the teacher to organize projects because of classroom misbehavior and the projects we do here are fun."

INTERPRETATION AND CONCLUSION

This study supports that project-based learning (PBL) has a positive effect on student comprehension and problem solving. The normalized gains of all PBL units reflected medium-high growth, while the non-treatment units had more of a variety of growth from low-medium gains to high gains. All of the pre-content assessments had a class average ranging in the 40's, which represented an even foundation of prior knowledge on all units. Originally, I thought the non-treatment units had the advantage of having higher post-test averages because the students would have just taken a unit quiz or test and would have been prepared for another assessment. This familiarity of testing may have been the cause of the high-normalized gain for the second non-treatment unit. This unit also took place following winter break when students returned refreshed, ready to learn and absorb information offering a fresh start. Additionally, students memorized a song to help them learn facts about the Sun for this unit. The retention of the song lyrics could have been beneficial to recalling learned information during the post-assessment. Overall, I was surprised with the consistency of the treatment units' medium-high normalized gain, as this reflects a more holistic learning growth.

The implementation of PBL helped students develop their problem solving skills as they performed better when presented with a challenge concluding all PBL units. Originally, I was anticipating seeing a progressive trend of problem-solving skills over time with all treatment and non-treatment units. Even though this was not the result, I was still impressed that the students problem-solving skills were positive during PBL units and remained constant in the final three units. It was interesting to see the relationship between problem-solving skills and normalized gains as the higher the gain, the more likely to be efficient at applying problem-solving skills. This shows that students' comprehension plays a role on their ability to effectively solve a problem.

The post unit reflections were the most beneficial piece of data collected as the students enjoyed reflecting on their learning process and this helped with my reflection and performance as a teacher. It is clear that the majority of my students enjoy all of their science units, especially the PBL units. I learned from the unit reflections that my students respond positively to creativity and hands on learning. I think 90% of the students enjoyed the Shake-A-Thon because they enjoyed the earthquake content and the freedom of being able to choose the topic, type of project, and partners.

The results of student confidence from the unit reflections indicated that students were more confident during treatment units. I think these results come from the students being the main facilitators in their learning process and taking responsibility for their progress. Additionally, the majority of the students enjoyed PBL units and this enjoyment reflects their confidence with the content learned.

Students' positive confidence ratings on the unit reflections aligned with the higher normalized gains, indicating that a student is more likely to have a higher gain if they are confident in their understanding of material they have learned. The second non-treatment unit was an outlier as students had high gains but lower confidence. This may be due to the lower enjoyment rating of this unit or because the students memorized a song relating to this unit on the Sun, causing them to perform better on the assessment but still feeling less confident overall. The confidence indicated in the unit reflections and the problem-solving scores also demonstrated a clear relationship that the more confident students are, the better problem-solving abilities they have.

The results from the pre treatment and post treatment self-evaluation survey supported that student confidence in science grew throughout the implementation of PBL. I was pleased that my students became even more confident in explaining what they learned in science to others because communication is a key part in understanding and growing as student. Even though students have indicated that taking tests stresses them out or is their least favorite part of the non-treatment units, I am content that 62% of students indicated confidence when taking a test in science. This suggests that throughout the year, students have become more comfortable and adapted study skills to apply during testing in science.

With the exposure to four different PBL units, more students indicated that they enjoyed projects than tests in science when comparing the pre- to the post-self-evaluation survey. Even though motivation during group activities and attitudes towards presenting in front of others slightly decreased from the pre- to the post-self-evaluation, these reductions are so slight that the claim can be made that the majority of students reflect positive attitudes towards group work and presentations.

Technology was used in every project, with the main tool being the iPad. With a one-to-one student-iPad ratio, students easily shared slideshows, documents, collected authentic data, and conducted research. With this further exposure to iPads, 92% of students were able to claim that technology makes learning science easier. From observations and student interviews, I was able to confirm that students enjoyed using their iPads the most to make iMovies.

