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Implementing Meaningful Problem-Based Learning in a Middle School Science Classroom

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by

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DEDICATION

To my husband, thank you for being so supportive while I completed this program and research study. Thank you for your patience when I was up late many nights working on the computer. Thank you for always encouraging me to complete this process.

To my sweet daughter, thank you for always encouraging me to work hard. Thank you for making me smile when I was tired. Thank you for always checking on me even while you were away at college working on your own studies.

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ABSTRACT

The purpose of this action research study was to explore the impact of problem-based learning on science instruction in my eighth-grade college preparatory classroom. Constructivism was the framework for this study. Problem-based learning is based on constructivist principles, and it served as the instructional model for this study. PBL can foster the use of problem-solving skills, critical thinking skills, and communication skills, which are needed in the 21st century. This research study was centered around three research questions. The first question asked about the impact PBL has on students' science achievement. The second question asked how does PBL impact students' engagement towards science and learning. The third question asked how does PBL impact students' problem-solving skills.

This research study utilized a mixed-methods design. Quantitative and qualitative data showed that although some students struggled with abstract scientific concepts, PBL increased students' academic achievement in science. Data also showed that while students may need frequent redirection, the activities utilized while implementing PBL engaged most students. I also found that although students may need additional support, PBL improved students' problem-solving skills. An action plan was created to implement PBL school-wide. Implications for classroom practice and future research were also discussed.

Keywords: action research, problem-based learning, problem-solving skills, student engagement, mixed-methods

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LIST OF ABBREVIATIONS

MAP .... Measures of Academic Progress

PBL .... Problem-based learning

CHAPTER 1

INTRODUCTION

Eighth-grade science content is extremely abstract. Students are expected to learn difficult terms and complex concepts presented in the South Carolina College and Career-Ready Academic Standards. Many of the eighth-grade science standards are ideas students cannot see or touch, and my college preparatory students enter class with little prior knowledge. Forces and Motion is one of the first units covered during the school year. Students have to learn the meaning of concepts like Newton's laws of motion, acceleration, gravity, and reference frame, and they must apply this knowledge to various situations. I have used a variety of instructional strategies in my classroom to teach the unit. All lessons usually begin with direct instruction, and students take notes from my teacher-created presentations. Students then participate in some type of hands-on activity after a teacher-led discussion. I observed that students enjoy being able to move around and communicate with their peers during hands-on activities; however, when I checked for understanding of concepts there seemed to be a disconnect. For example, after giving students notes about Newton's Second Law of Motion and acceleration, they complete an activity where they have to change the mass that is placed on top of a toy car. Students recorded factors such as speed, distance, and time. At the end of the lab report, I ask students to define words such as motion, mass, and acceleration. My direct instruction had defined and explained all of these terms with examples; however, many of the students' lab reports had missing responses, and many students were not able to explain these terms in their own words. Student engagement decreased when the toy cars were put away, and students were not able to show that they had gained knowledge with the instructional strategies I had used.

Student engagement can be determined by many factors, and it has been defined as showing interest in the learning process (Godec et al., 2018). Student engagement in science relates to their motivation and enjoyment while learning the content (Hampden-Thompson & Bennett, 2013). For this research study, engagement will be defined based on the forms suggested by Fredricks et al. (2004) which are cognitive engagement, emotional engagement, and behavioral engagement. These types of engagement will be discussed further in Chapter 2.

There are many reasons why my college preparatory students may not be engaged when learning science content. First, students may have prior negative views about science. They may feel that science is for "nerds" or people who are not popular. They may also feel disconnected from the subject of science itself because most of the examples of scientists that that see in class are white males. Also, my students may feel that science is not important. Students do not attend science every day until grade six in my school district, and students are not assessed on their science content knowledge each year like they are for Math and English. Second, the pedagogies I am using to teach science may be ineffective. Classroom, district, and state assessments show that many of my college preparatory students are not mastering concepts as indicated by their assessment scores. Third, many students in my college preparatory class may view problem-solving as difficult. They relate problem-solving to complex math problems, and many find these types of problems hard to comprehend.

It is important for me to utilize instructional methods that will aid in teaching students skills to remember facts and problem solve. Problem-solving is a systematic method used to find solutions to problems, and students may increase their academic achievement in science when using problem-solving skills (Rahman, 2019). These skills can be applied to any content area, and they can be used throughout students' lives. Problem-solving skills are useful in careers based on science, and a science-based career may improve students' socioeconomic levels. This research study will focus on the two major problem-solving categories used by Rahman (2019): observation skills and critical thinking skills. Observation skills include competency in the areas of gathering information and identifying key points, while critical thinking skills consist of features such as identifying problems, making inferences, identifying strategies and solutions to solve problems, and selecting the best alternatives for solutions to problems (Rahman, 2019).

Traditional classrooms are unsuccessful at holding students' interests (National Science Resources Center, 1997). The National Science Resources Center (1997) voices the concern that students are not engaged because classroom instruction is focused on "things they know or cared little about" (p. 9). Students struggle with science content because they are not able to make connections with the information. Students may be familiar with processes and events that occur in science, but they struggle to explain these occurrences because the way that science is taught is not relevant to them.

Almarode et al. (2018) suggest "science education is seen as a series of experiments and experiences, rather than a purposeful exploration of ideas, skills, and strategies, including social skills" (p. 28). Instructional strategies that are teacher-led, only use demonstrations, and experiments alone may not be effective for learning science content.

Students need to develop their problem-solving skills because these skills can be transferred to new situations (Almarode et al., 2018). How science is taught is important for getting students to retain and apply information. Science is not a list of facts, but a way to explain natural phenomena using observations and experimentation (South Carolina Department of Education, 2015). Haydock (2011) states, "It is a process - a method of asking questions, hypothesizing, observing, testing, finding evidence, collecting data, analyzing, modifying conclusions, communicating, and requestioning (p. 1). It is more beneficial to teach processes and skills rather than facts that are meaningless to students. Also, it is critical that relevant prior knowledge is not disregarded when new learning occurs (Ward & Wandersee, 2002). Content will be more meaningful if students can make connections between science and their own prior life experiences.

Teaching science using problem-solving skills is important because these skills can be used in all content areas. South Carolina Department of Education (2015) describes science as being "an organized body of knowledge that includes core ideas to the disciplines and common themes that bridge the disciplines" (p. 3). Once students learn how to solve problems they can apply these skills to other classes. No matter the environment, when a problem presents itself, students will know the necessary steps to take to solve issues. Skills like creativity, critical thinking and problem solving, collaboration and teamwork, communication, and knowing how to learn are world class skills (South Carolina Department of Education, 2015). The National Science Resources Center (1997) states that students that use problem-solving skills when learning "were more successful in middle and high school science classes than were students taught in more traditional ways" (pp. 17-18). Problem-solving skills also "instill in children a world view that reflects an understanding of the importance of science to their everyday lives" (The National Science Resources Center, 1997, p. 18). Using a problem-solving approach to teaching increases students' success in the science classroom, other content areas, and in their daily lives.

Purpose of Study and Research Questions

In the 21st century, it is necessary to provide students with the skills they need to solve problems (Delisle, 1997; Rahman, 2019). Problem-based learning enables students to investigate ill-structured problems while collaborating and communicating. The purpose of this action research study was to explore the impact of problem-based learning on science instruction in my eighth-grade college preparatory classroom. Problem-based learning is defined as "an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem" (Savery, 2006, p. 112). By utilizing problem-based learning, I aim to increase students' mastery of science concepts, increase student engagement when learning science content, and increase students' use of problem-solving skills.

Conducting this action research provided me with new knowledge where the results are relevant to my classroom (Herr & Anderson, 2015, p. 67). This research allowed me to improve my instructional practices for college preparatory students. I wanted all students to be successful learning science content.

The research questions are as follows:

1. What is the impact of problem-based learning on students' achievement?
2. How does problem-based learning impact students' engagement towards science and learning?
3. How does problem-based learning impact students' problem-solving skills?

Positionality

Positionality means asking the question "Who am I in relation to my participants and my setting?" (Herr & Anderson, 2015, p. 37). It is important to know this information because my position has a direct impact on the methods I use to facilitate this action research. I am an insider because insiders "are researching their own practice or practice setting" (Herr & Anderson, 2015, p. 41). I am a teacher trying to improve the effectiveness of instructional strategies in my classroom.

I am an eighth-grade science teacher at S. Fox School (pseudonym). I have two classes of honors students and two classes of college preparatory (CP) students. I serve as the eighth-grade science department head, and I am a member of the district's science leadership team. These roles require me to show strong academic leadership that promotes differentiation of instructional practices to meet the needs of all students. It is also necessary that I provide professional development to the science department and mentor new teachers.

I have a natural love for science and problem-solving. I was always inquisitive as a child, and I would describe myself as being intrinsically motivated. I prefer working alone when problem-solving because I feel that others may not have the same interest level I do when learning about science. I always maintained high achievement in science courses. Placing in my middle school's science fair in eighth-grade further propelled my interest in science and problem solving. I realize that my middle school students may not have this same passion for science, and this may create bias.

I think it is also relevant to note my professional background. My undergraduate degree is in Biology. My collegiate courses were mostly comprised of biology, chemistry, and physics classes where the scientific method was used on a regular basis to problem solve. A year after graduating from college I began a career teaching science. I have been teaching science for twenty-five years. I think this is important information because my knowledge-base and experiences are far more substantial than eighth-graders. I view science in a different way because I have an awareness and understanding that relates to the concepts, whereas my students may not have these same experiences or knowledge to be able to make connections.

Significance of Study

Teaching science is challenging because students have to be engaged with the content and have experiences that will allow them to construct knowledge. Efforts are made to increase the engagement of students; however, college preparatory students may not receive the same opportunities as students in honors and advanced placement classes. Tracking and labeling create biased teaching practices. This study is significant because it will focus on the achievement of all students in a CP science class.

Also, middle school students are in a transition period. They want to be independent thinkers, and they are social and inquisitive. However, these students can quickly disengage in class if the content is not interesting or relevant to them. This study is important for eighth-grade, CP students who struggle with learning and applying science content. Utilizing problem-based learning (PBL) will provide an effective instructional strategy that will engage students and increase achievement in my science class. I will be able to teach students skills they can use beyond my classroom and how to apply these skills to real-world situations. The elements of PBL will generate lifelong, problem-solving skills for my students.

I am a member of this classroom community, and my students and I will benefit from this action research. The methods used in this study will allow me to examine and reflect on best practices to use in my classroom, and students will develop skills that can be transferred to other classrooms and settings. Communication, collaboration, and being able to solve problems are skills that are needed and used in various careers. Learning these skills is also important because they will teach students to see different perspectives. Audiences that might benefit from reading this study include other classroom teachers, educational administrators, and anyone utilizing PBL in their practices.

Theoretical Framework

Constructivism provides the framework for this study. Ultanir (2012) defines constructivism as “a learning or meaning-making theory that offers an explanation of the nature of knowledge and how human beings learn” (p. 195). Considering this theory, learning takes place when students construct knowledge.

Constructivist theory “is based on the premise that the act of learning is based on a process which connects new knowledge to pre-existing knowledge” (Dennick, 2016, p.

200). Meaning is created based on students' previous experiences, and students can make connections between prior knowledge and new knowledge. In a constructivist classroom, "The primary responsibility of the teacher is to create a collaborative problem-solving environment where students become active participants in their own learning" (McLeod, 2019). Direct instruction decreases when students take on a more active role, and the teacher becomes more of a guide. Creating ill-structured science problems for students to resolve aims to help students master scientific concepts and increase student engagement and achievement.

Research Design

Action research framed the design of this study. Action researchers try to answer problematic situations (Herr & Anderson, 2015, p. 4). I am a practitioner seeking to enhance instructional practices in my classroom. When discussing the role of the researcher Efron and Ravid (2013) state, "Their goal is to improve *their* practice and foster *their* professional growth by understanding *their* students, solving problems, or developing new skills" (p. 4). I am trying to incorporate best practices in my classroom to help students master science concepts and problem-solving skills. The design of this study utilized a mix-methods approach for research. I collected qualitative and quantitative data. Mixed methods studies synthesize both types of data to gain a better understanding of the experience being studied (Merriam & Tisdell, 2016). This design was appropriate because I wanted to evaluate student achievement, and I also wanted to reflect on my perceptions and my students' perceptions about the intervention.

The PBL design uses real-world problems to stimulate learning of content. To increase students' success, problem-based learning was implemented with a Forces and

Motion unit of study. Participants were eighth-grade students in my college prep class. Students were placed in groups and given ill-structured problems to solve. Students worked collaboratively to develop solutions to problems. Group findings and solutions were presented to the class. The intervention occurred over a course of four weeks.

Quantitative research uses numerical data that can be evaluated using statistics, and it can be used to identify patterns among variables (Creswell & Creswell, 2018). Quantitative data was collected using a pre- and posttest, a teacher-created rubric, and a student engagement survey. The pre-and posttest were administered to measure students' academic growth. This tool provided quantitative data the science department uses to measure science achievement. The teacher-created rubric was used to evaluate students' presentations to see if they gained problem-solving skills. A student engagement survey using a Likert scale also provided quantitative data about students' perceptions about their engagement towards PBL. Descriptive statistics was used to analyze the pre- and posttest, teacher-created rubric, and the student engagement survey.

Merriam and Tisdell (2016) state, "Qualitative data analysis is all about identifying themes, categories, patterns, or answers to your research questions" (p. 216). Teacher observations of students were used to collect qualitative data. The observations gave me a firsthand view into how students react (Merriam & Tisdell, 2016) to PBL, and they allowed me to observe students' engagement while using PBL. The teacher observations were also used to see how PBL impacted students' problem-solving skills. A coding system was used to analyze the teacher observations, and I observed themes as they emerged in order to help me understand the impact of problem-based learning on science instruction.

Time was major challenge for this study. I had to align my implementation and data collection period with the district pacing guide. A four-week time frame for students to effectively develop solutions to problems made the process seem rushed. Also, because so much of my instruction is normally teacher-led, my students had to transition to become active learners. I needed to slowly move away from direct instruction, and this required a period of transition for myself and my students.

Limitations

There were several limitations in this action research study, and Efron and Ravid (2013) state, “Limitations of your study should be acknowledged and discussed” (p. 216). First, my students did not have prior experience with PBL. Some students lacked communication and collaboration skills, and they struggled to remain focused during their discussions. Students needed to speak and listen effectively, and they needed to value others’ opinions. Some students were not used to working in groups to solve problems for extended periods of time, and this sometimes led to classroom disruptions. Providing additional opportunities for students to practice their collaboration and communication skills would have been helpful. Students also needed to be aware of my expectations for group work, and these expectations needed to be repeated frequently. Time constraints and district pacing limited how much time I spent practicing these skills and reviewing expectations with my students.

The second limitation dealt with data collection. I was the teacher surveying students in my class. My students’ responses may not have been truthful or expressed their actual feelings. They may have been hesitant to respond honestly for fear of receiving a negative consequence. Students may have felt obligated to respond to survey questions in a way that would please me.

Dissertation Organization

Chapter one served as an introduction to the action research dissertation. Chapter two presents a detailed review of literature and current research. Chapter three explains the methodology of the intervention in detail. In chapter four, the data collected during the interventions will be discussed. Chapter five will conclude with a review of the results, describe implications for practice, and discuss future recommendations.

Definition of Terms

- College preparatory – a course of study that offers an intellectually stimulating curriculum that prepares learners for college or work (Allensworth et al., 2009).
- Problem-based learning – an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem (Savery, 2006).
- Problem-solving skills – useful skills that help you find solutions to problems effectively (Rahman, 2019).
- Science - a way of understanding the physical universe using observation and experimentation to explain natural phenomena (South Carolina Department of Education, 2015).
- South Carolina Academic Standards – the knowledge and core ideas to the disciplines and common themes that bridge the disciplines (South Carolina Department of Education, 2015).

- Student engagement – displaying involvement in the learning process by showing interest in understanding content (Godec et al., 2018).

CHAPTER 2

REVIEW OF THE LITERATURE

The problem of practice for this action research study is that the instructional strategies I have used in class have not been effective in helping students recall or apply abstract scientific concepts. Students have struggled to understand the relevance of scientific ideas and apply them to real-world situations. Large amounts of information have been given to students, but few connections have been made with the content (Hadzigeorgiou & Schultz, 2019; Haydock, 2011). Further attention must be given to identifying the instructional strategies that will be the most effective at engaging students to learn science content and helping them to remember, understand, and apply information.

