

DOES PROJECT BASED LEARNING AS A TEACHING STRATEGY INCREASE  
STUDENT LEARNING AND INTEREST IN EARTH SCIENCE?

by

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## ABSTRACT

This project evaluated the effectiveness of using project based learning in an Earth science classroom. Specifically, student learning, engagement and interest, and connections made to student's lives were observed. Using two different units with two different groups of students, it was found that project based learning can have an impact on student learning. Although, in this case the project based format could not be considered the major factor that influenced student growth. Findings did suggest that there was a positive influence on student engagement and interest in Earth science.

## INTRODUCTION AND BACKGROUND

I teach 6<sup>th</sup> grade science at Wamego Middle School in Wamego, Kansas.

Wamego is a small town in northeast Kansas. The district as a whole has an enrollment of approximately 1600 students PreK-12. Wamego Middle School's enrollment is around 330 students this year with 107 students in 6<sup>th</sup> grade. The students come from diverse socioeconomic backgrounds. However, most of the students are from middle class families. We have a free/reduced lunch rate of 39%. We do not have a lot of ethnic diversity at my school with the majority of students classified as Caucasian. Less than 3% are classified as African-American, Asian, or Hispanic. We also have a small percentage of ELL students. The 6<sup>th</sup> grade students come to the middle school with varying degrees of science instructional experiences during elementary school. Some students reported receiving science instruction once a week, others only once or twice per month. During their 4<sup>th</sup> grade year, they were required to participate in a district science fair. This was their most intense science educational experience. Their 4<sup>th</sup> grade year was also the year that state testing occurred for science, so more classroom time was devoted to science in order to prepare for the test. Prior to and after that 4<sup>th</sup> grade experience, the amount of time spent on science instruction was left to teacher discretion. Throughout their elementary years, the science instruction was tied to their literacy curriculum. As a 6<sup>th</sup> grader, this is their first experience having science instruction every day, as a stand-alone topic, that is not directly tied to monitoring their reading fluency or writing techniques.

In my past teaching experiences, I have found that when students are used to this traditional type of science instruction, the students who are successful academically in science are the ones who have good reading and comprehension skills. Those who don't have those skills, struggle with understanding the material and therefore have lower levels of achievement. I have also noticed that with that type of instructional strategy, the overall interest and engagement levels for all students in science is lower. As a result, when met with this scenario, I changed my teaching to include more inquiry-based activities. The inquiry based activities helped to increase interest, engagement and student achievement, especially when I taught life sciences. This could have happened for many reasons, but I feel like the students were able to relate to the life science standards and topics easier through the inquiry activities. Unfortunately, I was not as successful in adapting the physical science and Earth science units when I tried including inquiry-based activities. This past school year, however, I completed a physical science unit where I used a project-based lesson format and the students were more engaged than they had been when I covered the same concepts in the past. With my capstone project, I wanted to see if the same can happen if I applied a project-based lesson format to the Earth science units.

The purpose of my project was to increase student learning and interest during an Earth science unit through the implementation of Problem Based Learning. My primary focus was to answer the question: Does project based learning (PBL) as an instructional strategy increase student learning in an Earth science unit? Secondary research questions I explored included: Will using the PBL instructional strategy increase interest and

engagement in Earth sciences? Will the use of PBL in Earth science help students make connections to their own lives and understand the importance of learning Earth science?

### CONCEPTUAL FRAMEWORK

Project based learning is a concept that has been present for almost a century, but has only relatively recently been applied to primary and secondary education. Initially, PBL was applied as a method of instruction in medical schools as a means to give medical students a practical way to apply their learning and hone their skills before working professionally.

PBL has its roots in the early 20<sup>th</sup> century educational theories of John Dewey. Dewey specifically felt that education should be a balanced approach between the knowledge given to students and the student's interests and experiences. A portion Dewey's philosophy was that a student is should be seen as an individual with unique interests and capabilities that can contribute to a classroom, while the teacher should be seen as a facilitator that can create learning opportunities to nurture a student's abilities (Simon & Stack, 2010). Echoes of this philosophy can be heard when taking into consideration what is stated in the National Science Education Standards: "...science is an active process. Learning science is something that students do, not something that is done to them. "Hands-on" activities, while essential, are not enough. Students must have "minds-on" experiences as well" (NRC, 1996 p. 2) and more so when considering the National Research Council report *Taking Science to School* that is referred to in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* which states that a variety of instructional approaches are needed to fully develop

student proficiency. These instructional strategies include those led exclusively by the teacher and those led primarily by the student, teacher led activities, collaborative small group investigations, or student led activities (NRC, 2012). By employing these varying instructional strategies, PBL among them, a student's interests and capabilities can be maximized for optimal learning opportunities.

Several views or approaches to PBL exist, but they have common characteristics and benefits. I will address the overall characteristics of PBL as well as effectiveness on student learning and student engagement. Problem-based learning has been interpreted in many different ways, and is often a term used interchangeably with project-based learning. As suggested by Strevy (2014), the starting point for each differ in that problem-based learning might start with a given problem and project-based learning might start with a question generated by students or teachers. For the purposes of this classroom research project, I will be focusing on problem-based learning.

#### Characteristics of Effective PBL Activities

There are several common qualities or components within the different interpretations of problem-based learning. Overall PBL can generally be defined as hands-on, inquiry based learning that centers on real-world problems that may be generated by students or teachers, investigated by students and then ultimately come to a resolution (Torp & Sage, 1998). It is not a culminating event at the end of a unit or an activity that supplements a curriculum, rather it is the curriculum (Bell, 2010). The main characteristics of PBL are 1) students have a level of control of their learning, 2) the problem or situation is relevant to the students in some way, and 3) PBL is rigorous in

that the problem is not easily solved with one right answer found in a textbook (Krauss & Boss, 2012).