VALUE

This study, which implemented project-based learning (PBL), impacted my teaching in a variety of ways. Foremost, the purpose of this study was to improve my students' problem solving skills as I noticed my students were less independent at the beginning of the school year than other sixth grade classes I previously taught. Knowing that problem-solving ability is a life-long skill, I wanted the projects to challenge students to collaborate with others and develop a final product with myself only acting as a guide throughout the process. Providing my students with this greater sense of responsibility, I noticed ownership and leadership improving in my students from the first PBL unit. At the end of the 2015-2016 school year, two eighth grade teachers, noted that the sixth graders had better problem-solving skills than the current eighth graders during a separate math and science challenge. The teachers comments on their planning process and collaboration without recognizing that my current study focused on improving problem solving skills. This acted as additional reassurance, apart from the data I collected, that my students had benefitted from implementing PBL instruction.

I learned through this process that data collection is a powerful tool to better understand your students and yourself as a teacher. Even though some of my students expressed not liking the process of the pre- and post- assessments, they demonstrated amusement and curiosity when they received their assessments back concluding each unit. I think this student self-reflection process is important so they can see how much they learned and take a closer look at the information they did not understand fully or already forgot. In the future, I plan to continue using these assessments to verify what I need to address more thoroughly, however I will not administer the assessments as frequently due to time constraints, rather combine the assessments to comprise of a larger topic.

I learned from this study that students really appreciate having a choice in their work as they feel like they have more freedom. From the first to the final PBL unit, students progressively were provided with more freedom of making their own decisions. I think this marathon versus sprint approach of easing students into more choices for their project was effective, as they were able to gain more experience and learn the pros and cons of working with others while setting goals.

Through implementing PBL, I have learned the importance of presenting student work publically. Not only does this provide students with a more authentic learning experience, but I see my students feeling proud of their product and enjoying observing other variations of the same project. One of the PBL projects required students to make an iMovie and upload it to YouTube so it could be shared semi-privately with family and friends. We had an iMovie day in class and I cannot decide if it was more enjoyable watching the final iMovie products or watching the students' reactions to seeing them or their friends in a video clip. Out of the entire final product delivery methods, iMovies are one that I will be sure to use as long as I have access to this technology.

Through this study I have learned how valuable my students opinions are in shaping what I teach, how I teach, and being in tune with my audience. The reflections that I collected from my students have helped me to plan how I will revise units in the future, making them as enjoyable and understandable as possible. I appreciated the random compliments that were revealed anonymously in these reflections as they boosted my confidence and motivation, instilling that I was on the right path. I implemented this study to become a better teacher and to bring out the best in my students and I feel this was successfully accomplished.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD EXEMPTION

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

MONTANA STATE UNIVERSITY

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MEMORANDUM

TO: Justine Fox Schaen and John Graves

FROM: Mark Quinn, Chair *Mark Quinn CLJ*

DATE: November 30, 2015

RE: *"The Effects of Implementing Science Project Based Learning on Student Confidence and Problem Solving Skills" [JS113015-EX]*

The above research, described in your submission of November 23, 2015, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

SAMPLE PROJECT GUIDELINES

Planet Project:
Planets in Our Solar System

Introduction: Have you ever left Planet Earth? Would you like to do so? What planet would you want to visit? Let's start searching the eight planets to gather some information that will help YOU choose the planet to which you wish to learn more out and convince others to want to explore it further!

Task: In this project you will be responsible for finding critical information about a planet of your choice, completing a graphic organizer, developing a brochure, and finally creating a presentation to share with the class using Prezi or Keynote.

1. You need to complete your **graphic organizer** by researching your planet. You also need 2 separate facts of YOUR choice added to the graphic organizer (these facts should be focused towards why future missions should visit your planet). Be sure to cite all resources information was gathered from. Here are some websites to get you started on your research:

    - http://space-facts.com/
    - http://solarsystem.nasa.gov/
    - http://nineplanets.org/tour/
    - http://www.kidsastronomy.com/solar_system.htm

2. You will create a one-page informational planet **brochure** with the research gathered on your graphic organizer. This brochure should also contain a picture of your planet. Your brochure will be distributed to the audience before your presentation.

3. You will use Prezi or Keynote to create your **presentation**. Each student will cooperatively work with group members and create an 8+ slide (total) slide show. All facts in the graphic organizer must be included in your presentation. You must have at least 1 slide that aims to convince your audience that future exploratory missions should be sent to your planet.