Instructional strategies that have often been used in my class are teacher-centered and utilize rote learning which has been the standard for teaching and learning (Lee & Blanchard, 2019; Merritt et al., 2017). Today's students are not content with being passive learners and participating in instructional activities like listening to lectures, note-taking, and reading and answering questions (Wermuth, 2020). These idle instructional strategies may not be the most effective in engaging students to learn subject matter.

Purpose Statement

The purpose of this action research study was to explore the impact of a problem-based learning (PBL) instructional approach in an eighth-grade college preparatory science classroom. Brush and Saye (2017) state that PBL is more effective than traditional instructional strategies for retaining information and progressing skills. This study examined the effectiveness of using PBL to engage students to learn science content, and it examined whether or not PBL impacted students' academic achievement and promoted the use of problem-solving skills. Current instructional strategies used in the classroom have not been the most effective in helping students recall and apply scientific concepts; therefore, this mixed-methods action research study investigated the following research questions:

1) What is the impact of problem-based learning on students' achievement?

2) How does problem-based learning impact students' engagement towards science and learning?

3) How does problem-based learning impact students' problem-solving skills?

Chapter Organization

Major themes will be addressed in this chapter to highlight the need for this action research study. First, this chapter discusses how the learning theory constructivism frames the problem of practice and supports the proposed interventions of problem-based learning. Next, the historical perspectives that underlie the problem of practice will be examined in detail. Then, diversity and equity issues relating the problem of practice will be addressed. Related research will then be analyzed for commonalities and differences. Lastly, a summary will be given of the relevant research and literature.

Seeking to obtain relevant literature for this action research study and to answer the research questions (Machi & McEvoy, 2016), I began with online inquiries using the University of South Carolina's online library. This online databased provided me with doctoral dissertations relevant to this study. Literature was also collected from sources such as Interdisciplinary Journal of Problem-Based Learning (IJPBL) and Education Resources Information Center (ERIC). Google searches were conducted to locate relevant literature such as peer reviewed journal articles. Keywords used to search for literature included problem-based learning, effective strategies for teaching science, middle school students, and student engagement. Additionally, textbooks required for the Ed.D. program at the University of South Carolina were used as a source to identify relevant literature.

Theoretical Framework

A theoretical framework is the structure that supports the creation of knowledge for a research study, and it provides subject matter that connects the purpose, problem of practice, and the research questions (Grant & Osanloo, 2014). The theoretical framework gives an extensive review of literature that provides a foundation for the topic. The foundation explains existing knowledge about the topic. The theoretical framework for this research study is based on constructivism and problem-based learning. Constructivism serves as the educational learning theory. Problem-based learning serves as the model for the instructional intervention.

Constructivism

Constructivism is a learning theory that has had a tremendous impact on education in the last twenty-five years (Dennick, 2016; Jones & Brader-Araje, 2002;

Shah, 2019). Constructivism can be defined as a learning theory where learners construct new meaning from their prior knowledge and experiences (Jones & Brader-Araje, 2002; Shah, 2019; Ultanir, 2012). New learning can be created and transformed by what the learner already knows (Olusegun, 2015). However, one's viewpoint and position can change the meaning of constructivism (Jones & Brader-Araje, 2002; Shah, 2019). Varying perspectives of constructivism have been presented by originators Jean Piaget, John Dewey, Lev Vygotsky, and Jerome Bruner (Olusegun, 2015).

Piaget and Dewey cultivated theories that led to progressive education that focuses more on students' experiences rather than traditional learning (Flinders & Thornton, 2017; Ultanir, 2012). Ultanir (2012) describes Jean Piaget's beliefs about constructivism as a cognitive constructivist's where knowledge is not understood instantly, and there is a structure, or schemata, where learners organize new information by building onto their prior knowledge. Piaget's perspective focuses on the development of the individual (Soran University et al., 2019). In contrast, Dewey believed that learning is a social construct where students work cooperatively and problem solve by being active participants in their learning (Ultanir, 2012; Williams, 2017). Dewey abandoned conventional methods such as rote memorization (as cited in Waks, 2018). He placed the child at the center of learning, and he believed learning should involve social interactions (as cited in Flinders & Thornton, 2017; Waks, 2018).

Vygotsky was a social constructivist, believing learning is impacted by social development (Liu & Matthews, 2005; Shah, 2019). Vygotsky added to the constructivism ideology when he linked exploration and discovery involving meaningful social interactions to knowledge construction (Jones & Brader-Araje, 2002; Liu & Matthews, 2005; Shah, 2019; Vygotsky, 1978). Piaget and Vygotsky were similar in their beliefs in that that they were both concerned with the growth of the individual and the idea that new knowledge could be created when children take active roles in the learning process (Sharkins et al., 2017). Vygotsky developed the concept of "zone of proximal development" (ZPD) (Jones & Brader-Araje, 2002; Shah, 2019; Vygotsky, 1978) that describes there are tasks a learner cannot do, tasks a learner can do with assistance, and tasks a learner can do by themselves (Vygotsky, 1978). The area where the learner can accomplish a task with assistance is the ZPD (Vygotsky, 1978).

Jerome Bruner also contributed different meanings and viewpoints to constructivism. Bruner (1960) believed that children should begin constructing knowledge at an uncomplicated level first, and then return to more difficult concepts later. This would scaffold the learning for students and help students to resolve problems on their own (Bruner, 1960). Bruner suggested that learning is most successful when students create a system to organize their knowledge, and this system is most effective when students are allowed to discover knowledge (Bruner, 1961). This is viewed as a constructivist approach because while students discover knowledge, they are constructing knowledge. Piaget, Dewey, Vygotsky, and Brunner were pioneers who contributed various perspectives on the theory of constructivism, but they all shared a common focus on how children learn.

The principles of constructivism describe how knowledge is accessed, created, and developed. One principle is that learners have individual prior knowledge that is unique to each person, and knowing this information will help to engage students (Garbett, 2011; Ladachart & Ladachart, 2019). Another principle is that learning is a process (Olusegun, 2015) where students are active (von Glasersfeld, 1989; Shah, 2019). Teachers are facilitators that provide opportunities for knowledge to be constructed (Merritt et al., 2017; Shah, 2019; Williams, 2017). Next, learning is a social process where group work and collaboration are a necessity (Jones & Brader-Araje, 2002; Shah, 2019). Students can share ideas and learn to respect others' perspectives while working in groups. A final principle of constructivism is students' engagement in problems that are meaningful and relevant to them (Mohammed & Kinyo, 2020). The goal of constructivism is for learners to create new meaning by building on previous experiences encountered in their lives (Ultanir, 2012). Applying the principles of constructivism places students at the center of teaching and learning (Jones & Brader-Araje, 2002; Shah, 2019).

Problem-based Learning

PBL is the most groundbreaking constructivist method of teaching in which students acquire knowledge by solving real-world problems (Funa & Prudente, 2021). PBL has foundations rooted in the constructivist theories of John Dewey (McCaughan, 2013; Torp & Sage, 2002). Dewey (1916) emphasized student-centered learning and problem-solving involvement as a way to intrigue learners. PBL had its beginnings in medical education (Barrows, 1996; Torp & Sage, 2002) through the efforts of Howard Barrows at McMaster University where he realized medical students learned information, but they struggled with the clinical application of their knowledge (Savery, 2006). PBL became the centerpiece of that medical school, later filtering down to the curriculum in other medical and professional schools (Barrows, 1996).

Definitions of PBL may vary depending on the researcher. A clinical-medicine education definition, a functional or curriculum definition, and a constructivism definition of PBL all differ (Merritt et al., 2017). Savery (2006) defines PBL as "an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem" (p.12). This definition best fits this study because it focuses on students learning in a classroom where using PBL allows them to explore their interest and seek answers to problems by using the skills of collaboration, research, reasoning, and reflection (Sockalingam & Schmidt, 2011). Relating to Savery's (2006) definition of PBL, students learn problem-solving skills that can be used in other disciplines and outside the classroom in their personal lives (Müller et al., 2017).

There are several guiding principles for PBL. PBL focuses on student-centered learning (Barrows, 1996; Brassler & Dettmers, 2017; Ronis, 2008; Torp & Sage, 2002). Students are grouped together for collaboration (Barrows, 1996; Ronis, 2008; Savery, 2006). The teacher is not the main center for knowledge, and the teacher serves as a facilitator (Barrows, 1996; Brassler & Dettmers, 2017; Ronis, 2008; Torp & Sage, 2002). In order to spark learning, real-world problems are presented for students to solve, (Barrows, 1996; Brassler, & Dettmers, 2017; Hung, 2016; Sockalingam & Schmidt, 2011) and students are held accountable for their own learning (Barrows, 1996; Savery, 2006). Also, when using PBL, problem-solving skills mature (Barrows, 1996; Müller et al., 2017).

Because memorization and recall continue to be a pillar in education (Merritt et al., 2017), memorization, and not critical thinking, is recognized as success in classrooms

(Ladson-Billings, 2009). Repetition of facts that are not meaningful to students is not an effective instructional method (Klemm, 2007), and PBL is a strategy that can be used to increase students' learning (Lee & Blanchard, 2019). PBL gives meaning to ideas and increases student motivation by allowing learners to make connections with real-world situations (Hung, 2016).

Although PBL has proven to benefit medical school students (Barrows & Tamblyn, 1980; Torp & Sage, 2002), efforts are still being made to effectively incorporate PBL in K-12 settings (Ertmer & Simons, 2006; Lee & Blanchard, 2019; Torp & Sage, 2002). The environment for K-12 learners is extremely different from medical school students, and K-12 learners have different intellectual needs (Torp & Sage, 2002). Implementing PBL in public schools has been complex because rigid curricula lead teachers to focus more on memorization and less on critical thinking (Savery, 2006). However, more current trends show that PBL has a positive effect on student achievement and is more effective than traditional teaching methods when it is implemented effectively (Brush & Saye, 2017; Strobel & Barneveld, 2009). At the middle school level, effective implementation requires real-world problems that students will find relevant to their lives (Torp & Sage, 2002).

PBL has foundations in constructivism. PBL is a strategy that focuses on knowledge construction by engaging learners to find solutions to problems (Merritt et al., 2017; Torp & Sage, 2002). The problems used in PBL are relevant to students' lives (Hung, 2016). Using PBL, students become active learners by engaging in student-centered activities that utilize higher-order thinking skills (Merritt et al., 2017; Savery, 2006; Torp & Sage, 2002).

Historical Perspectives

This action research study explores the impact of a problem-based learning approach on students' learning in my eighth-grade college preparatory classes. The historical perspective includes an overview of the history of PBL, trends in science education, science and social justice, and state trends that may impact this research study. While some researchers identify the positive effects of PBL (Liu et al., 2019; Moon, 2018; Muniz, 2019), other researchers have identified problems implementing PBL (Fletcher, 2018; Moon, 2018). A discussion of these successes and problems is included in this section.

Science concepts are complex and abstract; therefore, engagement is necessary in order learn and comprehend science (Hadzigeorgiou & Schultz, 2019). Student engagement consists of a variety of components including students' interests, personal identity, maturity, and prior experiences with the subject matter (Hadzigeorgiou & Schultz, 2019). Students' participation, interests, attitudes towards learning, and endurance to learn can all indicate engagement (Godec et al., 2018). Using the description provided by Hadzigeorgiou and Schultz (2019), true engagement allows students to learn content and apply what they have learned in other areas of their lives.

Present day instructional strategies are not engaging for students because Industrial-Age classroom practices (Senge, 2012) are still prominent in today's classrooms. These teaching methods focus on teaching students how to read and write, and student achievement is based on the memorization of facts. Desks are aligned in rows, and students sit passively in their seats listening to teachers lecture. Instructional strategies that promote self-directed learning, collaboration, and communication are needed to engage students and prepare them for our changing world (Senge, 2012).

Historical Perspective of PBL

Although Dewey (1938) discussed concepts associated with PBL, structured implementations of this student-centered pedagogy began in the medical field. During the 1960s, PBL originated at McMaster University as an unconventional way to engage medical students to problem-solve and use critical thinking skills. Barrows (1996) described the engagement of medical students with their experiences:

> The McMaster group noted that students were disenchanted and bored with their medical education because they were saturated by the vast amounts of information they had to absorb, much of which was perceived to have little relevance to medical practice. (p. 4)

Lecturing was not effective for clinical application, and engagement among the medical students increased when they had opportunities to work with actual patients and solve real-life problems. Reports promoted by the Association of American Colleges were seen as support for implementing instructional methods that would encourage a decrease in lecture hours and increase independent learning and problem-solving (Barrows, 1996). In the 1980s and 1990s, PBL became an accepted strategy for teaching and learning, and other medical schools began to embrace the practice (Savery, 2006).

After the expansion of PBL in other medical schools, nursing schools, and professional programs, PBL curricula began to expand to K-12 schools and colleges (Torp & Sage, 2002; Wirkal & Kuhn, 2011). Through the use of PBL, students in school apply the same learning strategies as professionals in the real-world. PBL is also particularly effective for educators as it provides students with the proper motivation and allows them to become engaged, active learners by taking control of their own learning (Hmelo-Silver, 2004; Liu et al., 2019; Muniz, 2019; Savery, 2006).

There are some concerns with the implementation and effectiveness of PBL, as it has not been utilized by most K-12 educators (Hmelo-Silver, 2004; Tawfik et al., 2021; Wirkal & Kuhn, 2011). Ribeiro (2011) discusses how PBL requires teachers and students to change their roles in the classroom, and this requires time and training. Instruction becomes less teacher-centered and more student-centered, and the knowledge and skills needed to effectively utilize PBL may not be provided by administration. In terms of recall, PBL has proven to be more successful than conventional lecture in higher education; however, there is a gap in the research for the effectiveness of PBL in primary and middle level education (Merritt et. al., 2017). Liu et al. (2019) also notes that even though PBL has been shown to benefit all students, research is limited for at-risk students. Students with learning, social, and emotional disabilities may be considered at-risk, as well as students in danger of failing.

Trends in Science Education

As stated by Luft et al. (2008), science education in the United States has changed drastically in the last few centuries evolving from just being a collection of knowledge to a more student-centered approach. Curriculum ideologies have encouraged advancements in American curriculum, but these beliefs have also caused disagreements that have slowed the improvement of the curriculum (Schiro, 2013). The influence of different ideologies can be seen throughout the history of American education, and these views have had a direct impact on science instruction.

The standardization of education began early in America's history. The curriculum used by schools was left up to individual states, and this caused an inconsistency in students' preparedness. In 1893, the Committee of Ten was formed with a goal of standardizing coursework for high school (Bybee, 1977). Trends that emerged were that science content was "heavy and didactic" (Luft et al., 2008, p. 23).

In the early 1900s, most students that attended school were among the privileged and were preparing to attend college (Luft et al., 2008). During this era, teaching methods at this time utilized the Scholar Academic ideology where the purpose of education is to help students learn the masses of knowledge for a discipline (Schiro, 2013). For this ideology, students' interests are not a priority.

Science instruction in American history began with the utilization of didactic teaching methods (Bybee, 1977), and these strategies continued to be used frequently in science classrooms even when recommendations from education professionals called for change. From 1915 to 1955, the aim of science education was to create productive members of society by focusing on practical content (Luft et al., 2008). During this era, teaching methods utilized Social Efficiency ideology where the purpose of education is to train students to be productive members of the society (Schiro, 2013). In an effort to progress beyond the Social Efficiency ideology, in 1924 the American Association for the Advancement of Science released a report that stressed scientific thinking and inquiry as an objective of science, and in 1934 the Commission on Secondary Curriculum of the Progressive Education Association released a report emphasizing the importance of making the curriculum relevant to life's problems (Luft et al., 2008). John Dewey was a founding member of the progressive movement, and he believed that learning should be relevant to students (Luft et al., 2008). Despite proposals for an improved curriculum that would be meaningful to students, widespread implementation of inquiry in science classrooms did not occur (Bybee, 1977).

From 1955 to 1980, the United States heavily emphasized science progress, and a historic event that led to this reform was the launching of Sputnik by Russians (Bybee, 1977; Luft et al., 2008). Americans were fearful that they were falling behind, and reforming science curriculum became a priority. Many scholars continued to advocate for changes in the curriculum. Jerome Bruner supported discovery learning and the belief of teaching students how to learn, and Jean Piaget supported the concept that thinking skills emerge through experiences (Luft et al., 2008). These thinking skills connect to science process skills that are still used in science classrooms today. However, students struggle with learning content because it is not relevant to them, and these skills are often not applied to real-world situations where students can make connections with scientific concepts (National Science Resources Center, 1997).