In a classroom setting, PBL components include a relevant problem or situation that is presented to students prior to learning major concepts of a topic. In doing this, the students have a focus or reason for the learning and they know that the information they will gather is for solving the problem (Gallagher, 1995). The problem presented is within the context of curriculum and learning standards, but is relevant because it often involves a situation that could directly affect students or is of high interest to students. It is often “messy and ill-structured” and can change with the addition of new information acquired by students throughout the process (Torp & Sage, 1998). Another component of PBL in the classroom is student collaboration. PBL promotes collaboration and communication skills as students share ideas. They learn to listen to one another and respect each other’s point of view as they work to solve a problem together (Bell, 2010).

The effectiveness of Project-Based Learning can be attributed to several things. An increase in engagement is one facet of that effectiveness. Project-Based Learning often is a long process covering many weeks or months and while PBL can increase engagement in its own right, it can be hard to sustain this engagement for a long period of time. It is important to address motivation when looking to increase engagement in any activity and PBL is no different. One way to address motivation, and therefore engagement, is by using scaffolding. Specifically because of the time that PBL involves, it is especially important to develop scaffolds that “better enlist student interest, maintain student direction, and control frustration” (Belland, Kim & Hannafin, 2013 p. 247). In

order to increase motivation and engagement, the scaffolds used must be specifically designed to intentionally support motivation (Belland et al., 2013). Often the framework of PBL acts as a scaffold to help the motivation and engagement of students. The characteristic of the problem being relevant to students, connected to student interests and involving some kind of student choice is a scaffolding technique that fosters value in the project or problem (Belland et al., 2013). Promoting cooperation and collaboration rather than competition among students is another scaffolding technique that increases motivation. Effective cooperation ensures that all group members are contributing the best of their abilities and strengths in order to achieve the group goals. By explaining why cooperation helps, a group is able to achieve its goals more effectively. (Belland et al., 2013).

#### Impact of PBL on Student Learning

There are many documented benefits to using a PBL format in the classroom. PBL allows students to go deeper in their learning and have a greater understanding of a topic. They become independent thinkers and learners who have increased motivation to learn (Bell, 2010). PBL makes what students learn relevant to themselves and the world. It provides an explanation and understanding for why they are learning what they are learning. PBL supports creative and critical thinking, and metacognition when students generate ideas for gathering and interpreting information as well as using evidence to defend solutions to problems or questions (Torp & Sage, 1998). A 2009 study compared 4<sup>th</sup> grade students who received PBL instruction and direct instruction. After the intervention, five students from each group were presented with a problem scenario to see

if they could transfer problem-solving skills to a new situation. The students with PBL instruction were able to generate more problem-solving strategies (15 responses) than students receiving direct instruction (six responses). The PBL students were also able to identify more resources for finding and gathering information when trying to solve the given problem (17 responses) than the direct instruction students (seven responses) (Drake & Long, 2009).

This same study also showed that there was significant growth in content knowledge regarding the aspects of electric circuits for the group of students who had PBL instruction compared to the group of students who had direct instruction. The PBL group had a mean score for growth between their pre- and post-tests of 5.86, while the direct instruction group had a mean score of 4.13 for growth (Drake & Long, 2009).

#### Impact of PBL on Student Engagement

Student attitudes towards Project-Based Learning go hand in hand with student engagement and motivation. Not surprisingly, a positive student attitude lends itself to a more effective learning outcome while a more negative attitude has a less effective learning outcome. One study showed that over the course of three years, students in a variety of entry level college courses where PBL was implemented, there were more positive reactions than negative reactions to the elements of PBL (Pepper, 2010). According to Pepper (2010), based on a set of themes of PBL instruction devised from student reflections, 33.4% of students saw working in groups as an enjoyable part of PBL, while 20.9% of students did not favor working in groups. Sharing ideas was also perceived as more positive with 21.7% of students enjoying that aspect of PBL.

However, the theme of being a self-directed learner was seen to be a more negative (32.2%) than positive (8.7%) experience for students. The author suggested that while this was disappointing, these were similar results to previous semesters before PBL was implemented (Pepper, 2010). Overall, this study showed that there was more about PBL that students enjoyed, than what they didn't enjoy. The author concluded that student feedback indicated that learning was enhanced through working in groups and sharing ideas, but not as much through self-directed learning (Pepper, 2010). I feel that if this research had been completed with elementary or middle school students, more scaffolding would be in place to guide students to become more comfortable with being a self-directed learner.

In conclusion, PBL is well documented to be an effective instructional method that engages students in a meaningful way. It promotes qualities such as collaboration, communication, self-direction and problem solving in students that they will be able to apply throughout their lives and in many different career paths. While there are differing views and approaches to PBL, there are many common attributes to the implementation of PBL. Starting with a given problem or student generated question connects to student interests and promotes student ownership of their work. Having a problem to solve or question to answer promotes self-directed learning and desire to achieve a solution. The rigorous nature of PBL is challenging to students, but the collaborative nature is inclusive to students of all abilities. These commonalities can affect student attitudes towards learning which in turn can have an effect on student engagement and learning outcomes.

## METHODOLOGY

In my intervention, I addressed the need for higher engagement in an Earth science unit in order to achieve a desired level of content mastery and positive attitude towards Earth science in general. In this section I will explain my plan for intervention, address the specifics of the participants involved and the data collection methods used.