4. You will create a **script** using Microsoft Word or Google Docs. Your script will be read during your final presentation. *HINT: You should limit the amount of text on a slide and include text in your script to read aloud to the class.*

5. Each slide should have a heading, script, and graphic. No sound will be included but you may include *some* animation.

6. We will be using class time to work on our projects. Should you need more time to complete your project, you will need to work on it at home or at afterschool. If you need to use the computer lab afterschool let me know so I can plan accordingly.

7. We will be presenting in class ___________________________. Have fun, work cooperatively, and I look forward to viewing your final presentation. I am sure they will be out of this world!

APPENDIX C

SAMPLE PROJECT RUBRIC

Rubric for Evaluating Planet Project				
Objective	*1*	*2*	*3*	*4*
Team complied data on planet by completing the graphic organizer, using reliable resources	Team struggled to effectively compile and gather data on their planet, the graphic organizer was incomplete with little accuracy, and the team cited at least two resources by the graphic organizer due date.	Team compiled and gathered data on their planet, lacked detail and accuracy in the completed graphic organizer, and cited at least three resources by the graphic organizer due date.	Team effectively compiled and gathered data on their planet, completed the graphic organizer using some detail with few errors, and cited at least four resources by the graphic organizer due date.	Team effectively compiled and gathered data on their planet, completed the graphic organizer in detail with accurate information and cited at least four significant resources by the graphic organizer due date.
Team developed a planet brochure to distribute to audience members during their presentation.	Team developed a planet brochure that includes few facts from the graphic organizer. The brochure was not completed by the due date.	Team developed a planet brochure that includes most facts from the graphic organizer. The brochure was completed by the due date.	Team developed an informational planet brochure that includes all facts from the graphic organizer. The brochure was completed by the due date.	Team developed a well-organized, informational planet brochure that includes all facts from the graphic organizer. The brochure was completed by the due date.
Team organized data on planet by creating a slide show using Prezi or Keynote	Most team members played a role in creating a slide show to share some of their planetary facts. The slide show used few graphics and most of the slides were difficult to follow. The slide show was not completed by the due date.	All team members played a role in creating an 8+ slide show to share most of the planetary facts from the graphic organizer. The slide show used some graphics that related to the planet's facts. Some of the slides were difficult to follow. The slide show was completed by the due date.	All team members played a role in creating an organized 8+ slide show to share most of the planetary facts from the graphic organizer. The slide show used graphics that related to the planet's facts. Most of the slides were easy to read. The slide show was completed by the due date.	All team members played a role in creating an organized 8+ slide show with all planetary facts from the graphic organizer. The slide show used graphics that enhanced the information being presented. The slides were easy to read and follow with limited text. The slide show was completed by the due date.
Team created an educational script to go with the Prezi or Keynote.	The team created a script that does not align with the slide show. Some facts from the graphic organizer are explained in the script. The script lacks flow and detail. The script was not completed by the due date.	The team created a script that follows the slide show. Some facts from the graphic organizer are explained in the script. The script is informative but is difficult to follow. The script was completed by the due date.	The team created a script that follows the slide show. Most facts from the graphic organizer are explained in the script. The script is informative and has a nice flow. The script was completed by the due date.	The team created a script that follows the slide show. All facts from the graphic organizer are explained in the script. The script is informative, flows nicely, and is entertaining to the audience. The script was completed by the due date.
Team presented a planet presentation that informed the audience of a particular planet and persuaded the audience to want to send future missions to the planet.	Some members played a role in presenting information to the audience. The presentation was not well rehearsed and did not include a recommendation for a future mission to the planet.	All team members played a role in presenting information to the audience. The presentation was not well rehearsed and included a recommendation for a future mission to the planet.	All team members played a role in presenting information to the audience. The presentation was professional and included a recommendation for future mission to the planet.	All team members played a role in presenting information to the audience. The presentation was professional and included convincing recommendations for future missions to the planet.

APPENDIX D

SELF EVALUATION SURVEY

Self Evaluation

Please provide complete and accurate information for each statement in this questionnaire. Circle the answer that best describes your feelings. Participation in this survey is voluntary and participation or non-participation will not affect a student's grades or class standing in anyway.