After the 1980s, several reports were published that criticized science education and presented the United States as making unsatisfactory progress in science. A *Nation at Risk* (National Commission on Excellence in Education, 1983) detailed the academic underachievement in the United States. The reform initiative *Project 2061* (American Association for the Advancement of Science, 1993) suggested specific statements of what students should learn in science, math, and technology. *Tapping America's Potential* (Business Roundtable, 2005) reported the U.S. falling behind in science and technology. These reports show that progress in science is not where it needs to be. Society, education goals, and the student population in classrooms are drastically changing; however, the same instructional methods from hundreds of years ago are still being used in science classrooms today.

State Trends

The South Carolina Science Standards made a transition from 2005 to 2014, shifting from a focus on Bloom's Taxonomy and Inquiry to Science and Engineering Practices. This progression relates to PBL because the goal of the standards moves from a teacher-centered environment to a learner-centered environment by requiring students to design devices and find solutions to problems. The South Carolina Department of Education (2018) begins with an introduction to 8th-grade standards that states:

> As science educators we must take a 3-dimensional approach in facilitating student learning. By addressing content standards, science and engineering practices and crosscutting concepts, students are able to have relevant and evidence-based instruction that can help solve current and future problems. (p. 3)

The revised standards aim to assist students in knowledge construction by utilizing real-world problems that are relevant to their lives.

Teaching Science and Addressing Problem-Solving

Effective teaching strategies for science in the 21st century require students to do more than be experienced with using science process skills and recall facts (National Research Council, 2007; Rahman, 2019). There are several guiding principles for teaching science effectively. First, science instruction should actively engage students in the application of science (Banilower et al., 2010; National Research Council, 2012). This requires students to ask questions, perform investigations, and offer solutions to problems that are posed. Second, guidance may be essential when students use problem-solving skills because these skills require critical thinking (National Research Council, 2012). Third, it is important to elicit students' prior knowledge and make connections to their experiences in order to strengthen their understanding of the content (Banilower et al., 2010; Ladachart & Ladachart, 2019; National Research Council, 2012). Last, effective teaching involves collaboration that requires students to communicate and participate in discussions to enhance their learning in science (Johnson, 2012; National Research Council, 2012).

When teaching science, students must be able to think scientifically by utilizing and enhancing their problem-solving skills (Antonenko et al., 2014; National Research Council, 2012). Problem-solving transforms learning into an active, relevant, and engaging experience (National Research Council, 2012; Torp & Sage, 2002). Problem-solving should be defined, discussed frequently, and reiterated as an important skill in order for students to understand its meaning (Rahman, 2019). It is also important to divide the process of problem-solving into fundamental elements and examine the components in detail (Antonenko et al., 2014; Torp & Sage, 2002). These teaching strategies promote a student-centered learning environment. However, students will need support and encouragement while learning and utilizing these strategies (National Research Council, 2012; Torp & Sage, 2002).

Science for All Students

Students at S. Fox school (pseudonym) are grouped based on their ability levels using a tracking system. Classes are categorized as honors or college preparatory (CP). Allensworth et al., (2009) describes college preparatory as a course of study that offers an intellectually stimulating curriculum that prepares learners for college or work. However, many students in CP classes are considered at-risk. These students may be considered at-risk due to low scores on high-stake assessments, they may have Individualized Education Plans for learning disabilities, and they may be in danger of failing core content classes. Researchers have noted that tracking systems are unsuccessful, and they continue a system of inequalities for underprivileged students (Modica, 2015; Portes, 2008). Biased curriculums are created due to ill-formed perceptions about ‘good’ science students (Godec et al., 2018).

All students should be able to experience a quality science education and have opportunities to learn complex scientific concepts (National Research Council (U.S.), 2012; (Next Generation Science Standards, 2013). The success of a quality education is measured by student achievement. Student performance as it relates to achievement gaps can be harmful because these gaps privilege certain types of knowledge over others (Kozleski, 2010). Existing achievement gaps between honors and CP students remain problematic due to inequalities in science instruction (Portes, 2008).

The National Research Council (2012) addresses the principles of an equitable science classroom by stating:

> Equity in science education requires that all students are provided with equitable opportunities to learn science and become engaged in science and engineering practices; with access to quality space, equipment, and teachers to support and motivate that learning and engagement; and adequate time spent on science. In addition, the issue of connecting to students’ interests and experiences is particularly important for broadening participation in science. (p. 28)

PBL creates equity in classrooms because it gives students the tools needed to increase their academic achievement. This instructional model uses ill-structured problems to help students make meaning using “collaborative, self-directed learning” (Savery, 2006). When PBL is well-planned, it can benefit all students (Liu et al., 2019). High expectations are maintained for students as they develop motivation, communication, and problem-solving skills. PBL acknowledges diverse backgrounds of students and their experiences because this method of teaching creates problems that are real-world and personally relevant (Lee & Blanchard, 2019). Problems can address concerns of students that will create authentic connections. PBL creates a learner-centered environment where students take control of their own learning (Barrows, 1996), and equity is created by cultivating each student’s abilities and interests and preparing them for real-world settings.

PBL and Assessments

Assessments are important in the classroom because they indicate whether instructional goals are being met. Teachers assess students’ knowledge because federal, state, and local directives require them to do so, but teachers also assess students because the results guide instruction in the classroom (Anderson, 2003). Student performance gives teachers an awareness of when to move on, reteach, or try a different instructional approach.

PBL creates distinctive challenges regarding assessments that reflect how and what students learn (Glazewski, 2018; Grant & Tamim, 2019). The assessments should focus on learner-centered, constructivist learning models because “traditional methods of assessment fail to measure authentic learning, knowledge, or understanding” (Ronis, 2008, p. 93). Assessments should go beyond conventional tests and stimulate inquiry, discovery, and making connections (Ronis, 2008). Processes and skills that are used when problem-solving like self-directed learning, critical thinking, and communicating can be difficult to examine and analyze (Anderson, 2003), and in preparing students for mandated assessments, many teachers regress to using tests that focus on recall and memory (Grant & Tamim, 2019).

Appropriate assessments for student learning should be developed for PBL, and these evaluations may not look like traditional assessments. Ali (2019) suggests beginning with pinpointing the learning outcomes. Then, use a scoring guide like a teacher-created rubric (Ali, 2019) with set criteria to identify if learning goals are met.

It is necessary to review related research for this problem of practice in order to understand the progress that has been made on this topic. A review of relevant research shows the effectiveness of strategies used; however, gaps may be found in the research.

Effectiveness of PBL

Research studies have indicated that PBL has a positive effect students' growth and understanding. Moon (2018) studied the impact of PBL in an eighth-grade earth science classroom. The goal was to observe the effects of PBL on students' conceptual understandings and observe the teacher-researcher's perceptions while implementing a series of PBL scenarios. The participants included 27 students from one of the researcher's science classes. Groups for the PBL lessons were created based on gender with a focus on females. A case study using qualitative data was collected for a period of eight weeks, and coding was used for data analysis. Moon (2018) found that students showed an increase in their comprehension while using PBL, however, the ability to transfer tasks decreased for all of the PBL scenarios. Moon (2018) also found a connection with PBL tutor and creating a more equitable science classroom; however, Moon (2018) noted that additional research was needed. Like Moon's (2018) research, the present study observed student understandings in an eighth-grade science classroom. The present study also focused on students' perceptions and teacher perceptions while PBL was being implemented. Also, Moon's study focused on gender, while the present action research did not.

Muniz (2019) evaluated the impact of students creating knowledge through collaboration while problem-solving (Knowledge Creation PBL) on student achievement using a quasi-experimental quantitative study. The study utilized purposive sampling of two middle school classrooms. Thirteen fifth and sixth graders attending a private school received PBL instruction, and a control group consisting of 22 fifth and sixth grade students received direct instruction. Muniz (2019) used descriptive statistics to analyze pre- and posttest scores and each construct of a teacher-created rubric. Inferential statistics were also used to analyze pre- and posttest data. Findings revealed that both groups made academic gains; however, there was not a notable difference in achievement between the group receiving direct instruction over the group receiving PBL instruction (Muniz, 2019). With regards to being able to define a problem, students' gain scores were significantly higher in the control group receiving direct instruction than students in the experimental group receiving PBL instruction; however, gains in all other areas were not statistically dissimilar (Muniz, 2019). This study and the present action research study both use descriptive statistics to analyze pre and posttest to measure student achievement.

In addition to growth and understanding, some researchers focus on students' attitudes towards learning a subject. Fletcher (2018) investigated the effects of solving problems relevant to students while empowering them to become global citizens (Global Problem Based Learning) on achievement and attitudes in advanced math classes. The participants in this study were in the 11th or 12th grade. 25 students participated in the action research portion of the study. This study utilized mixed-methods research consisting of teacher observations, surveys, focus groups, discussion boards, and unit tests. Triangulation was used to ensure the validity of the study. In summarizing the findings, Fletcher (2018) found that GPBL had a positive impact on students' attitudes towards learning math; however, using GPBL did not allow students to convey math knowledge from one concept to another. This study and the present research study both obtain qualitative and quantitative data to measure student achievement and students' attitudes towards learning a subject.

Similarly, Liu et al. (2019) researched students' attitudes towards learning. Liu et al. (2019) noted a deficiency of PBL studies being conducted with at-risk students and researched if the effects of PBL could be noted with the underrepresented students. The participants consisted of 32 disadvantaged middle school students from schools with high percentages of free and reduced lunch and high percentages of minority students. Seventeen of the participants were boys and fifteen were girls. This was a mixed-methods study using pre- and posttest scores, open-ended questions, and teacher and student interviews. Coding and a web-based digital text was used to analyze data. Liu et al. (2019) found that by using PBL, students significantly improved their knowledge and attitudes towards science. Females scored lower on the pretest resulting in their gains in science knowledge appearing to be larger, however, there was no significant difference in knowledge and attitudes towards science between girls and boys. Likewise, in the present study, data was gathered about students' perceptions about learning and their attitudes towards science; however, all of the students in the present study were not considered to be at-risk.

PBL and Student Engagement

PBL produces engagement when students have to generate ideas about a problem, use real-world problems in the classroom, and when students are responsible for their own learning (Rotgans & Schmidt, 2011). Defining and measuring engagement can be complex because it consists of many conceptual ideas. Godec et al. (2018) define engagement as showing interest in the learning process; however, researchers focus on different constructs when defining behavior. Fredricks et al. (2004) list the dimensions of engagement as being behavioral, emotional, and cognitive. Appleton et al. (2006) describe engagement using the dimensions academic, behavioral, cognitive, and psychological. Finn and Zimmer (2012) describe the dimensions of engagement as being academic, social, cognitive, or affective. This research study will focus on cognitive, emotional, and behavioral engagement because these constructs can be operationalized, and they are the most observable for me.

Cognitive engagement can be defined as the time and effort put forth by students when attempting to learn (Fredricks et al., 2004; Rotgans & Schmidt, 2011). Cognitive engagement can be difficult to measure, but it can be operationalized by observing assignment performance (Appleton et al., 2006; Fredricks et al., 2004). Emotional engagement can be defined as the reactions students display in response to learning, and it can be operationalized by observing positive and negative emotions expressed by the students (Fredricks et al., 2004). Behavioral engagement can be defined as the observable conduct of students in response to learning, and it can be operationalized by observing positive and negative behaviors related to conduct and being on-task (Fredricks et al., 2004). For this research study, I observed and documented cognitive, emotional, and behavioral engagement using a student survey and teacher observations.

Summary

PBL is a student-centered pedagogy that requires students to solve ill-structured problems to help them learn content. Research shows that implementing this instructional model has a positive impact on students' attitudes towards learning and on their achievement. However, some research findings show that students are not able to transfer their understandings to other skills and topics. This action research study examined best practices for students to construct knowledge in a middle school, CP science classroom. This study observed the impact of PBL on students' achievement, how PBL impacted students' engagement towards science and learning, and the impact of PBL on students' problem-solving skills.

CHAPTER 3

METHODOLOGY

Chapter 2 provided a review of literature and explained the theoretical framework for this action research study. This chapter gives details of the methodology used to answer the research questions about the PBL intervention that took place in an eighth-grade, college prep science classroom. This chapter describes the research design, research setting and participants, procedures that provide details about the intervention, data collection instruments, data analysis strategies, and the timeline used for this study.

Problem of Practice

The pedagogy used in my classroom has frequently utilized teacher-led discussions and teacher demonstrations to teach content. Most of the labs and activities result in all students having the same outcomes, and the activities usually have only one right answer. Students are not able to explore and construct their own knowledge due to the fact that most of the instruction is teacher centered. These types of instructional strategies have proven to be ineffective in aiding students to learn scientific concepts.

The purpose of this action research study was to explore the impact of problem-based learning on science instruction. Specifically, this study sought to examine the impact of PBL on academic achievement, student engagement, and the use of problem-solving skills for eighth-grade college prep students. An expectation of this study was that it would create a learning environment that was more student-centered, and students would own their learning. This action research study investigates the following research questions:

1. What is the impact of problem-based learning on students' achievement?
2. How does problem-based learning impact students' engagement towards science and learning?
3. How does problem-based learning impact students' problem-solving skills?

Research Design

This was an action research study. Action research requires members of a group to seek change using a systematic process when there is an identified problem (Herr & Anderson, 2015). In seeking to improve a practice, action research calls upon the researcher to create a plan, implement the plan, conduct observations, and reflect on the outcomes for future action (Herr & Anderson, 2015). This type of research requires collaboration among the participants, and it is often used in educational settings (Herr & Anderson, 2015). Action research makes it possible for teachers to improve their practice (Herr & Anderson, 2015), and it also allows students to become active participants in the research process because it gives them a voice (Beaulieu, 2013). During this study, I was a teacher observing students in my own classroom. I was reflecting on the implementation of an instructional model that I can use in the future to improve my students' learning, and the results of this study will help guide my instruction.

This study utilized a mix-methods design. This type of design merges quantitative and qualitative designs by gathering, analyzing, and interpreting both types of data (Creswell & Creswell, 2018). Klehr (2012) states, "Quantitative and statistical data can provide useful insight into areas of student skill mastery and indicate important subgroup trends, areas that are important to school reform efforts and often motivate teachers toward deeper inquiry" (p. 123). Collecting this type of data highlighted students' academic strengths and weaknesses, and it informed me as to whether or not students had mastered learning goals and state standards. Qualitative data adds additional details to quantitative data by helping researchers holistically observe their classroom practices (Klehr, 2012).

Using a mixed-methods design allowed me to evaluate the process and the outcomes (Creswell & Creswell, 2018) of implementing PBL. Quantitative data provided insight on how students were feeling throughout the intervention, and qualitative data provided insight about my feelings about the PBL process. Examining quantitative data using statistics also allowed me to communicate students' academic gains. Analyzing both types of data aided me in answering my research questions. This design was appropriate for this study because I wanted to go beyond measuring student achievement. I wanted to reflect on my perceptions and my students' perceptions about the intervention itself.

To increase students' success, PBL was implemented with a Forces and Motion unit of study. PBL is a learner-centered instructional model that allows students to gain knowledge by solving ill-structed problems (Savery, 2006). PBL requires certain skills like critical thinking, working cooperatively, and communication. These skills are major components of PBL because they allow students to view different perspectives to effectively come up with solutions (Ertmer & Simons, 2006).

Research Setting

S. Fox School (pseudonym) is a public middle school in the suburban Southeast. It is one of 21 schools that make up a larger PK-12 institution. There are a total of four middle schools in this institution. S. Fox School is rated above average in school quality compared to other schools in the area, and students at this school perform above average on state tests (South Carolina Department of Education, 2019). Currently, S. Fox School has a student population of 969 students. The demographics of the student population are Caucasian at 54%, African American 32.4%, multi-racial 6%, Asian 3.4%, Hispanic 4%, Native American .1%, and Hawaiian .1%. Within this population, 34% of the students receive free and reduced lunch.

When students enter eighth grade, they either take honors science or college preparatory science as one of their four core classes. Students that qualified for the Gifted and Talented program during elementary school enter the honors track and are enrolled in honors science. All other students are enrolled in CP science. Parents and guardians are allowed to waive their student into an honors science course even if they do not meet the recommended prerequisites.