My primary focus was to answer the question: Does project based learning (PBL) as an instructional strategy increase student learning in an Earth science unit? Secondary research questions I explored included: Will using the PBL instructional strategy increase interest and engagement in Earth sciences? Will the use of PBL in Earth science help students make connections to their own lives and understand the importance of learning Earth science?

### Participants

The participants in this intervention were 6<sup>th</sup> grade students. I teach five sections of 6<sup>th</sup> grade science. Each section averages around 20 students. I used two sections for my Intervention group and two sections for my Comparison group. I completed two different units of instruction using the project based instruction and alternated the Intervention group and Comparison group when I began the second unit. Group A had 39 students and was comprised of 18 girls and 21 boys. There were 2 African-American students and 37 Caucasian students. The majority of students in this group were of average academic ability, with one student labeled as an Exceptional Learner (EL), which is the label used in my district for gifted students. There were 2 students in this group who were inclusion special education students. Group B had 42 students with 21 girls

and 21 boys. Within this group, one student was Hispanic and 41 students were Caucasian. The majority of students in this group was also of average academic ability, and included 2 EL students and 4 inclusion special education students.

### Intervention

The Intervention took place over the course of two units. The first unit taught was the Plate Tectonics Unit and the second unit was the Erosion Unit. Group A began the plate tectonic project as the Intervention group and Group B was the Comparison Group during the same unit. Group B began the erosion project as the Intervention group and Group A was the Comparison group during the same unit.

The Plate Tectonics Unit began when we returned from winter break. Before beginning the Plate Tectonics Unit, I administered the Student Survey (Appendix D) to Group A and Group B to gauge their interest levels in Earth Science as well as their learning preferences. I also administered the Plate Tectonics Pre-Test (Appendix B) in order to understand what level of knowledge the students had coming in to the unit.

I began the unit with an introduction for both groups by showing pictures of damage caused by earthquakes. These pictures included damaged roads, buildings, and cities. The students in both Group A and Group B were very engaged by these photos and impressed with the amount of damage that could be caused by an earthquake. The class discussions that occurred in both groups during this introductory lesson were enriching and engaging. The students wanted to know why and how the land could move so much to create a large split down a road. Or how one building could be completely destroyed but the one next to it could still be standing, seemingly undamaged. Towards

the end of the lesson is where Group A and Group B start to diverge in their experiences for this unit.

After the discussion, Group A was introduced to the problem they were going to solve during this unit. I informed the students that just like scientists and engineers in real life, they were going to try to solve a problem of creating a building that could withstand the effects of an earthquake and ultimately keep people safe. They were to construct a tower that had to withstand a simulation of an earthquake with given constraints of time and building materials. I then had them work with their table team to create a list of things they would need to know in order to successfully create this tower. The lists they created had some aspects of the tower requirements, but overall, their lists were about learning more about how earthquakes occur, where they occur most, and how much damage they can cause. I used the items on this list to guide the lessons to scaffold their knowledge of plate tectonics and patterns of earthquake occurrences within a certain area. The lessons for Group A included more hands on and data related lessons (I. Salter, personal communication, January 8, 2016). For example, they looked at earthquake data to determine a pattern of occurrences of earthquakes. This led into knowledge of the plate locations, boundary types and plate movement. After each lesson, the class would look over their list of items they wanted to know in order to design a successful tower and there would be a discussion of which items had been addressed. This time was used to clear up misunderstandings as well as add or delete items from the list. Towards the end of the unit, students were given the requirements and constraints of their tower designs (E. Muller, 2014). They worked with their team to design, build, and test their

tower. Before testing their towers with the earthquake simulator, the group gave a short presentation on their design aspects.

For Group B, after the introductory lesson with the pictures, they learned similar content as Group A through my normal teaching approach, but without the goal of solving a problem. My normal teaching approach consisted of teacher lecture using power point presentations and student note taking, as well as class discussion. Students participated in activities that demonstrated basic principles of plate tectonics and earthquakes. These were sometimes completed individually, but more often completed with a group of students. They used graphic organizers to organize information given through lecture or from the textbook. The textbook was used as a reference to complete activities as well as questions given to check for understanding as part of the textbook curriculum. At the end of this unit, both groups were administered the Plate Tectonics Post Test (Appendix B).

The Erosion Unit began toward the middle part of February. For this unit, the groups were alternated to where Group A was the Comparison Group and Group B was the Intervention Group. Before beginning the unit, I administered the Erosion Pre-Test (Appendix A) to Group A and Group B to gauge their prior knowledge of erosion. Students were also asked to complete a reflection in their science notebooks (Appendix E). They were asked to reflect on a prompt given about the importance of studying Earth Science as well as how studying Earth Science can help people. This was done to evaluate their opinions and level of personal connections to Earth Science.

I introduced this unit in similar fashion to the Plate Tectonics Unit. I showed both Group A and Group B pictures of instances where erosion had caused damage to roads, coastlines, and areas where buildings were compromised. Similar to the previous unit, class discussions were enriching and engaging. The students were generally more familiar with the concept of erosion than they were with earthquakes, but they were still amazed at the destructive power of water through erosion and the impact it could have on people. Even with their familiarity of erosion, class discussion during this lesson led to students wanting to know how such drastic changes could happen to an area, and why didn't people stop it. Again, this is the point in the unit where the two groups separated in their learning process.