1. **Using technology in science makes learning easier.**

Strongly Disagree Disagree Agree Strongly Agree

2. **I feel more motivated when we are doing group activities in science class.**

Strongly Disagree Disagree Agree Strongly Agree

3. **I am confident in my ability to explain learned science concepts to others.**

Strongly Disagree Disagree Agree Strongly Agree

4. **I learn better when working in groups in science class.**

Strongly Disagree Disagree Agree Strongly Agree

5. **I feel nervous when my teacher calls on me in science class.**

Strongly Disagree Disagree Agree Strongly Agree

6. **If I don't know the answer to a question in science, I feel defeated.**

Strongly Disagree Disagree Agree Strongly Agree

7. **I become anxious and forget important concepts during a science test.**

Strongly Disagree Disagree Agree Strongly Agree

8. **I like to go up to the board to answer questions or present during science.**

Strongly Disagree Disagree Agree Strongly Agree

9. **I would rather complete a project or make a presentation than take a test in science class.**

Strongly Disagree Disagree Agree Strongly Agree

10. **I do not like to ask questions in class because I don’t want to look dumb.**

Strongly Disagree Disagree Agree Strongly Agree

11. **I like to share what I have learned in science class with my parents/family.**

Strongly Disagree Disagree Agree Strongly Agree

12. **During science I feel motivated to work hard and achieve success.**

Strongly Disagree Disagree Agree Strongly Agree

APPENDIX E

SAMPLE PRE AND POST CONTENT TEST

Name: ____________________________________

The Earth's Moon Pre-Assessment

1. Lola and Tony noticed the Moon in the sky during the day. What can they conclude about the Moon based on this observation?

    A. There was not a new Moon on that day.
    B. There was an eclipse of the Sun on that day.
    C. The Moon was rising earlier than usual that day.
    D. The Moon shone more brightly than the Sun on that day.

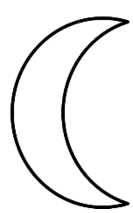
2. When Earth's shadow falls on the Moon, the shadow causes a _______.

    A. High tide
    B. Lunar eclipse
    C. Low tide
    D. Moon phase

3. Which of the following statements best describes one way that the moon is different from Earth?

    A. The Moon is not solid.
    B. The Moon has no gravity.
    C. The Moon has almost no atmosphere.
    D. The Moon receives almost no solar light.

4. A student observed the Moon on a Tuesday. She drew a picture of its shape in her journal, as shown below:



    Approximately how long will the student have to wait before she can see the Moon with this same shape and position again?

    A. 7 days
    B. 14 days

C. 28 days
D. 365 days

5. During the first quarter phase, how much of the face of the moon that we see is illuminated by the sun?

   A. 25%
   B. 50%
   C. 75%
   D. 100%

6. The diagram shows the locations of the Sun, Earth, and the Moon.

   Which of these is possible only when the Sun, Earth, and the Moon are aligned as shown?

   A. Solar Eclipse
   B. Third Quarter Moon
   C. Lunar Eclipse
   D. First Quarter

7. What is the moon phase during a lunar eclipse?

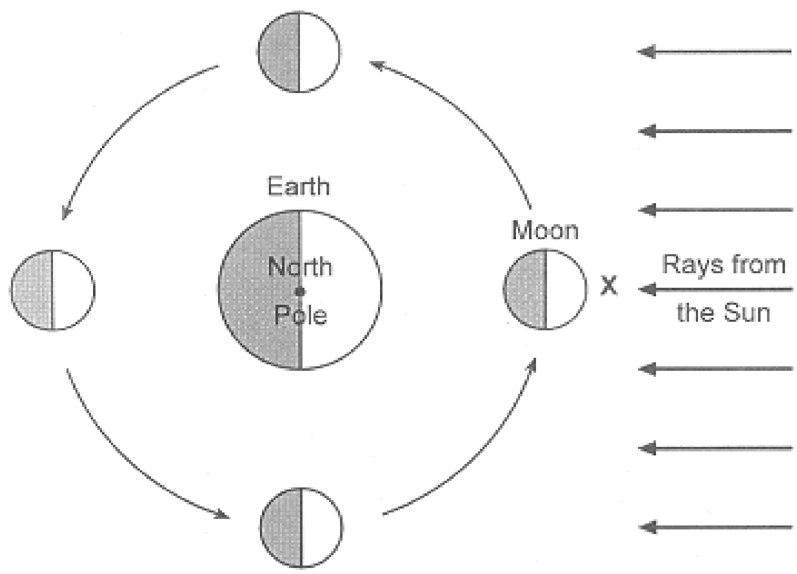
   A. New Moon
   B. First Quarter
   C. Third Quarter
   D. Full Moon