Participants

The participants in this study are eighth-grade middle school students in my fourth-period, CP science class. They attend this class for 56 minutes each day. Students in this class are extremely diverse in terms of race, gender, cultural background, socioeconomic status, and academic achievement levels. There are 20 students in this class, but two students will not be included in the data. One student is on intermittent homebound, and one student is a non-verbal special needs student; therefore, 18 students served as participants for this study.

In the class, 12 students are male and six are female. Of those, eight students are white, nine are African American, and one student is Hispanic. Learning accommodations are provided to nine students in this class, which are summarized in Table 3.1.

Table 3.1 Summary of Student Accommodations

Type of Accommodation	**Number of Students**
Frequent checks for understanding	1
Frequent redirection	2
Small group testing	2
Extended time for assignments	3
Extended time for tests and quizzes	3
Preferential seating	4

Historically, several of the participants for this study had not met the state's expectations for academic achievement in science. These students were last tested on a state level science assessment in in the sixth grade during the 2018-2019 school year. The results are recorded for 13 students because students take either the science or social studies state assessment in sixth grade. The state identifies students' performance levels based on four categories: Exceeds Expectations, Meets Expectations, Approaches Expectations, and Does Not Meet Expectations. Students that are Approaching Expectations need additional support, and students that Do Not Meet Expectations need significant support to be prepared for the next grade level and college and career learning (South Carolina Department of Education, 2019). Based on data from S.C. PASS Scores, no students were in the category Exceeds Expectations, five students were in the category Meets Expectations, three students were in the category Approaches Expectations, and five students were in the category Does Not Meet Expectations (South Carolina Department of Education, 2019).

MAP (Measures of Academic Progress) data also indicates the diverse learning needs of the participants in this class. Students in this class had reading scores below the national average of 218 and math scores below the national average of 225. Table 3.2 summarizes students' Fall MAP data for the year 2022. The percentile rank tells where the students scored in comparison with other students in the same grade across the country.

Table 3.2 Fall MAP Data

Student Percentiles	**MAP Data for Reading (Class average 209.2)**	**MAP Data for Math (Class average 213.6)**
> 80%	0	0
61-80%	5	3
41-60%	5	3
21-40%	2	6
< 21%	6	6

Pseudonyms will be used throughout the study to protect the identity of the participants and setting.

Pre-Intervention Activities

The intervention used for this research is based on PBL. Students in this class were not familiar with PBL, and the pre-intervention gave students an opportunity to practice skills necessary for PBL, such as collaborating and communicating through two collaborative activities. The first activity was called *The Marshmallow Challenge* (Original Design Challenge, 2014). It was used to help students practice working in groups and communicating. I used it to observe students' interactions while working together, and I provided feedback as to how they could improve their collaboration and communication skills. The second activity that I modified from a lesson called *Penny Raft STEAM Activity* (Schaffer, 2020) allowed me to observe whether or not students applied the suggestions I made after the first activity, and it gave them another chance to practice their collaboration and communication skills. Finally, a pretest (See Appendix A) was given before instruction began with this unit. The pretest could be completed in one class period, and was administered using students' Chromebooks. This pretest gave me insight into students' content knowledge and skills, and it allowed me to see individual strengths and weaknesses for each student. This pretest gave me an understanding of each student's prior knowledge, and it informed me about which content areas need to be given more attention.

Intervention

PBL was originally created as a specific approach to help medical school students problem solve (Barrows & Tamblyn, 1980). Students approach learning in a variety of ways, and the process for implementing PBL should be appropriate for the students (Torp & Sage, 2002). Torp and Sage (2002) designed a model for implementing PBL in the K-12 setting that is based on a constructivist pedagogy. This model reverses traditional roles in the classroom by requiring students to become active learners while teachers become facilitators (Torp & Sage, 2002). This model presents ill-structured problems to students to solve while working in collaborative groups (Torp & Sage, 2002). The intervention for this research study used Torp and Sage's model (2002) to implement PBL. The steps to implement PBL are as follows: Prepare the Learners, Meet the Problem, Identify What We Need to Know, Define the Problem Statement, Gather and Share Information, Generate Possible Solutions, Determine the Best Fit of Solutions, Present the Solution, and Debrief the Problem (Torp & Sage, 2002).

Under constructivism, teachers serve as facilitators of learning and support students' thinking. Particularly in this intervention, learning was scaffolded during each step, using Torp and Sage's PBL model (2002). Students were supported with coaching, and my role as the teacher waned as students were allowed to construct their own knowledge. This intervention was implemented with a Forces and Motion unit of study. Students were presented with problems relevant to their lives, and they were asked to offer solutions to the problems. Table 3.3 summarizes the intervention. A detailed explanation of the intervention that includes daily objectives, activities, and student handouts is in Appendix B.

Table 3.3 Summary of the Intervention

Steps to Implement PBL	Day of Intervention	Student Activities	My Role As A Facilitator
Step One: Prepare the Learners	1-3	• Brainstormed experiences with forces and motion • Created definitions of key terms	• Scaffolded learning • Provided encouragement
Step Two: Meet the Problem	4	• Identified the problem	• Provided a resource that introduced the problem (The assistant principal introduced problems occurring in the recess area.)
Step Three: Identify What We Need to Know	5	• Completed a chart about ideas (Know/Information Needed/Ideas and Thoughts) • Shared ideas	• Observed students' ideas about the problem • Listened and provide encouragement • Monitored students' progress • Redirected students when needed
Step Four: Define the Problem Statement	6-7	• Used a concept map to describe ideas about the causes, indicators, solutions, and consequences of the problems • Explained how ideas connected to forces and motion.	• Monitored and facilitated discussions by asking students questions about the problem

Steps to Implement PBL	Day of Intervention	Student Activities	My Role As A Facilitator
Step Five: Gather and Share Information	8-10	• Viewed videos to gain information about Newtons' Laws of Motion • Discussed content learned • Researched solutions to the problems using the Internet • Described the relationship between the research and the problems at hand	• Allowed students to work collaboratively • Provided guidance • Monitored progress
	11	• Made direct observations about how forces impact the motion of objects • Shared and discuss findings	• Allowed students to work collaboratively • Provided guidance • Monitored progress
	12	• Developed mini-experiments to test how forces impact the motion of balls • Recorded observations on a handout • Shared findings	• Allowed students to work collaboratively • Provided guidance • Monitored progress
Step Six: Generate Possible Solutions	13	• Listed strategies to solve the chosen problem	• Guided students to resources that offered strategies to solve their chosen problem • Monitored students' needs • Offered encouragement

Steps to Implement PBL	Day of Intervention	Student Activities	My Role As A Facilitator
Step Seven: Determine the Best Fit of Solutions	14	• Communicated the solutions offered by the group • Reached a consensus about the solution	• Observed groups to make sure they remained on task • Offered support by asking clarifying questions
Step Eight: Present the Solution	15-17	• Created a Google Slides presentation • Listened to the ideas of other groups • Asked questions and commented on the presentations of other groups	• Provided an active learning opportunity by having students listen to the ideas of other groups
Step Nine: Debrief the Problem	18	• Reflected on the intervention • Reflected on thinking about their learning	• Listened to students' discussions • Asked clarifying questions
	19	• Reviewed unit concepts	• Reviewed unit concepts
	20	• Completed posttest	• Administered posttest

Data Collection Instruments

For this study, data measured students' achievement in science, students' engagement towards learning and science, and how PBL impacted students' problem-solving skills. I used qualitative and quantitative methods for data collection. Data was collected during the first semester of the 2022-2023 school year, between September and October 2022. Table 3.4 displays the research questions with the corresponding data collection instruments and type of data to be analyzed.

Table 3.4 Research Questions and Data Collection Instruments

Research Question	**Data Collection Instrument**	**Type of Data**
Research Question #1 What is the impact of problem-based learning on students' achievement?	Pre- and posttest	Quantitative
Research Question #2 How does problem-based learning impact students' engagement towards science and learning?	Teacher observations of students	Qualitative
	Student engagement survey using Likert Scale	Quantitative
Research Question #3 How does implementing problem-based learning impact students' problem-solving skills?	Teacher observations of students	Qualitative
	Teacher-created rubric for presentation evaluation	Quantitative

Qualitative instrument. Qualitative instruments provide holistic accounts about what is occurring in a setting (Creswell & Creswell, 2018).Teacher observations of students served as the qualitative instrument for this research study.

Teacher observations of students. An observation is using sensory organs like sight and hearing to collect data, and observations allow researchers to document the activities and behaviors of students (Creswell & Creswell, 2018). Direct observations give comprehensive understandings about what is occurring in the classroom (Efron & Ravid, 2013), and through observations I was able to detect patterns and recurring actions students displayed. For this research study, observations gave me a first-hand account of student conversations and group dynamics, and I was able to document their expressions and reactions as they collaborated to solve problems. I collected descriptive notes, writing down what I saw and heard while observing events that occurred in class.

This instrument provided data for two research questions. For research question 2, this instrument allowed me to observe students' engagement towards science and learning. Observations of students' cognitive, emotional, and behavioral engagement were documented. For cognitive engagement, I observed students' attempts and efforts made to complete assignments and activities. For example, assignments varied in their level of critical thinking that was required by students. I observed if students made attempts to complete certain parts of assignments or if they completed all parts of assignments. For emotional engagement, I observed reactions students displayed in response to learning. For example, I observed students' facial expressions to see if they appeared to be happy or sad. I also listened to their comments to see if they appeared to be calm or anxious. For behavioral engagement, I observed students' conduct that could be positive or negative behaviors related to conduct and being on task. For example, if students were collaborating, interacting, and involved in on-task communication, I documented that as positive behavioral engagement. If students needed redirecting and were having off-task discussions, I documented that as negative behavioral engagement.

For research question 3, I observed the impact of PBL on students' problem-solving skills. I observed if students were able to clearly identify their problems, gather relevant content information, make inferences, and identify solutions to their problems. I listened to comments made by students, and I also observed information students wrote on handouts provided to them throughout the intervention. Observations were collected daily throughout the four weeks of the intervention. See Appendix C for the teacher observations template that was used.

Quantitative instruments. Quantitative instruments provide measurable, numerical data that can be analyzed using a systematic approach (Creswell & Creswell, 2018). The quantitative instruments used in this research study were a pre- and posttest, a student engagement survey using a Likert scale, and a teacher-created rubric used to grade students' final presentations.

Pre- and posttest. Pre- and posttests provide assessment data, and this information can be used to monitor students' achievement (Efron & Ravid, 2013). The assessment for this research study was created by teachers at S. Fox School, and it is used by all eighth-grade science teachers. The data gathered from this test is used to inform our instruction. Using the data from this assessment, I identified students' strengths and weaknesses for the Forces and Motion unit of instruction. It was important to use this assessment because the questions mirror district benchmark questions, and they are similar to questions on the end-of-year state assessment. The pre- and posttest consists of 10 multiple-choice questions. The questions are standards-based, and they vary in complexity. Some questions require simple recall, and some questions require higher-order and critical thinking. A posttest was also be administered to students. This assessment was the same as the pretest. This instrument provided data for research question 1, and it was used to measure academic growth after the intervention took place. The analysis of the pre- and posttest allowed me to identify how individual students progressed and determine the impact of PBL on students' achievement. See Appendix A for the pre- and posttest.

Student engagement survey. Surveys can provide quantitative data about the participants' beliefs and opinions, and they can also help researchers identify relationships between variables (Creswell & Creswell, 2018). Surveys are useful because they allow information to easily be gathered from many participants (Efron & Ravid, 2013). For this research study, the survey utilized a Likert scale to supply data about the students' perceptions of their engagement with the PBL activities. I asked students to complete a fixed 12-question survey during the beginning, middle, and towards the end of the PBL intervention. This instrument provided data for research question 2, as students were asked to rate their experiences as it relates to their cognitive engagement, emotional engagement, and behavioral engagement. See Appendix D for the student engagement survey.

Teacher-created rubric for presentation evaluation. Rubrics use authentic grading to measure students' achievement (Efron & Ravid, 2013). They are useful because they provide information that can be used to identify specific areas to improve students' learning and strengthen instruction (Efron & Ravid, 2013). This instrument provided data for research question 3, and it was used to evaluate students' presentations. The rubric evaluated students on six different criteria. The descriptors include: ability to identify the problem, gathering of relevant information, solutions offered, organization, language, and appearance. See Appendix E for the teacher-created rubric.

Data Collection Methods

Data collection began one day before the PBL intervention with the Forces and Motion pretest, and it ended with the Forces and Motion posttest. During the PBL intervention, quantitative and qualitative data were both collected. The following section provides more details regarding the data collection process.

Quantitative Instruments

Pretest and Posttest. Pre- and posttest (see Appendix A) were utilized in this study. Students were given the Forces and Motion pretest the day before the PBL intervention began. Students completed the 10 question, multiple-choice assessment on their Chromebooks using a program provided my district called All-in-Learning. They could access the pretest using a link I shared with them in Google Classroom, and the test was not timed. Once students completed the assessment, they clicked the submit button, and I was able to access their answers in the All-in-Learning program. I administered the posttest at the end of the intervention in the same manner as the pretest.

Student Engagement Survey Questions. The student engagement survey was administered using Google Forms three times during this study. Students completed the surveys on Day 7, Day 12, and Day 17 of the PBL intervention. The students could access the form using a link I shared with them in Google Classroom. Students' responses were automatically saved. Once they completed the survey, I was able to view their responses online (see Appendix D). Students could take as much time as they needed to complete the survey questions.

Students' Presentations. A teacher-created rubric was used to score students' presentations. The rubric consisted of seven criteria. Identification of the problem, Gathering of relevant content information, solutions, and collaboration measured students' problem-solving skills. Other criteria scored included organization, language, and appearance. Students could receive a score of one to three, with one being the lowest score and three being the highest score. Teacher comments were also placed on the rubric to provide feedback to students.

Qualitative Instruments

Teacher Observations. Classroom observations were recorded using a teacher observation form each day during the intervention. The top of the form had a place to document the date, the day of intervention, and the number of participants that were present each day. The form consisted of sections to record cognitive engagement, emotional engagement, and behavioral engagement. It also included sections where I could write if I observed students' observations skills and critical thinking skills. Teacher reflections could also be documented on this form. The teacher observations were handwritten on the form.

Data Analysis Strategies

The following section describes the methods used to analyze the quantitative and qualitative instruments.

Quantitative Instruments

Quantitative data was collected using pretest and posttest, student engagement surveys, and student presentations. The quantitative data was analyzed using descriptive statics. These statics measured changes in academic achievement, levels of engagement, and students' use of problem-solving skills.

Qualitative Instruments

Qualitative data were collected using teacher observations, and it was coded. Codes are pieces of information that provided insight to the data and may be pertinent in answering research questions (Merriam & Tisdell, 2016). I typed all of my observations into a Word document on the computer, and I reviewed my observations line-by-line to identify codes. Once codes were identified, I sorted similar codes manually and placed them into categories. As suggested by Creswell and Creswell (2018), once these categories were organized, I organized the reoccurring patterns into themes. These themes captured important information about students' experiences, and it also allowed me to make connections between different types of data (Merriam & Tisdell, 2016).

Rigor and Trustworthiness

Rigor and trustworthiness refer to the level of confidence in data, methods used, and interpretation of findings to confirm the value of a study (Efron & Ravid, 2013). Research findings must be logical and valid in order for the results to be beneficial to your practice (Efron & Ravid, 2013). Validity is important in qualitative and quantitative studies; however, it is addressed differently by each type of research (Efron & Ravid, 2013). This section describes the measures taken in this study to maintain rigor and trustworthiness.

Quantitative. For quantitative research, validity refers to the relevance of the instruments and how appropriate they are for the study (Efron & Ravid, 2013). Validity for assessment scores increases when there is content-related, construct-related, and criterion-related evidence that supports students' responses (Creswell & Creswell, 2018). Criteria for the teacher-created rubric that assessed students' presentations required students to be able to gather relevant and accurate content information about the ill-structured problem, and this demonstrated content-related evidence. The rubric shows construct-related evidence by assessing students reasoning processes when they offer solutions to the problem. Students were required to list the pros and cons of their solutions, and they also identified and addressed consequences of their solutions. Criterion-related evidence is supported when learners can apply a performance to a current or future task (Creswell & Creswell, 2018). The teacher-created rubric assessed students' problem-solving skills of being able to identify a problem and offer solutions. To increase the validity of the rubric, I also asked other members of the eighth-grade science department to review the rubric to ensure that I was measuring what I claimed to measure. Five college preparatory students from my homeroom also reviewed the instrument to make sure the language was clear.