Group B was introduced to the problem they were to solve after the class discussion. I informed the students that they were to solve a problem much in the same manner that scientists and engineers would. The scenario presented was that a house that had been built close to a river many years ago was now at danger of falling into the river. The river had changed course over many years and was slowly eroding the riverbank side that the house was on, bringing the river closer and closer to the house. The students were to design a solution that would prevent the house from falling into the river and slow further erosion. Their designs would be tested with a model set-up of a river and house. The design had to meet the given constraints and requirements in order to be considered successful. Once students knew what problem they were to solve, they worked with their teams to generate a list of what they felt they needed to know in order to be successful in solving the problem. Much like the intervention group during the

Plate Tectonics Unit, there were some questions about the design requirements, but overall, they had items concerning erosion and how it happens. This list is what I used as a basis for my lessons during this unit to scaffold their knowledge of erosion. The lessons for Group B were more hands on and addressed issues like the variables that can contribute to rate of erosion. Again, after the lessons, the Group B classes reviewed their initial list of items they wanted to know to see which items had been addressed and which ones they felt could be eliminated or if they needed to add something. Towards the end of the unit, Group B was given the requirements and constraints of the design. Their designs had to allow for the least amount of sediment load in the river, could not dam the river, and had to represent natural materials or man-made solutions to erosion with the ultimate goal of preventing the house from falling in the river. They worked with their teams to design, bring materials, and build their solution to the erosion problem. The designs were tested in a stream table used to simulate a river and a toy house on one bank of the river. Prior to testing, teams explained their thinking behind why they thought their design would work and how it addressed the requirements. After testing, the team examined how successful their design was and offered alternatives that could improve the outcome.

Group A, the Comparison Group, learned similar content during this unit through my normal teaching approach. Teacher lecture, power point presentations, and student note-taking were used as a starting point for information. Students also completed class activities that demonstrate basic erosion, weathering, and deposition principals. The student textbook was used as a reference during activities and to complete provided

questions regarding erosion to check for understanding. At the end of this unit, I administered the Erosion Post-Test (Appendix A). To see if there had been a change in how students relate to the importance of learning about Earth Sciences to their own lives, I also asked student for student reflections to prompts given (Appendix E).

Data Collection

Since my overarching question is regarding student learning, I used pre- and post-tests for each of the units about Earth processes to gauge if there is a gain in content knowledge. I used pre- and post-unit surveys for students to self-report their feelings on their interest levels regarding Earth science. I used reflections in science notebooks to gather data about how students can relate their personal lives to what we have learned in our Earth science unit. I also used student interviews as a way to collect data regarding engagement and attitudes towards Earth science. I chose 9 students to interview who have a range of ability levels and who I felt could answer questions fully and honestly.

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.

Table 1  
*Triangulation Matrix*

| Focus Question  | Data Source 1 | Data Source 2 | Data Source 3 |
|---|---------------|---------------|---------------|
| <i>Primary Question</i><br>Does project based learning (PBL) as an instructional strategy increase student learning in an Earth science unit? | Pre-test      | Post-Test     |               |

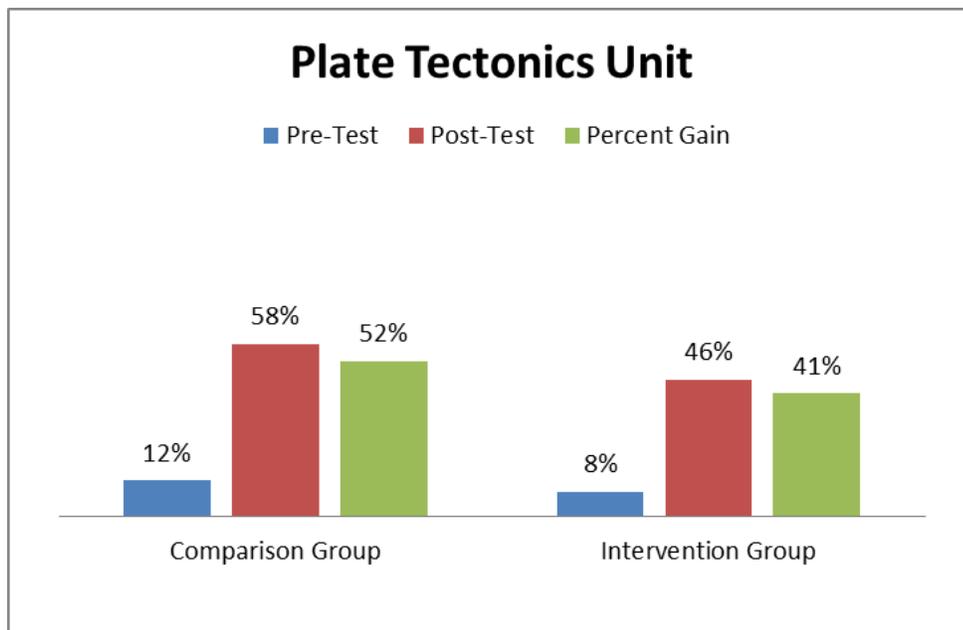
|  |  |                    |                    |
|--|--|--------------------|--------------------|
| <i>Sub-Question 1</i><br>Will using the PBL instructional strategy increase interest and engagement in Earth sciences?   | Pre-unit Survey                          | Post-Unit Survey   | Student Interviews |
| <i>Sub-Question 2</i><br>Will the use of PBL in Earth science help students make connections to their own lives and understand the importance of learning Earth science? | Student Reflections in Science Notebooks | Student Interviews |                    |

#### DATA AND ANALYSIS

Data collection began with students participating in surveys about their preferred learning methods, opinions of Earth science and problem solving. After this, students completed pre-tests and post-tests before and after each unit of instruction to assess content knowledge. In between the comparison unit and treatment unit and again after the treatment unit, students responded to reflection prompts to gauge a level of connection and importance of Earth science. The surveys were conducted again after the final unit to measure any change in opinions or levels of engagement in Earth science. Finally, students were interviewed to gather data on levels of engagement during the units and connections between learning Earth Science and their own lives.