8. Which of the following is responsible for lighting the Moon's surface?

   A. Heat and energy from inside the Moon
   B. Sunlight
   C. Shiny rocks on the Moon

D. The speed of the Moon's rotation

Base your answers to questions 9 and 10 on the diagram below.

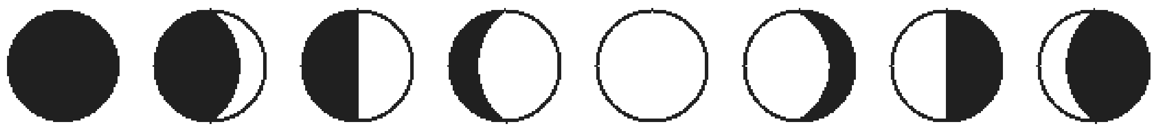


9. Circle *one* motion of the Moon and *one* motion of Earth that allow an observer in Madison, Wisconsin to see one cycle of the phases of the Moon.

Circle one:	Moon's rotation	Moon's revolution
Circle one:	Earth's rotation	Earth's revolution

10. Circle the Moon Phase that would be visible to an observer in Madison, Wisconsin at night when the Moon is in Position X shown in the diagram above.

Circle one:



Short Answer:
Answer the following questions using complete sentences. You may draw diagram to further explain your answers.

A) What time of day is it when we are experiencing a new moon phase?
B) Is this phase visible from Earth? Why or why not?

APPENDIX F

PROBLEM SOLVING RUBRIC

Problem Solving Rubric

Score	Description
4	Student selects and implements relevant concepts and strategies needed to solve the problem. • Student uses resources provided and information from the problem to solve the answer. • The solution and all relevant work is correct.
3	Student selects appropriate strategies to solve the problem but the solution is not entirely correct because one of the follow is apparent: • Evidence of a misconception • The response is generally correct but it is unclear how the student arrived at the solution
2	Student selects appropriate strategies to solve the problem but the solution is not correct because of one or more of the following: • Evidence of misconceptions • Student failed to consider relevant variables • Student did not carry out the investigation far enough to reach a solution • The solution is generally correct, however, there is no information showing how the student arrived at the solution
1	Student provides an incomplete and/or incorrect response/solution. Additionally, one or more of the following are apparent: • Student failed to consider relevant variables • Only some concepts relevant to the problem are understood • The student selected an inappropriate strategy to solve the problem.
0	• The response is blank. • OR the response only repeats information stated in the problem.

APPENDIX G

UNIT REFLECTION QUESTIONNAIRE

Unit Reflection

Participation in this survey is voluntary and participation or non-participation will not affect a student's grades or class standing in anyway.

1. What was your favorite part about this unit? Explain.

2. What was your least favorite part about this unit? Explain.

3. Rate your opinion on the following questions:
   (*1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree*)

   a. I enjoyed this unit.1 2 3 4 5

   b. I am confident in explaining what we learned to others. 1 2 3 4 5

4. **(Optional)** Explain why you selected these ratings?

APPENDIX H

INTERVIEW QUESTIONS

Post Survey Interview Questions

Participation in this interview is voluntary and participation or non-participation will not affect a student's grades or class standing in anyway.

1. Would you rather take a test or do a project during science class? Why?
2. Do you like working individually or in groups during science class? Why?
3. What has been one of your favorite activities during science class so far? What did you like about it?
4. What has been one of your least favorite activities during science class so far? What did you not like about it?
5. How confident do you feel learning new concepts during science class?
6. How confident do you feel explaining learned science concepts to others?
7. How do you feel about using your iPad to engage in science activities? Explain.
8. Is there anything else you would like me to know?