Reliability can be defined as the degree that procedures are consistently accurate (Creswell & Creswell, 2018). Assessments are reliable when quality test questions are written (Efron & Ravid, 2013). The pre- and posttest was created and reviewed by eighth-grade teachers at S. Fox Middle School. Teachers ensure assessments are aligned with the district's curriculum, the state standards, and unit objectives. This increases the validity of this instrument. This assessment includes 10 questions that assesses various concepts covered in the Forces and Motion unit, so students had multiple opportunities to demonstrate their knowledge of the subject matter. This pre- and posttest has been used by teachers for several years. It gives consistent results among the teachers, measuring students' pre-existing content knowledge and gains made after instruction has occurred.

To increase validity, the student engagement survey included questions aligned with how I operationalized cognitive, emotional, and behavioral engagement. I found exact behaviors I could observe for each type of engagement. Also, the student engagement survey was shown to other eighth-grade science teachers for review. The survey was also given as a pilot test to five college prep students in my homeroom to make sure the language used in the survey was clear before administering the survey to the research participants.

Qualitative. For qualitative studies, validity requires the use of rich data to determine the accuracy of the findings (Creswell & Creswell, 2018). In order to maintain rigor and trustworthiness of the qualitative data, the following strategies were used for validity.

***Prolonged engagement*.** Prolonged time in the setting allows the researcher to gain a thorough understanding of the situation being studied (Creswell & Creswell, 2018). This was achieved by the amount of time I spent in the classroom with my students and by the length of time during which observations were collected throughout the intervention.

***Thick description*.** A thick description gives readers a detailed account of the research, and it allows others to see the participants' perspectives (Creswell & Creswell, 2018). I recorded observations of my students daily during the intervention, and what I saw and heard allowed me to write a thick description to communicate my findings.

***Disciplined subjectivity*.** It is important for researches to reflect on their own biases when conducting action research (Efron & Ravid, 2013). I discussed my personal biases that may impact my analysis of the results under positionality in Chapter 1 and through analysis.

***Triangulation*.** Efron and Ravid (2013) state, "Triangulation is the practice of relying on more than one source of data by using multiple methods or obtaining varied perspectives" (p.70). It allows researchers to "confirm emerging findings" (Merriam & Tisdell, 2016, p. 244). This strategy also allowed me to show similarities and differences found within the data. Triangulation was achieved by using several instruments that include quantitative instruments because this was a mix-methods study.

Ethical Considerations

Research requires information to be collected from participants and about participants; therefore, ethical issues must be considered (Creswell & Creswell, 2018). Ethical issues arise in all types of research, and measures should be taken to address these issues throughout the entire research process (Creswell & Creswell, 2018).

Before beginning the research study, codes of ethics and protection from human rights violations should be considered (Creswell & Creswell, 2018). I received approval from the University of South Carolina institutional review board, and I also gained approval from my school district to conduct this study. My student participants were under the age of 18, so I followed the guidelines required by my district that included: obtaining a signed consent form from parents (Appendix F), explaining in the letter of consent what an ill-structured problem is, suppressing all personally identifiable data, and eliminating any identification of the school, district, and staff members.

When analyzing data, it is important to maintain the privacy of the participants (Creswell & Creswell, 2018). Pseudonyms were used for all students and the school, and the school district was not identified by name. Information obtained throughout the research study was protected and stored in a confidential manner. All electronic documentation pertaining to the study was kept on a double-locked computer. All paper files were kept in a locked drawer in a locked room. The investigators associated with the study and the IRB had access to identifying information. Once the study was complete, all identifying data was destroyed.

All participants should receive the benefits of the study (Creswell & Creswell, 2018). All students in my college prep classes were taught using the PBL instructional model. The same intervention was conducted with all students utilizing the same standards, instructional goals, and objectives for the Forces and Motion unit of study.

Timeline for Procedures

Procedures began in the fall of 2022, and continued through the 2022-2023 school year as outlined in Table 3.5.

Table 3.5 Timeline for Procedures

Date	Activity
March 2022	IRB approval to conduct research
September 2022	District approval to conduct research
September 2022	Pre-intervention activities The Marshmallow Challenge Activity Penny Raft STEAM Activity Forces and Motion Pretest
September 20-October 21	Intervention
September 20-October 21	Data collection
October 21	Forces and Motion Posttest
November 2022 - February 2023	Data analysis
March 2023	Finalizing dissertation

Summary

The purpose of this study was to examine the effectiveness of using PBL in an eighth-grade CP science class. This chapter explained the research design, research setting, data collection measures, and data analysis strategies used to answer the research questions in this study. The next chapter will discuss the findings in the study.

CHAPTER 4

ANALYSIS OF FINDINGS

This chapter presents the findings from a mix-methods action research study that implemented PBL as an intervention. The problem of practice for this study was based on my observations of ineffective instructional strategies I used in my middle school classroom when trying to get students to learn and apply scientific concepts. I wanted to explore the impact of PBL on students' achievement, how PBL affects students' engagement towards science and learning, and how does implementing PBL impact students' problem-solving skills. The quantitative data were collected from a knowledge and proficiency pretest and posttest, a student engagement survey that measured students' perceptions about their engagement towards PBL, and a teacher-created rubric to measure problem-solving skills observed in presentations created by students. Teacher observations of students served as the qualitative data collection instrument for this study, which allowed me to observe students' engagement and reflect on my perceptions of how PBL impacted their problem-solving skills. The analysis and findings of the data collected through the PBL intervention are presented in this chapter.

Knowledge and Proficiency Pretest and Posttest

Before the intervention, students answered 10 questions on the pretest. The purpose of the pretest was to collect data on students' knowledge and proficiency on the content covered in the Forces and Motion unit of study. After the PBL intervention, students completed the posttest. The purpose of the posttest was to see if students gained knowledge. The posttest was the same as the pretest, and all of the questions were multiple-choice. Data were collected from 18 students for the pretest and the posttest. The analysis of students' pretest and posttest average scores and a question-by-question analysis that explains specific concepts are discussed below.

Students' Pretest and Posttest Average Scores

The class average was 37.8% on the Forces and Motion pretest. Students' scores ranged from 20% - 80%. One student scored 80%, one student scored 70%, one student scored 60%, and all other students scored below 60%. This indicates that a few students had prior knowledge about the content, but most students had little prior knowledge or experience with concepts pertaining to forces and motion.

The Forces and Motion posttest was administered on the 20th day of the intervention, and the class average was 78.9% on the posttest. Students' scores ranged from 40% - 100%. Two students scored 40%, two students scored 60%, one student scored 70%, six students scored 80%, three students scored 90%, and four students scored 100%. The posttest scores indicate students' growth in learning the forces and motion concepts for this instructional unit.

The pretest and posttest consisted of 10 questions, and each question was worth 10 points. Therefore, a gain of 10 points means one additional question was answered correctly. Figure 4.1 below shows a comparison of students' pretest and posttest scores. The students have been placed in order by ascending gains made between the pretest and posttest.

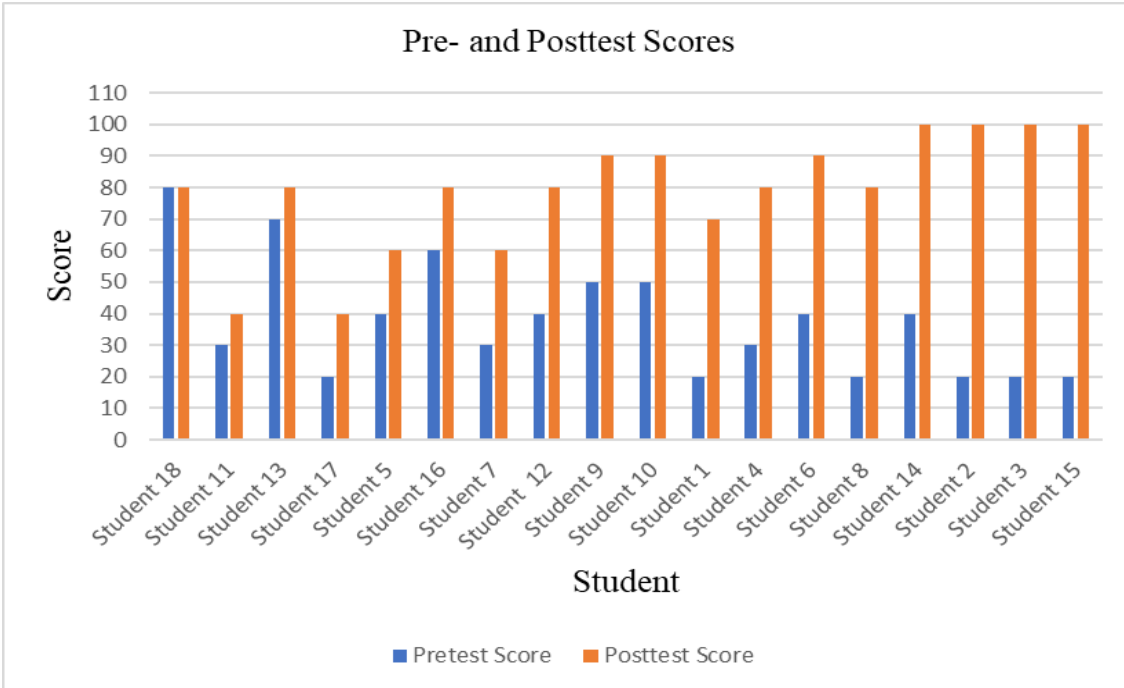

Figure 4.1 Comparison of Pretest and Posttest Scores

When analyzing the differences between students' pretest and posttest scores, 17 students increased their achievement. Students with gains increased their scores by 10 to 80 points. This shows an increase in knowledge; however, students' knowledge increased for some questions more than others, and this will be discussed in the next section.

Student 18 is an outlier because he scored high on the pretest with a score of 80%, and this student received the same score on the posttest. Although his pretest and posttest scores are the same, the first question he missed was the same question he missed on the pretest. The second question he missed was a different question; therefore, this student's achievement needs to be examined further.

The science department uses ranges to describe students' knowledge towards learning and meeting standards where a score of 90 – 100 is proficient, 89 – 80 is close to proficient, 79 – 70 is progressing, and 69 and below needs intervention. These ranges align with the district's grading scale, and they also indicate how students' would perform on the state's science assessment. Table 4.1 below shows the ranges used by the science department to describe students' knowledge towards learning and meeting the standard, and it shows the letter grade and number of students receiving each grade on the pretest and posttest.

Table 4.1 Students' Knowledge Level and Letter Grades

Student Knowledge Level	Pretest Score	Posttest Score
A (Proficient)	0	7
B (Close to Proficient)	1	6
C (Progressing)	1	1
D (Needs Intervention)	1	2
F (Needs Intervention)	15	2

Overall, the number of students that need intervention after instruction decreased, and the number of students moving up in the categories of Close to Proficient and Proficient increased. Before the intervention, no students were categorized as Proficient. However, after implementing the intervention, seven students' knowledge level were categorized as Proficient. There was one student Close to Proficient before the intervention, and six students were categorized as Close to Proficient at the end of the intervention. One student was categorized as Progressing before the intervention, and a different student was categorized as Progressing at the end of the intervention. Sixteen students' knowledge level was categorized as Needs Intervention before the intervention, and after the intervention this number decreased to four students.

After the implementation of the intervention, 17 students moved to a higher knowledge level, and the student that did not move to a higher knowledge level had a pretest score that indicated he already had prior knowledge about most of the content that would be covered in this unit. The PBL instructional model engaged students by utilizing real-world problems to stimulate learning, and students completed activities that required them to be active learners. Following the PBL model, students were introduced to problems that were relevant to them, they researched information themselves, students created mini-experiments to observe the effects of forces and motions, had ongoing discussions while generating solutions to their problems, and created presentations to share their findings. These activities led to a more student-centered classroom, and the increase in students' knowledge levels suggests that the activities were successful in aiding students to learn the content.

Although most of my students made gains from the pretest to the posttest, some students did not make enough gains. These scores indicate that 14 students with the letter grades A, B, and C would be considered successful with the Forces and Motion unit. However, four students with letter grades D and F need additional remediation. Student 5 (grade of D) made gains of 20 points, Student 7 (grade of D) made gains of 30 points, Student 11 (grade of F) made gains of 10 points, and Student 17 (grade of F) made gains of 20 points. Based on my observations, Student 5, Student 7, and Student 17 needed a lot of redirecting throughout the intervention. These students wanted to leave class each day to go to the restroom, I frequently had to ask them to remove Air pods from their ears, and their discussions were often off-task. These students display disruptive behaviors in response to learning in my class and other classes as well which could have impacted their performance in this unit.

It is important to note that a student with a letter grade of D would progress to the next grade level; however, a student with a letter grade of F would be retained. Although the school year is 180 days, when students are retained they attend summer school for 10 days to advance to the next grade level. Students do not have a chance to master the learning in this short period of time, and many of these students remain behind in their learning and skills development. Student 11 (Grade of F) attended summer school last year, and he needs additional remediation that the PBL intervention could not address alone.

Students made gains on all questions from the pretest to the posttest. The activities used throughout the intervention were learner-centered, and these gains show that the PBL intervention might have played a role in it.

Question-by-Question Analysis

It is also important to analyze each question item on the assessment because each question focused on a different concept. The following section provides a brief description of the concepts being taught for each question, and an analysis of students' pretest scores, posttest scores, and the range that would be used to describe students' learning and meeting the standard.

Question Number 1

Question 1 asked students to select the correct definition of a force. The class average moved from close to proficient to proficient. The close to proficient pretest score indicates that students had prior knowledge about the meaning of a force, and they may have had prior experiences with forces. In fact, state standards indicate that the term force has been taught at a previous grade level. I observed students using their Chromebooks to research the definition of a force on Day 2 of the intervention, and students participated in class discussions and came to a consensus about the class definition that should be used for the term force on Day 3 of the intervention. While learning this content, students were able to create new knowledge in relation to their pre-existing knowledge, and the activities they completed allowed them to be social while building knowledge. The posttest score indicates that the activities students' completed throughout the intervention helped them to gain additional knowledge about what a force is. Table 4.2 below shows the concept that was addressed for Question Number 1, students' class average for the pretest and posttest, and the range that describes their learning and meeting the standard.

Table 4.2 Analysis of Question Number 1

Concept	Pretest Score and Knowledge Level	Posttest Score and Knowledge Level
Define a force.	88.9% Close to proficient	94.4% Proficient

Question Number 2

Question 2 asked students to select the correct definition of gravity as being a non-contact force. The class average showed no change in the knowledge range, remaining at the needs intervention level. Although the class average increased by 22.3%, students' posttest scores indicate they need additional intervention. Defining gravity as a non-contact force is an abstract concept that requires critical thinking. Much of my instruction was teacher-led before the PBL intervention. Although students completed many lab activities before the intervention, these activities did not require students to use critical thinking skills when learning about abstract concepts. Also, I talked about gravity being a non-contact force, but students did not complete any activities during the intervention that allowed them to interact with the content. Table 4.3 below shows the concepts that were addressed for Question Number 2, students' class average for the pretest and posttest, and the range that describes their learning and meeting the standard.

Table 4.3 Analysis of Question Number 2

Concept	Pretest Score and Knowledge Level	Posttest Score and Knowledge Level
Define gravity as being a non-contact force.	44.4% Needs intervention	66.7% Needs intervention

Question Number 3

Question 3 gave students a scenario of a student kicking a ball, and students were asked to select the correct answer choice as to why gravity pulls the ball down. The class average moved from needs intervention to close to proficient. These scores indicate that the scenario given in the question was relevant to my students' interests. They have experience with kicking balls, and most of them have observed the effects of this action. Once students understood the meaning of gravity, they could use this knowledge and apply it to a new situation.

The concept of how gravity can change the motion of an object was also reviewed and reinforced throughout the intervention. During Day 2 and Day 3 of the intervention, this concept was introduced when students had to define key terms and explain the terms using words they are familiar with. They were allowed to use their Chromebooks, and I observed students being engaged while they were having discussions and completing these activities. During Day 11 of the intervention, students watched a video about gravity, and they were able to record how gravity impacts the motion of objects while observing other students outside during recess. Being able to make observations of other students seemed to interest students, and the activities utilized during the intervention were relevant them. Table 4.4 below shows the concepts that were addressed for Question Number 3, students' class average for the pretest and posttest, and the range that describes their learning and meeting the standard.