While the results of the post-tests for both the Plate Tectonics Unit and the Erosion Unit indicate that there was an increase in content knowledge for both the Comparison Groups and Intervention Groups, the data does not indicate that the increase

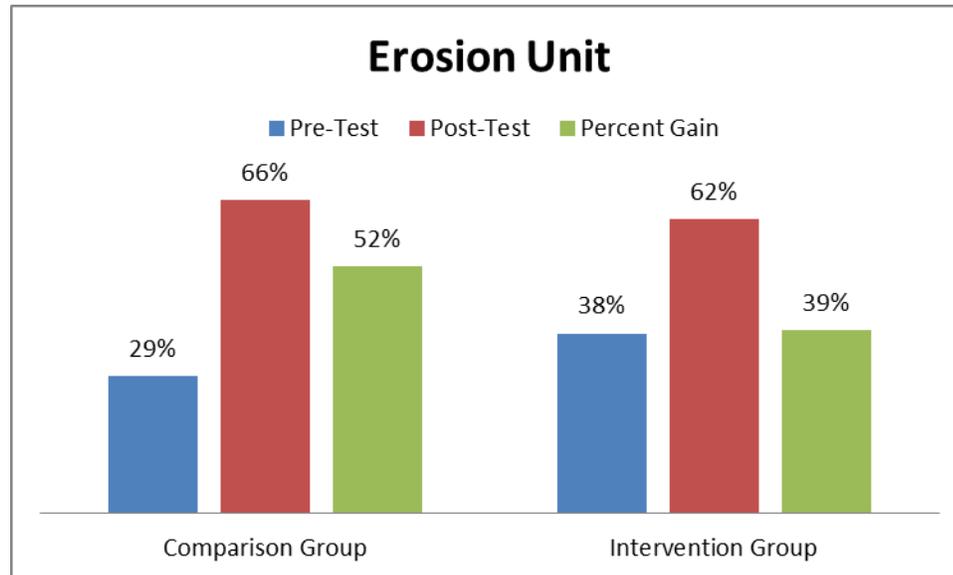
was due to the PBL intervention put in place. This result is also supported by comments from students during the interview process who stated, “I didn’t feel as prepared for the test when we did the project”, and “When we were doing the unit without the project, I didn’t necessarily like it better, but I felt like I got more information on the topic from the book.” In the Plate Tectonics Unit, the Comparison Group averaged a score of 12% ( $n=40$ ) on the pre-test, while the Intervention Group had an average score of 8% ( $n=37$ ). At the end of the unit, both groups had increases in post-test scores. The Comparison Group post-test scores averaged 58% with a 52% gain and the Intervention Group scores averaged 46% with a 41% gain (Figure 1).



*Figure 1:* Plate tectonics unit pre-/post-unit test results.

Results for the Erosion Unit showed that the average score for the Comparison Group pre-tests were 29% ( $n=37$ ) and the average score for the Intervention Group was 38% ( $n=38$ ). At the end of the Erosion Unit, both groups showed a growth in content

knowledge. The Comparison Group's post-test average score was 66% with a 52% gain and the Intervention Group's post-test average was 62% with a 39% gain (Figure 2).



*Figure 2:* Erosion unit pre-/post-unit test results.

Data from student surveys (Table 2) indicates that the PBL teaching strategy was responsible for increasing student interest in Earth science. The pre-unit survey showed that 36% of students indicated that generally Earth science topics were interesting to them, while the post-unit survey showed that student interest dropped by a small amount to 32% of students who felt Earth science topics were interesting. However, when asked about working on a project with a problem to solve, 61.3% of students indicated on the pre-unit survey that they were more interested in Earth science. This rose to 86.7% on the post-unit survey signifying that this increase was a direct result of the students experiencing the unit in a PBL format.

The data from the survey also shows an increase in student engagement through the use of PBL. Prior to the unit, students indicated that only 38.7% agreed with the

statement that they liked solving problems in science, and 61.3% preferred working with a team to solve problems in science. After the units, survey results showed increased agreement with both of these statements. 53.3% of students liked solving problems in science (an increase of 14.7%) and 73.3% preferred working with a team to solve problems (an increase of 12%). This is also supported with statements that students made during interviews. The majority of students said they were more interested in the unit that had a project than the unit that did not have a project. Comments included, “The project was more fun, I put a lot of effort in and I learned a lot,” and “I liked that we were bringing stuff and building it, not just writing about doing it,” and “I liked the project because I learn better hands on.” Only 11% of students interviewed indicated that they had more interest in the unit without the project ( $n=9$ ).

Student learning preferences changed with the implementation of PBL instruction. Prior to the units, 33.3% of students were in agreement with the statement that they learned more by reading the textbook and answering questions. The post-unit survey showed that this decreased by 18.6% so that only 14.7% of students were in agreement with the statement. 48% of students indicated that they learned more by listening to lecture and class discussion in the pre-unit survey and 40% of students agreed with that statement on the post-unit survey. This is in contrast to the statement about learning more by doing hands on activities. On the pre-unit survey, 85.3% of students agreed with that statement. On the post-unit survey, there was an increase to 89.3% of students who agreed with the statement.