Table 4.4 Analysis of Question Number 3

Concept	Pretest Score and Knowledge Level	Posttest Score and Knowledge Level
Explain how gravity can change the motion of an object.	27.8% Needs intervention	83.3% Close to proficient

Question Number 4

Question 4 asked students to select the correct factors that influence friction. The class average moved from needs intervention to close to proficient. Students' class average on the posttest increased by 55.5%, and this indicates that the activities used during the intervention aided them in learning the content. Students had to define friction and create a class definition of friction during Day 2 and Day 3 of the intervention. They watched a video about friction and then they had the opportunity to observe how friction impacts the motion of objects while observing other students outside during recess on Day 11 of the intervention. Additionally, students developed mini-experiments to test how different forces impact the motion of the balls during Day 12 of the intervention.

These activities allowed students to be interactive, and the experiences provided by the intervention facilitated their learning. Table 4.5 below shows the concepts that were addressed for Question Number 4, students' class average for the pretest and posttest, and the range that describes their learning and meeting the standard.

Table 4.5 Analysis of Question Number 4

Concept	Pretest Score and Knowledge Level	Posttest Score and Knowledge Level
Identify the factors that friction depends on.	27.8% Needs intervention	83.3% Close to proficient

Question Number 5

Question 5 gave students a scenario of a person losing control of a car due to rain, and students had to select the correct choice of what would need to occur in order for the person to gain control of the car. Although the class average increased by 44.4%, students remained in the needs intervention range. The posttest score indicates that this question might not have been relevant to students. My students are not old enough to legally drive. They do not have driving experiences, and none of the activities completed during the intervention addressed friction or the wheels of a car coming into contact with a different surface. Table 4.6 below shows the concepts that were addressed for Question Number 5, students' class average for the pretest and posttest, and the range that describes their learning and meeting the standard.

Table 4.6 Analysis of Question Number 5

Concept	Pretest Score and Knowledge Level	Posttest Score and Knowledge Level
Explain possible outcomes for increasing or decreasing friction.	16.7% Needs intervention	61.1% Needs intervention

Question Number 6

Question 6 gave students a description of one of the Laws of Motion, and it asked students to select the answer that correctly identified the Law. The class average moved from needs intervention to progressing. This indicates that students gained knowledge by completing the activities implemented during the intervention. Students watched videos about Newton's Laws of Motion on Day 8 – Day 10 of the intervention, and they had to research additional information about Newton's Laws and relate it to the problems they were trying to develop solutions for. Once students searched for relevant information, they had to paraphrase the content and create their own meaning by making connections to their problems. I observed some students copying and pasting large amounts of information. When I asked students what did some of the words in their research mean, they did not know. Therefore, researching information about Newton's Laws was an activity that challenged students.

Although the class average increased by 50%, Question 6 may have been difficult for students because of the way the question was structured. Newton's First Law, Newton's Second Law, and Newton's Third Law were all options for the answer, and this required students to have some knowledge about each Law. Students were exposed to all of Newton's Laws; however, based on their pretest average (27.8%), they did not have a lot of prior knowledge about this concept. Also, they struggled with researching the concepts and relating them to their problems. They were not used to conceptual thinking because they were used to me giving them all of the information. Table 4.7 below shows the concepts that were addressed for Question Number 6, students' class average for the pretest and posttest, and the range that describes their knowledge towards learning and meeting the standard.

Table 4.7 Analysis of Question Number 6

Concept	Pretest Score and Knowledge Level	Posttest Score and Knowledge Level
Distinguish between Newton's Laws.	27.8% Needs intervention	77.8% Progressing

Question Number 7

Question 7 asked students to review data in a table about balls of different masses being kicked with the same force, and then students had to select the correct answer choice for which ball would travel the greatest distance. The class average moved from needs intervention to close to proficient. Student were able to observe this concept during Day 11 and Day 12 of the intervention. On these days, my students observed other students playing with balls during recess, and they created their own mini-experiments to explore this concept. Students' average increased by 44.4% which indicates the activities used during the intervention provided experiences that facilitated knowledge construction, and students could apply the information to a new situation. Table 4.8 below shows the concepts that were addressed for Question Number 7, students' class average for the pretest and posttest, and the range that describes their knowledge towards learning and meeting the standard.

Table 4.8 Analysis of Question Number 7

Concept	Pretest Score and Knowledge Level	Posttest Score and Knowledge Level
Analyze data to show how mass impacts the distance an object travels.	38.9% Needs intervention	83.3% Close to proficient

Question Number 8

Question 8 asked students to select the correct answer for an example that illustrated Newton's Third Law of Motion. Although students' average increased by 55.5%, they remained at the needs intervention level. During Day 8 – Day 10 of the intervention, students viewed videos about each of Newton's Laws, and I observed students working collaboratively in groups researching additional information about Newton's Laws. The increase in the posttest score indicates that these activities did foster students' learning. However, throughout the intervention, I did not observe students discuss Newton's Laws in their groups while trying to solve their problems. Additionally, I observed students being distracted with videos and websites not related to forces and motion content. I tried to redirect them to focus on content relevant sites, but I should have provided more guidance with their Internet searches. Table 4.9 below shows the concepts that were addressed for Question Number 8, students' class average for the pretest and posttest, and the range that describes their learning and meeting the standard.

Table 4.9 Analysis of Question Number 8

Concept	Pretest Score and Knowledge Level	Posttest Score and Knowledge Level
Identify examples of Newton's Third Law of Motion.	5.6% Needs intervention	61.1% Needs intervention

Question Number 9

Question 9 gave students a tug-of-war example to analyze, and students had to select the statement that correctly identified the net force. The class moved from needs intervention to close to proficient. The concepts for Question 9 were introduced during Day 2 and Day 3 of the intervention. On those days, students researched terms using their Chromebooks. They collaborated and had discussions that allowed them to create their own definitions using familiar words. Even though the class average score increased by 33.3%, tug-of-war was not discussed during the intervention. Unlike the driving scenario in Question 5, students were familiar with tug-of-war. This indicates that students were able to apply the knowledge they had created to a situation they might have been familiar with. Table 4.10 below shows the concepts that were addressed for Question Number 9, students' class average for the pretest and posttest, and the range that describes their learning and meeting the standard.

Table 4.10 Analysis of Question Number 9

Concept	Pretest Score and Knowledge Level	Posttest Score and Knowledge Level
Calculate net force, and determine if forces are balanced or unbalanced.	55.6% Needs intervention	88.9% Close to proficient

Question Number 10

Question 10 asked students to select the correct choice that explains why footballs and soccer balls are played with outside, but not bowling balls, as it relates to inertia. The class average moved from needs intervention to close to proficient. Based on the state's standards, inertia is a new concept for students. However, this question was made relevant to students by discussing football and soccer throughout the intervention, and some students developed mini-experiments that used footballs and soccer balls during Day 12 of the intervention. The mini-experiments allowed the learning to be interactive. The class average increased by 44.5%, which indicates that the discussions students were allowed to have and the mini-experiments students created increased their interest and engagement with this topic. Table 4.11 below shows the concepts that were addressed for Question Number 10, students' class average for the pretest and posttest, and the range that describes their learning and meeting the standard.

Table 4.11 Analysis of Question Number 10

Concept	Pretest Score and Knowledge Level	Posttest Score and Knowledge Level
Explain the relationship between mass and inertia.	44.4% Needs intervention	88.9% Close to proficient

Students performed better on the questions that incorporated strong PBL strategies. Students' knowledge levels were Proficient or Close to Proficient when they had prior knowledge about the concepts, when they were able to discuss things that were relevant to them, when the activities were student-centered, and when they learned through discovery. Students' knowledge level was Proficient on the posttest for Question

1. The pretest score for this question (88.9%) shows that students had previous experiences with forces. Students' knowledge level was Close to Proficient for Question 3, Question 4, Question 7, Question 9, and Question 10 on the posttest. The activities related to these questions required students to observe and record observations of other students, create mini-experiments to test how forces impact the motion of balls, and students were able to discuss things they enjoyed like football and soccer, and relate it to the content. These activities were student-centered, and they provided opportunities for students to collaborate. The activities for these questions allowed students to be active learners.

Although students made gains on all questions, students did not perform as well when there was not a strong PBL influence seen in the intervention. Students' knowledge levels were Progressing or Needs Intervention when they had no prior knowledge about the concepts covered in the unit or no prior experience with skills like researching information on the Internet. Students' knowledge level was Progressing or Needs Intervention for Question 2, Question 5, Question 6, and Question 8. The activities related to these questions required students to passively listen to me talk about non-contact forces, watch videos, and research information on the Internet without me providing them with experiences to do this effectively. Moreover, the pretest scores showed that students had little prior knowledge and experiences with these concepts, which made it harder for students to improve their performance.

In summary, this quantitative portion of the investigation shows that students' mastery of the content increased from the pretest to the posttest. This increase was seen for all questions on the assessment; however, the knowledge gains on describing gravity as a non-contact force, outcomes for increasing or decreasing friction, and identifying examples of Newton’s Third Law of Motion indicates additional interventions are needed for those specific concepts. However, the question-by-question analysis shows that PBL improved students’ performance more when they completed activities that allowed them to construct meaning for themselves. Students’ performance was much better as compared to previous years. For example, several of my students received a perfect score on the posttest where I did not observe this in previous years.

Student Engagement Survey Questions

The student engagement survey measured students’ cognitive engagement, emotional engagement, and behavioral engagement. The survey consisted of 12 questions, and it was administered towards the beginning of the intervention (Day 7), the middle of the intervention (Day 12), and towards the end of the intervention (Day 17). I have 18 students that completed the survey towards the beginning of the intervention. One student was suspended when the survey was administered during the middle of the intervention. Therefore, 17 students completed the survey during the middle of the intervention. All 18 students completed the survey towards the end of the intervention. Students worked in pairs at the beginning of the intervention, and groups of three to four students were formed during the middle of the intervention (Day 8). Two groups consisted of three students, and three groups consisted of four students. The percentages displayed in the pie charts were rounded, therefore one student is equivalent to approximately 6%.

Cognitive Engagement

Cognitive engagement indicates the extent of students' thinking and the effort they put forth. Questions one through four on the student engagement survey measured students' cognitive engagement.

I feel like I am working hard while completing the activities for this unit.

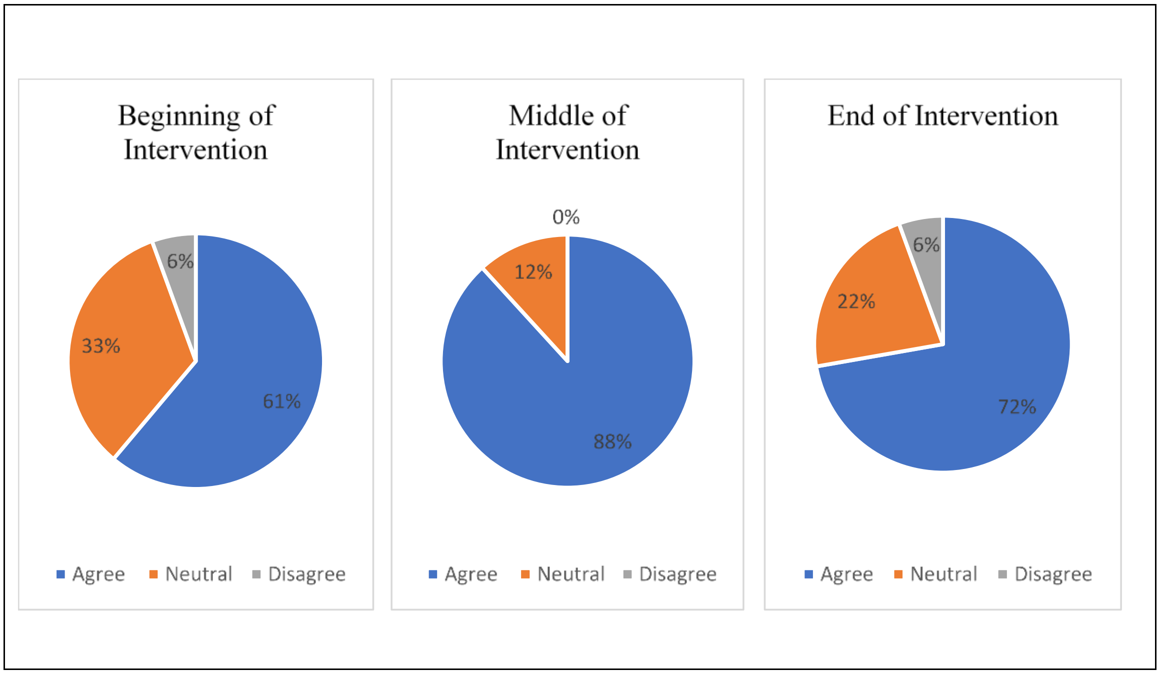

Figure 4.2 Comparison of Students' Responses for Question 1

As shown in Figure 4.2 above, the majority of students agreed that they felt like they were working hard while completing the activities for this unit. However, during the middle of the intervention, more students agreed that they were working hard. This increase in agreement could indicate that the activities during the middle of the intervention required students to use critical thinking skills at a higher level than at the beginning of the intervention. Students had to think in order to create the mini-experiments, and they may have perceived they were working harder because the cognitive load was higher. The percentage of students that agreed they were working hard while completing the activities for this unit decreased slightly toward the end of the intervention. This could be due to them mastering the information during the PBL activity. So, creating and presenting the information may have seemed easier to them because they had developed the learning themselves.

I made an attempt to complete all of the activities for this unit.

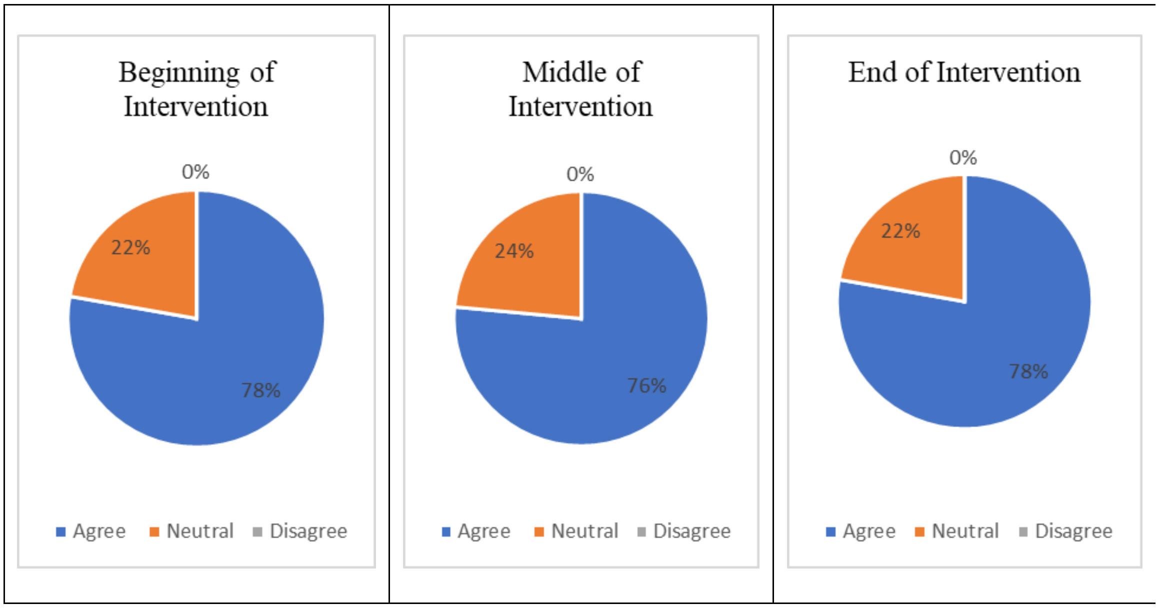

Figure 4.3 Comparison of Students' Responses for Question 2

As shown in Figure 4.3 above, most students agreed that they made an attempt to complete all of the activities for this unit. The percentages were consistent throughout the intervention, and this indicates that students wanted to give the activities a try. Most students may have attempted to complete all of the activities because the content addressed real-world problems that were relevant to them, and the activities were student-centered. However, this is generally the pattern seen with my students. My students usually try to attempt their activities although I need to remind them to stay on task and keep trying.

While completing the activities for this unit, I try to understand content more by relating it to things I already know.