Table 2  
*Student Survey Results-Percentage in Agreement With Statements (n=75)*

| Question   | Pre-<br>Intervention<br>(%) | Post-<br>Intervention<br>(%) | Change<br>(%) |
|--|-----------------------------|------------------------------|---------------|
| Earth Science topics and concepts are interesting to me.                                 | 36.0                        | 32.0                         | -4.0          |
| Concepts in Earth Science make sense to me.  | 53.3                        | 54.7                         | +1.3          |
| When learning about topics in Earth Science, I make connections to my own life.          | 26.7                        | 24.0                         | -2.7          |
| I learn more by reading the textbook and answering questions.                            | 33.3                        | 14.7                         | -18.7         |
| I learn more by listening to lecture and class discussions.                              | 48.0                        | 40.0                         | -8.0          |
| I learn more by doing hands on activities.   | 85.3                        | 89.3                         | +4.0          |
| I like solving problems in science.  | 38.7                        | 53.3                         | +14.7         |
| I prefer working with a team to solve problems in science.                               | 61.3                        | 73.3                         | +12.0         |
| I prefer working on my own to solve problems in science.                                 | 33.3                        | 28.0                         | -5.3          |
| I am more interested in Earth Science when reading the textbook and answering questions. | 17.3                        | 12.0                         | -5.3          |
| I am more interested in Earth Science when I listen to a lecture and class discussion.   | 45.3                        | 46.7                         | +1.3          |
| I am more interested in Earth Science when I work on a project to solve a problem.       | 61.3                        | 86.7                         | +25.3         |
| Learning about Earth Science is important.   | 65.3                        | 70.7                         | +5.3          |

There was a positive impact on student's ability to make connections to Earth science with the implementation of PBL. Data indicates that 67% of students interviewed made more of a connection to the unit where they had a problem to solve. 22% made

more connection to the unit without a project and 11% made a connection to both units ( $n=9$ ). For those students who were part of the Plate Tectonics unit project, comments made about their connections were usually about an acquaintance's experience or personal experience with an earthquake. One stated, "I have family that lives in Oklahoma, and I was there when there was an earthquake. I like knowing how the structures are built to be safe for earthquakes." Students who were part of the Erosion unit project most often mentioned seeing erosion happen along creeks and rivers in the area. The survey results contradict the statements from student interviews. 26.7% of students agreed to the statement saying they make connections to their own lives on the pre-unit survey. This dropped to 24% on the post-unit survey. Students were asked about the importance of studying Earth science between the comparison unit and treatment unit. 84% ( $n=44$ ) of responses were positive in regards to the importance of studying Earth science, but they weren't very specific about reason why it was important. Most responses included something about it being important for being a scientist or learning about the Earth. After the treatment unit, 94.5% ( $n=55$ ) of the responses indicated it was important to study Earth science and they were much more specific in their reasons. Many responses related to understanding earthquakes, how to prepare for them, knowing how to build structures to withstand earthquakes, and preventing erosion (Figure 3). Students were also asked to reflect on how studying Earth science could help people. After the comparison unit, 97.7% ( $n=44$ ) of responses showed that students felt that studying Earth science could help people, but most of those responses were comments about helping people in school or to be a geologist. After the treatment unit,

the number of responses showing studying Earth science could help people increases only slightly to 100% ( $n=45$ ). However, their statements showed more in depth reflections with comments being more specific. Examples of how students felt studying Earth science could help people included helping with erosion and erosion prevention, preparing for a natural disaster, understanding about Earth and solving problems related to Earth science (Figure 4). This is also supported with the student survey data. Students indicated on the pre-unit survey that 65.3% agreed with the statement that it is learning about Earth science is important. The post-unit survey showed 70.7% of students were in agreement with this statement, an increase of 5.3% (Table 2).

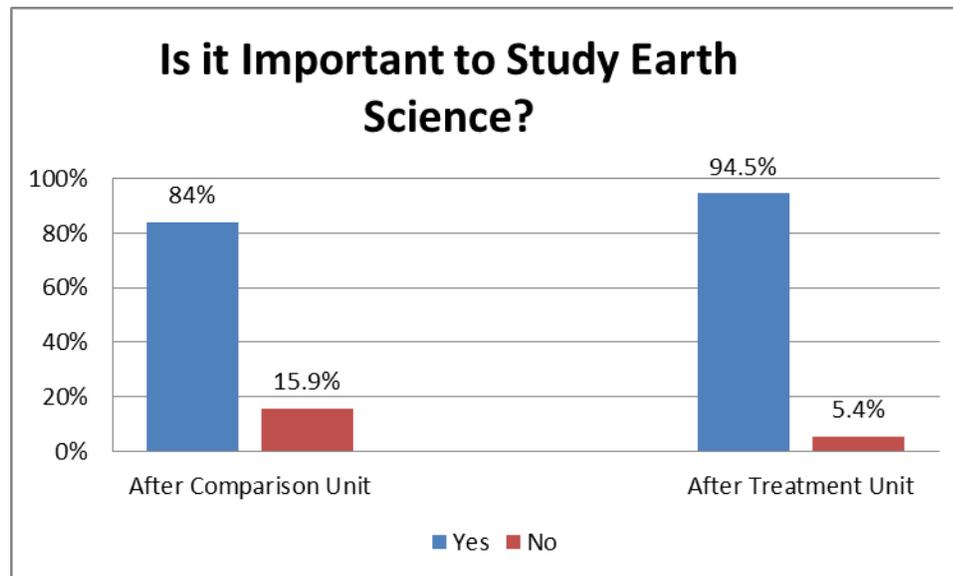


Figure 3: Student responses to notebook reflection.