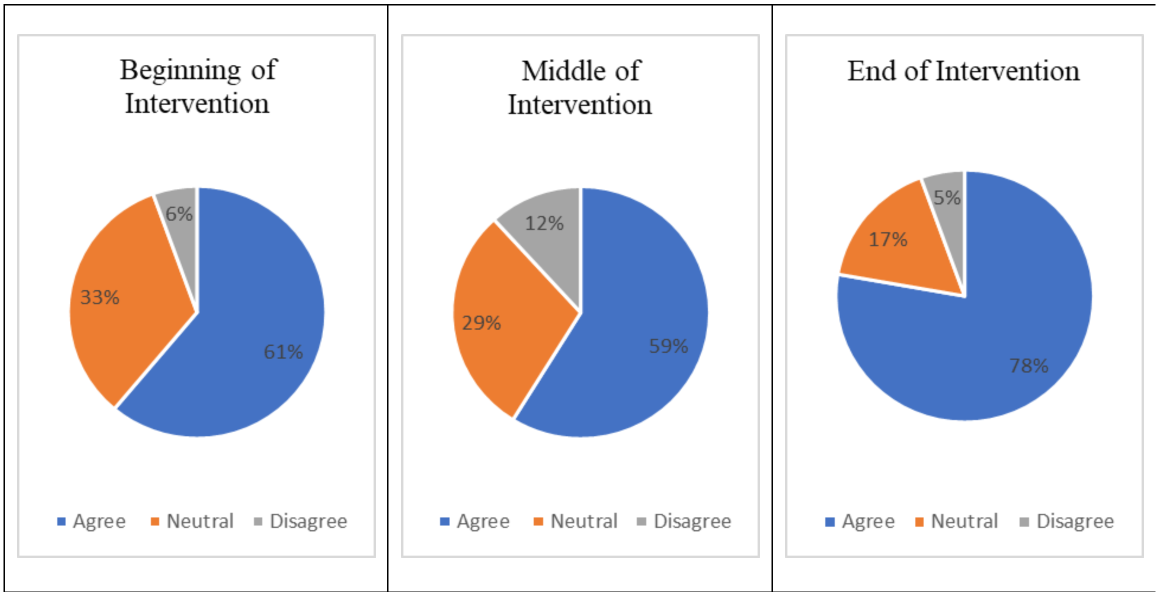

Figure 4.4 Comparison of Students' Responses for Question 3

Figure 4.4 above shows that most students agreed that they try to understand content more by relating it to things they already know. The problems addressed during this intervention (balls rolling into the street and injuries at recess) were relevant to all of these students because they go outside for recess every day, and they observe these issues occurring. During the middle of the intervention, students had to communicate how forces impact the motion of objects by observing other students during recess. They also created their own mini-experiments. This self-guided learning was engaging because it allowed students to use their prior knowledge and personal experiences to create new knowledge. Initially, some students may not have been sure about how to make connections with knowledge they already had (33%). However, at the end of the intervention, the percentage (78%) indicates that more students were able to make those connections.

While completing the activities for this unit, I make an effort to think about how the information is useful in the real world.

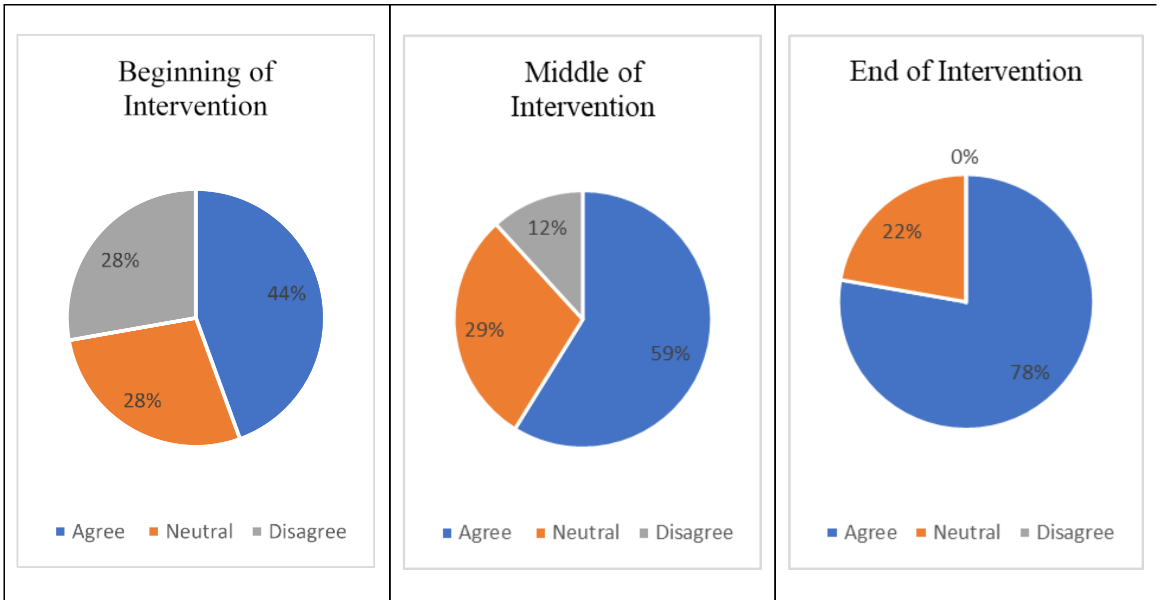

Figure 4.5 Comparison of Students' Responses for Question 4

As shown in Figure 4.5, the percentage of students that agreed that they make an effort to think about how the information is useful in the real world increased throughout the intervention. The percentage of students that disagreed with this statement completely diminished. This indicates that the activities used in this intervention were relevant to students, and the activities helped them apply their learning to real-world situations.

Cognitive engagement increases as students depend less on the teacher and are in control of their own learning (Rotgans & Schmidt, 2011). The student survey questions that measured cognitive engagement show that students put forth time and effort while attempting to learn. Most students felt like they were working hard, and they attempted to complete all of the assignments. PBL provides students with the proper motivation and allows them to become engaged active learners (Liu et al., 2019; Muniz, 2019). The PBL intervention had a positive impact on students' cognitive engagement because it allowed them to offer real-world solutions to problems that were relevant to them.

Emotional Engagement

Emotional engagement describes how students feel about their learning. Questions five through eight on the student engagement survey measured students' emotional engagement.

I think what we are learning about is interesting.

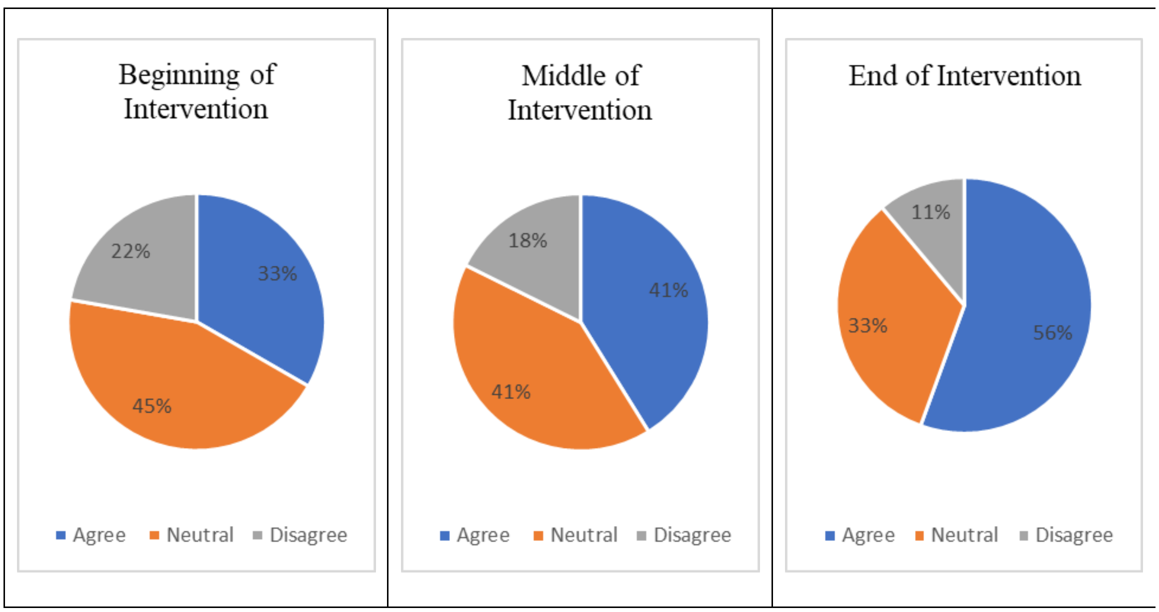

Figure 4.6 Comparison of Students' Responses for Question 5

Figure 4.6 above shows that the content became interesting to more students as the intervention progressed. Learning is a social process, and I believe that students being able to work in groups and collaborate made the learning more interesting. Also, students used exploration and discovery to construct new meaning during the middle of the intervention. The activities required students to communicate and have discussions, and being able to talk for extended periods of time was different for my students. The percentage of students that responded neutral decreased throughout the intervention, but this indicates that some students still are not sure about how they feel about what they are learning. From my observations when I taught this unit previously, I see students being more interested than in past years.

I think what we are learning about is boring.

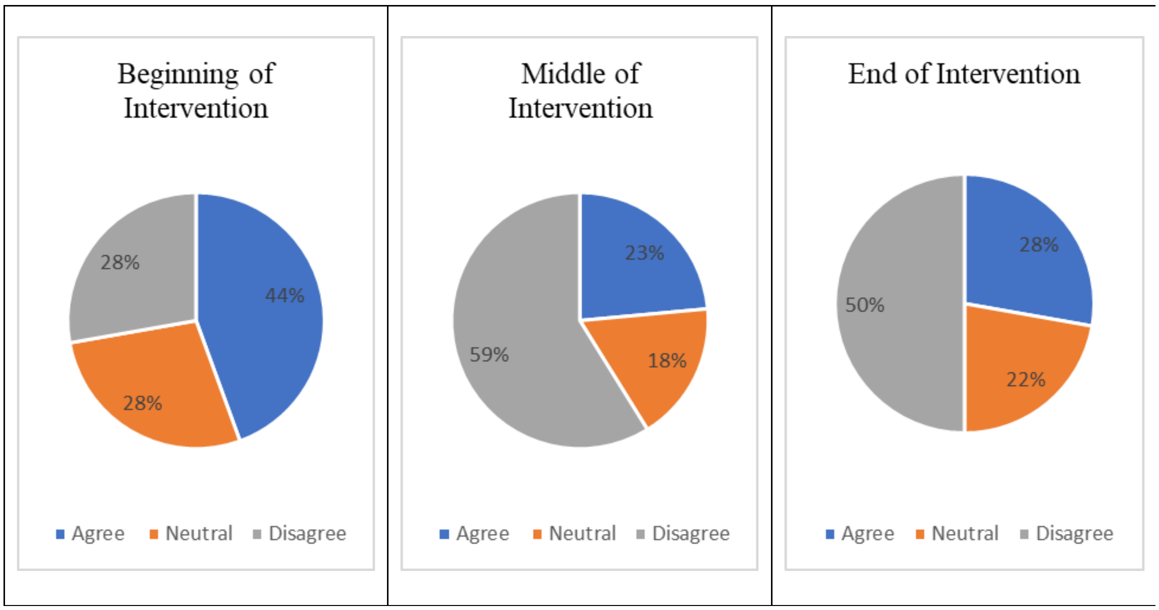

Figure 4.7 Comparison of Students' Responses for Question 6

This question asked the opposite of Question 5, and students' responses are aligned with Question 5. Their response indicate how they truly feel. Figure 4.7 shows that half of my students (50%) do not believe that what they are learning about is boring. This indicates that the type of activities being conducted in this intervention are engaging for students.

I feel happy working with my group when trying to solve problems.

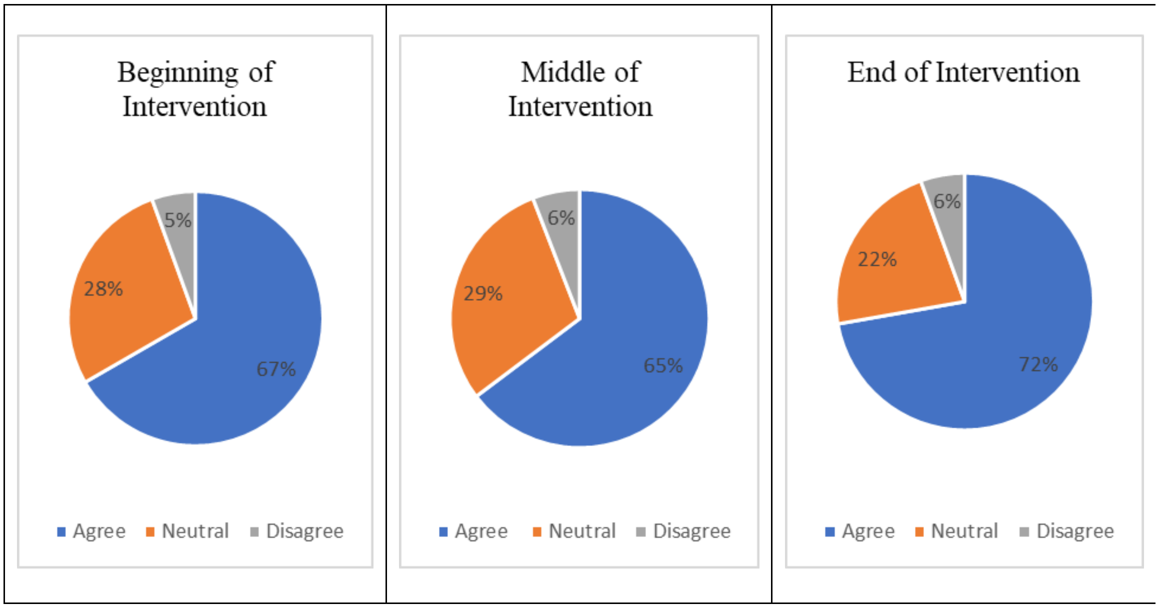

Figure 4.8 Comparison of Students' Responses for Question 7

As shown in Figure 4.8 above, the majority of students agreed that they feel happy working with their group when trying to solve problems, and the percentage of students agreeing with this statement increased throughout the intervention. This indicates that students enjoyed the social aspects of working in a group, and they were able to utilize life skills. Middle school students love talking, and PBL allowed students to practice their oral communication skills. Working in groups also allowed students to have designated roles and responsibilities. I observed serval students being excited about their roles as facilitator, recorded, timekeeper, or spokesperson. Students had to hold one another accountable, and their responses for this question indicate they enjoyed doing this. Also, students did not have to solve a problem on their own. Being able to collaborate created a positive classroom environment, and this encouraged students to be active participants.

I feel sad working with my group when trying to solve problems.

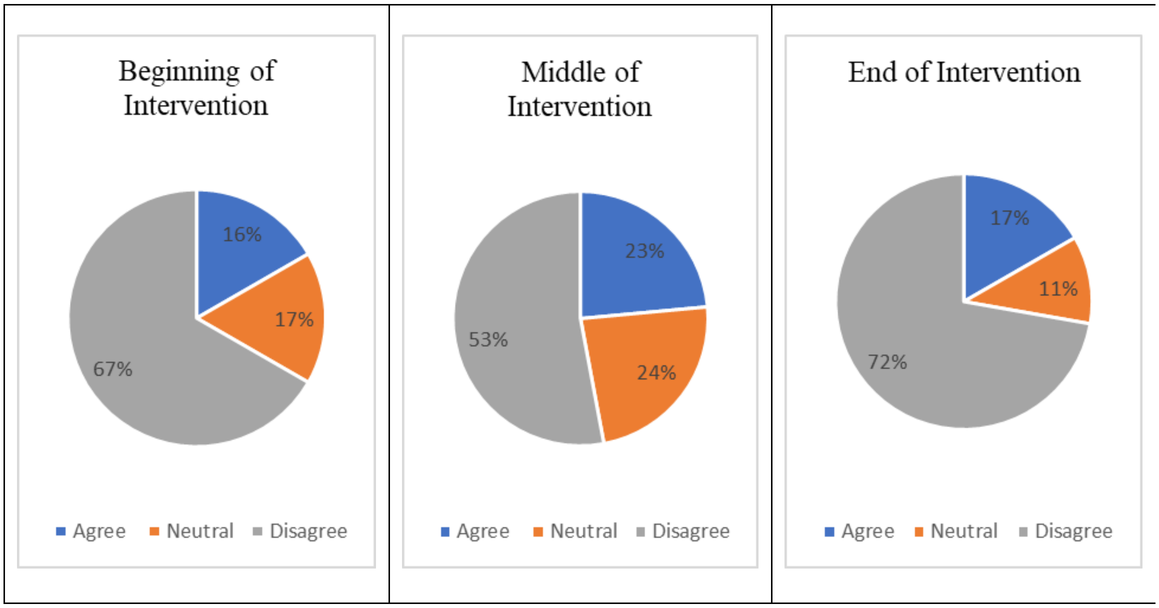

Figure 4.9 Comparison of Students' Responses for Question 8

As shown in Figure 4.9 above, at the beginning of the intervention, the majority of students disagreed (67%) with feeling sad while working with their group when trying to solve problems. This percentage decreased during the middle of the intervention, and the percentage of students who agree increased. Students were in pairs at the beginning of the intervention, and groups of three to four students were formed during the middle of the intervention. The slight increase in students feeling sad could be due to the changing group dynamics. Students had to find their place and perform designated roles in their new groups. At the end of the intervention, more students disagreed (72%) with feeling sad while working with their group. By this time, students had observed other students during recess, and they had conducted mini-experiments they created. I observed students being very social, and they appeared to be enjoying the activities. The data show that most students were not sad while working with their groups, and this aligns with students' responses in Question 7 stating they feel happy working with groups while trying to solve problems.