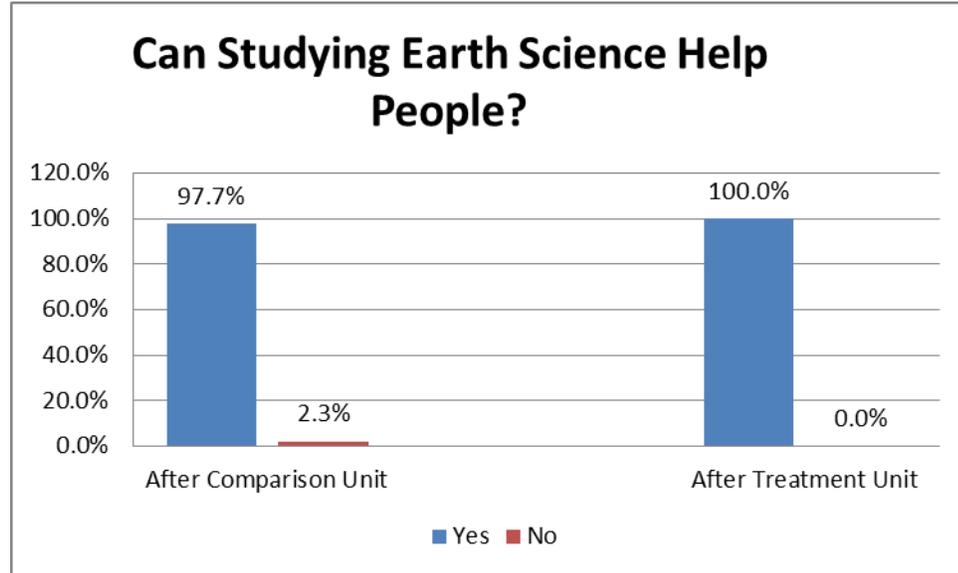


Figure 4: Student responses to notebook reflection.

#### INTEREPETATION AND CONCLUSION

This study has shown that PBL can be an effective instructional tool to use in the classroom. It has shown that there were several positive impacts on students studying Earth science due to the implementation of PBL.

While overall PBL instruction had a positive impact on student's experiences while studying Earth science, in this study there was not an increase in content knowledge that could be attributed to PBL. Students in both groups did have an increase in knowledge, but the treatment groups showed average percent gains of 40% while the comparison groups showed average percent gains of 52%. Literature states that the effectiveness of PBL is influenced by many things including engagement and motivation. Data from this study did show an increase in engagement, which leads me to believe that the reason for the lower academic achievement in the treatment groups could be attributed to students needing more scaffolding in instruction. During the units with the intervention groups, the engagement level was higher, the class discussions were richer,

and the students were excited to find out what they would do next. But at the same time, there seemed to be something about the way information was presented that just didn't stick with the students. During the student interviews, this observation was supported when two students mentioned not feeling prepared for the test when they were part of the intervention group because they didn't feel like they "got the information needed for the test". Though the unit was scaffolded to build the student's content knowledge, perhaps the information needed to be presented in a more structured format with more lecture and notes for students to refer to. I am somewhat disappointed that there wasn't more of an increase in the post-test scores compared to the pre-test scores. I feel the format of the test played a part in the reason for the low average scores. During the first semester, all tests were multiple choice. For the treatment and comparison units, the tests were in a short-answer format. I don't think students were used to expressing themselves in such a way to show complete understanding of a concept.

This study did show that student engagement and interest in Earth science can be increased with the implementation of PBL. Literature states that characteristics of PBL such as having relevant problems connected to student interests, collaboration and cooperation with peers, and student choice in how to solve problems all contributed to high levels of student engagement and interest. The data gathered through student surveys and interviews was supported with my observations of students during class. With the intervention groups, students were ready to find out what they were going to be working on and couldn't wait to get going on solving the problem. It was amazing to see them design a plan, defend their ideas to their peers, and overcome interpersonal

difficulties and design issues with their teams. In contrast, the students in the comparison group were often disappointed that they weren't doing the project like the other classes. More often than not, they would politely listen to lecture and complete the assignment as quickly as possible with minimal interaction with their peers. There wasn't that desire to go deeper and ask questions to understand more.

#### VALUE

The process of completing this Capstone project has given me great insight to my strengths and weaknesses as a teacher, as well as a plan of action that I can use to address changes that need to be made to help students succeed while in my class.

Overwhelmingly, I believe that PBL is a great instructional tool. However, it isn't the only tool, and it isn't always the right tool for every topic in Earth science. I plan to continue refining and using the PBL format for the Plate Tectonics and Erosion units in the future. The positive feedback from students and their high level of engagement during those units shows me that they do have value.

I will work on creating more scaffolding within those units to increase student content knowledge. After this experience, I feel that it is important for me to find the right balance between direct instruction through text media, lecture, and hands-on activities. I also feel that is important to keep in mind that when using hands-on activities, if that activity is put into the context of a problem to solve, there will be more buy in from students as they will see that there is a goal or purpose for the activity.

Another plan for next year is to take some components of the PBL format and apply them to other units that may not lend themselves to a full-blown PBL experience. I

will be working to find that balance for my instructional strategies in the future, so that my students will see the value of Earth Science in general and that there are real-world applications to what we learn in Earth science.

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APPENDICES

APPENDIX A  
EROSION PRE- AND POST-ASSESSMENT

### Erosion Pre- and Post-Assessment

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

1. The amount of sediment in a river is called
  - a. Volume of flow
  - b. Deposition
  - c. Turbulence
  - d. Load
2. What factors can affect how sediments move?
3. Explain the differences between erosion, weathering, and deposition.
4. What changes can people make to a river to slow the effects of erosion?

APPENDIX B

PLATE TECTONICS/EARTHQUAKES PRE- AND POST-ASSESSMENT

Plate Tectonics /Earthquakes Pre- and Post –Assessment

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

1. Explain the theory of continental drift.
2. What is the process of sea-floor spreading?
3. Compare how plates move at a divergent boundary, convergent boundary, and transform boundary.
4. Explain what sets convection currents into motion.
5. Where are faults usually found and why do they form?
6. What land features result from the forces of plate movement?
7. Explain the differences between P waves, S waves, and surface waves.
8. What kind of damage does an earthquake cause and what can be done to reduce the damage?

APPENDIX C  
STUDENT INTERVIEW

### Student Interview After Both Units

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

The interview questions will be tailored to the students depending on if they were in Group A or Group B.

1. Which unit did you have most interest in? The unit with the project or the unit without the project? Why?
2. Do you feel like completing the project to solve a problem in science helped you to better understand the material we were learning? Why or why not?
3. What did you like best and least about each unit?
4. What did you find most difficult about the unit with the project?
5. Which unit do you feel helped to prepare you most for the assessment? Why?
6. Were you able to make connections to your own life during either of the units? Which one(s) and why?
7. Is learning about Earth science important? Why or why not?
8. Did one of the units help you understand why learning about Earth science is important?
9. What improvements could be made to the unit with the project?
10. What improvements could be made to the unit without the project?

APPENDIX D  
STUDENT SURVEY

## Student Survey (Pre-Unit)

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. Please answer the following questions using the rating scale shown. Circle the number that best describes your opinion.

1 = Strongly Disagree

2 = Disagree

3 = Neutral (Neither Agree or Disagree)

4 = Agree

5 = Strongly Agree

|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 1. Earth science topics and concepts are interesting to me.                                     | 1 | 2 | 3 | 4 | 5 |
| 2. Concepts in Earth science make sense to me.  | 1 | 2 | 3 | 4 | 5 |
| 3. When learning about topics in Earth science, I make connections to my own life.              | 1 | 2 | 3 | 4 | 5 |
| 4. I learn more by reading the textbook and answering questions.                                | 1 | 2 | 3 | 4 | 5 |
| 5. I learn more by listening to lecture and class discussions.                                  | 1 | 2 | 3 | 4 | 5 |
| 6. I learn more by doing hands on activities.   | 1 | 2 | 3 | 4 | 5 |
| 7. I like solving problems in science.  | 1 | 2 | 3 | 4 | 5 |
| 8. I prefer working with a team to solve problems in science.                                   | 1 | 2 | 3 | 4 | 5 |
| 9. I prefer working on my own to solve problems in science.                                     | 1 | 2 | 3 | 4 | 5 |
| 10. I am more interested in Earth science when reading in the textbook and answering questions. | 1 | 2 | 3 | 4 | 5 |
| 11. I am more interested in Earth science when I listen to a lecture and class discussion.      | 1 | 2 | 3 | 4 | 5 |
| 12. I am more interested in Earth science when I work on a project to solve a problem.          | 1 | 2 | 3 | 4 | 5 |
| 13. Learning about Earth science is important.  | 1 | 2 | 3 | 4 | 5 |

## Student Survey (Post-Unit)

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way. Please answer the following questions using the rating scale shown. Circle the number that best describes your opinion.

1 = Strongly Disagree

2 = Disagree

4 = Agree

3 = Neutral (Neither Agree or Disagree)

5 = Strongly Agree

|   |   |   |   |   |   |
|---|---|---|---|---|---|
| 1. Earth science topics and concepts are interesting to me.                                     | 1 | 2 | 3 | 4 | 5 |
| 2. Concepts in Earth science make sense to me.  | 1 | 2 | 3 | 4 | 5 |
| 3. When I learned about topics in Earth science, I make connections to my own life.             | 1 | 2 | 3 | 4 | 5 |
| 4. I learned more by reading the textbook and answering questions.                              | 1 | 2 | 3 | 4 | 5 |
| 5. I learned more by listening to lecture and class discussions.                                | 1 | 2 | 3 | 4 | 5 |
| 6. I learned more by doing hands on activities.   | 1 | 2 | 3 | 4 | 5 |
| 7. I liked solving problems in science.   | 1 | 2 | 3 | 4 | 5 |
| 8. I preferred working with a team to solve problems in science.                                | 1 | 2 | 3 | 4 | 5 |
| 9. I preferred working on my own to solve problems in science.                                  | 1 | 2 | 3 | 4 | 5 |
| 10. I was more interested in Earth science when I read in the textbook and answering questions. | 1 | 2 | 3 | 4 | 5 |
| 11. I was more interested in Earth science when I listened to a lecture and class discussion.   | 1 | 2 | 3 | 4 | 5 |
| 12. I was more interested in Earth science when I worked on a project to solve a problem.       | 1 | 2 | 3 | 4 | 5 |
| 13. Learning about Earth science is important.  | 1 | 2 | 3 | 4 | 5 |

APPENDIX E  
NOTEBOOK REFLECTION PROMPT

Prompt 1:

Is it important to study Earth Science? Why or why not?

Prompt 2:

How can studying Earth Science help people?