PBL produces engagement when students have to generate ideas about a problem, use real-world problems in the classroom, and when students are responsible for their own learning (Rotgans & Schmidt, 2011). The student survey questions that measured emotional engagement show that the majority of students had a positive response to learning. Most students found the learning to be interesting, and most students were also happy while working with a group while trying to solve problems. The PBL intervention had a positive impact on my students' emotional engagement because it was student-centered and gave students ongoing opportunities to collaborate, socialize, and discover new meaning on their own.

Behavioral Engagement

For this research study, behavioral engagement describes students' conduct while learning. Questions nine through 12 on the student engagement survey measured students' behavioral engagement.

I feel like I have a chance to interact with my group members.

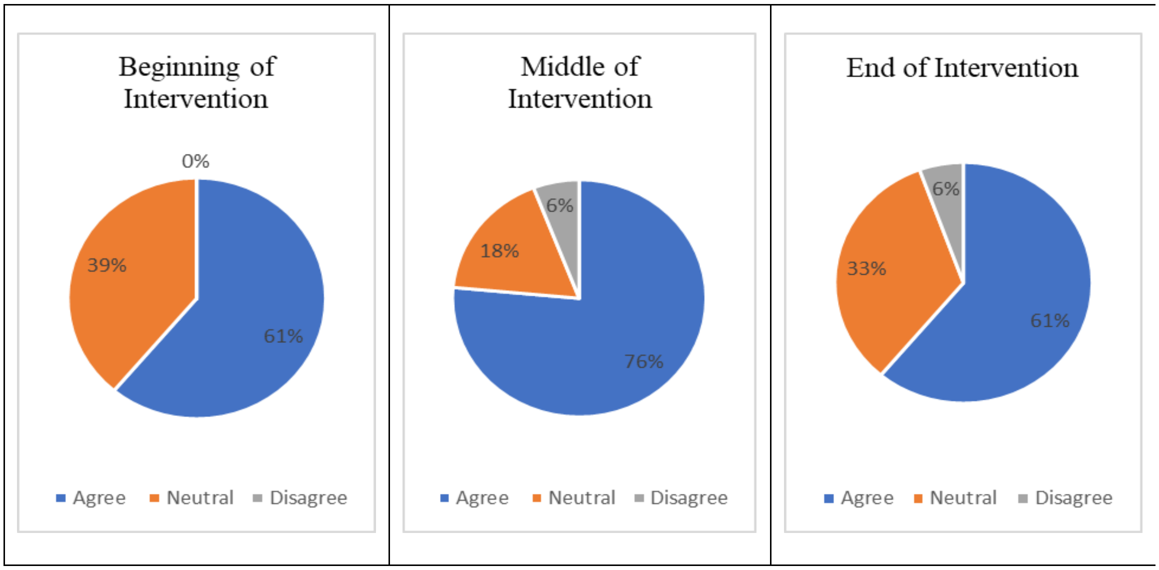

Figure 4.10 Comparison of Students' Responses for Question 9

As shown in Figure 4.10 above, most students agreed that they had a chance to interact with their group members. This percentage increased during the middle of the intervention. This could indicate that students had more opportunities to talk and have discussions during this part of the intervention. Students were able to go outside for two days during this time period, and this gave students opportunities to have discussions and conduct experiments they created. I observed students being social and building relationships because they had to work cooperatively to problem-solve. However, the number of students that agreed with this question decreased (61%) at the end of the intervention. The activities at the end of the intervention required students to generate solutions to problems, come to a group consensus, create a presentation, and present their findings to the class. I observed some groups being quiet when they were supposed to generate solutions. They may have been listening to other groups' discussions because several groups identified the same solutions. Also, I observed that some groups had less discussions while creating the presentation because they were typing slides and searching for graphics on the computer.

I enjoy talking with my group members.

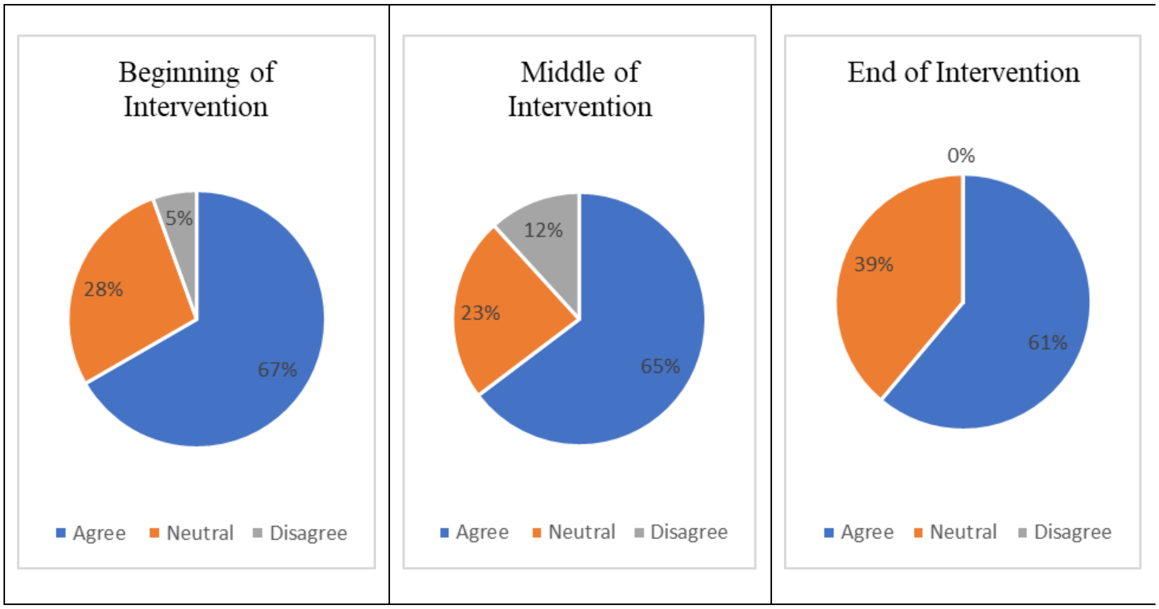

Figure 4.11 Comparison of Students’ Responses for Question 10

Figure 4.11 above shows that most students enjoyed talking with their group members throughout the intervention. Students mostly worked in pairs during the beginning of the intervention. After the problem was introduced, students had to share information they knew about the problem and any thoughts they had. They also had to complete concept maps with partners about causes, indicators, possible solutions, and consequences for each problem. I observed students having discussions during this time. Group members had assigned roles during the middle of the intervention. I had to frequently redirect some groups, but students carried on meaningful conversations. I observed several students discuss recent injuries that had occurred during recess and the causes of those injuries. I also observed students having ongoing conversations about the recess area that is designated for them and why the area can be problematic. At the end of the intervention, students continued to work in groups as they developed solutions and created their presentations. The percentage of students that enjoyed talking with group members decreased slightly, and this may be due to students spending more time creating their presentations. However, most of my students seemed to enjoy completing these activities with their group members. As Figure 4.11 shows, the percentage of students that disagreed with this question reached 0% by the end of the intervention.

My mind wanders while working with my group.

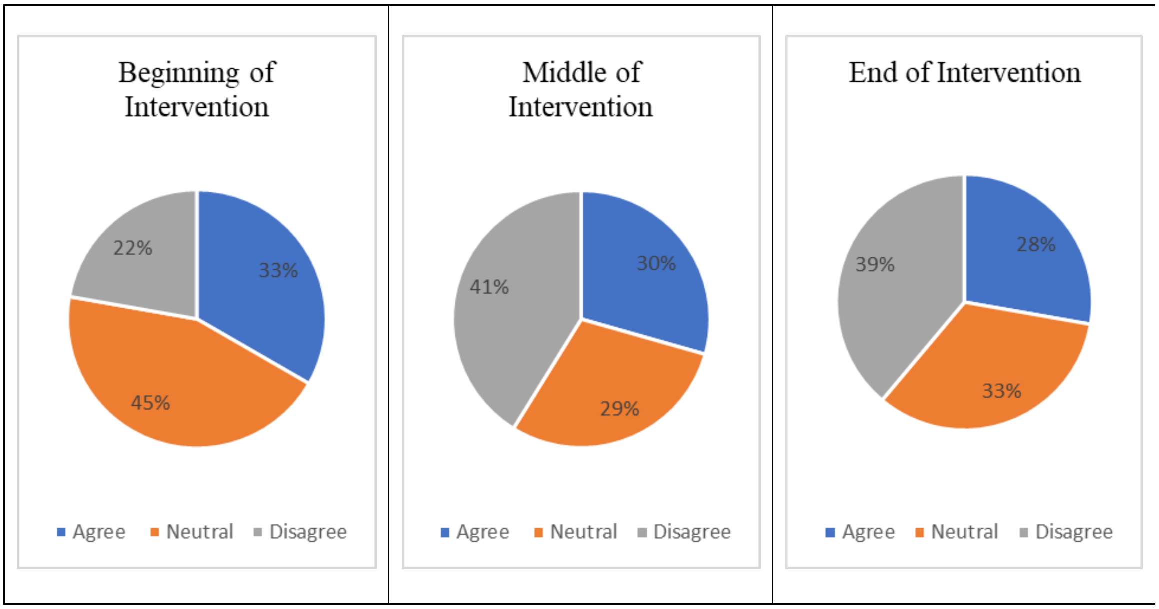

Figure 4.12 Comparison of Students' Responses for Question 11

Although mind wandering could indicate cognitive engagement, for this question I am focusing on the observable behaviors that result from students' minds wandering. Figure 4.12 shows that some students agreed that their mind wanders while working with their groups. This decreased slightly by the end of the intervention. Throughout the intervention, students were working together in pairs or groups. They had 56 minutes each day to complete their activities, and some students did not utilize the entire class period to complete their assignments. I observed some students leaving their groups to walk around the class, and I observed some of the discussions being off-task. There was a shift during the middle of the intervention with neutral responses transferring to the disagree category. Students may have enjoyed the activities during the middle of the intervention more because groups were formed during this time frame. Specific roles were assigned, and more students may have felt like their minds were not wandering because there was a group facilitator that was responsible for redirecting the group. I heard students redirecting their groups frequently.

I am an active participant in my group.

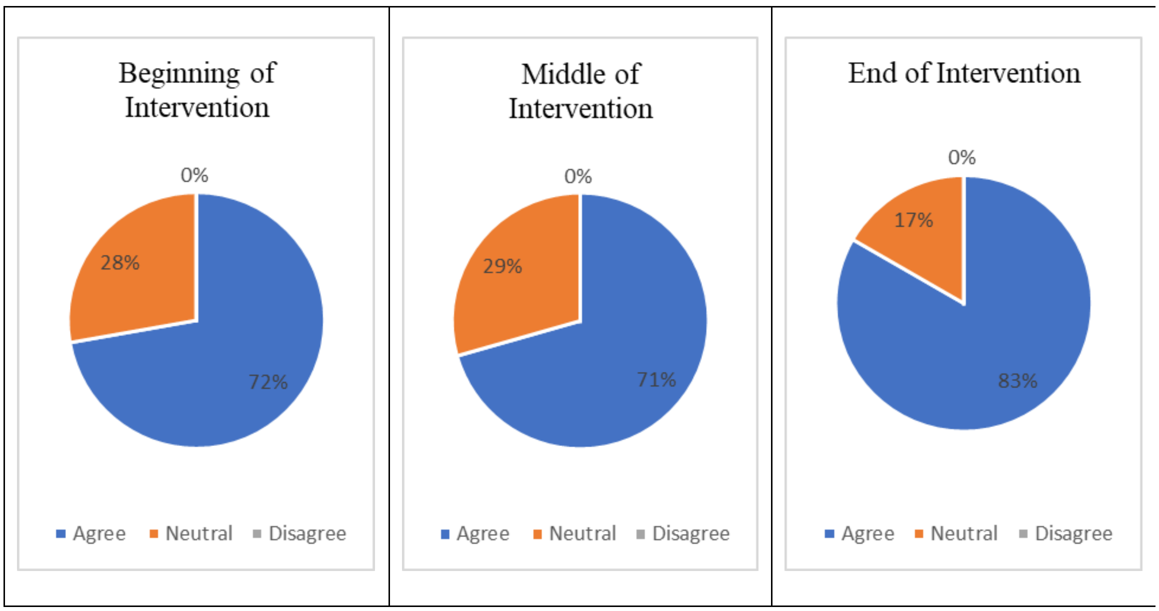

Figure 4.13 Comparison of Students' Responses for Question 12

Figure 4.13 shows that most students agreed that they were active participants in their group. Throughout the intervention, students were having discussions, researching information, conducting observations, and creating experiments and presentations. Students were collaborating with their groups, and each student also had a specific role in their group. The learning was student-centered, and students were taking control of their own learning. Several students gave neutral responses for this question, but the neutral responses started to decrease by the end of the intervention. Students had to generate strategies to solve their chosen problem at the end of the intervention and create a presentation to share their findings. These activities required higher-order thinking skills because students had to list several strategies along with the pros, cons, and consequences of each strategy. Students were relying on each other to accomplish this task. I observed students completing handouts to help them organize their ideas, and I observed students working together to create their presentations. They were being active learners.

As stated by Fredricks et al. (2004), behavioral engagement is the observable conduct of students in response to learning, and these behaviors can be positive or negative. The student survey questions that measured behavioral engagement show that most students showed positive behavior as it relates to conduct and being on-task. Most students felt they had a chance to interact with their group, and most students enjoyed talking with their group. Even though some students' stated their minds wandered while working with their group, the percentage for this response decreased slightly by the end of the intervention. PBL had a positive impact on students' behavioral engagement because most students were active participants, and took control of their own learning.

In summary, the results from the student engagement survey questions indicate several findings. First, the cognitive engagement questions show that most students put forth time and effort attempting to learn. Students felt they worked hard during the intervention, and they attempted to complete all of the activities. Second, the emotional engagement questions show that most students displayed positive emotions in response to learning. Most students found the learning to be interesting. The results suggest that the content was interesting because students were able to collaborate in groups, and this gave students time to be social. Finally, the behavioral engagement questions show that most students exhibited positive behaviors in response to their learning. Most of my students felt like they had a chance to interact with their group members. Students enjoyed talking with their group members, and most students were active participants.

Students' Presentations

Students were asked to create presentations about the ill-structured problems they wanted to offer solutions to. The presentations required students to demonstrate four major skills used with PBL including: ability to identify the problem, gathering of relevant content information, solutions offered, and collaboration. Other skills addressed by the presentation included: organization, language, and appearance. Students could receive a score of three, two, or one for each skill, with three being the highest score and one being the lowest score. The findings from my students' presentations are presented below.

Identification of the Problem

Students were asked to clearly identify their problem, and they were assessed on whether the problem was clearly identified, somewhat identified, or not identified. The problems for this unit were introduced by the assistant principal; however, it was important for students to be able to state the problem because sometimes instructional goals are not clear to students. Having students identify the problems also served to keep them focused on the goal of the presentation. Figure 4.14 below shows the score that was given to each group when identifying the problem.

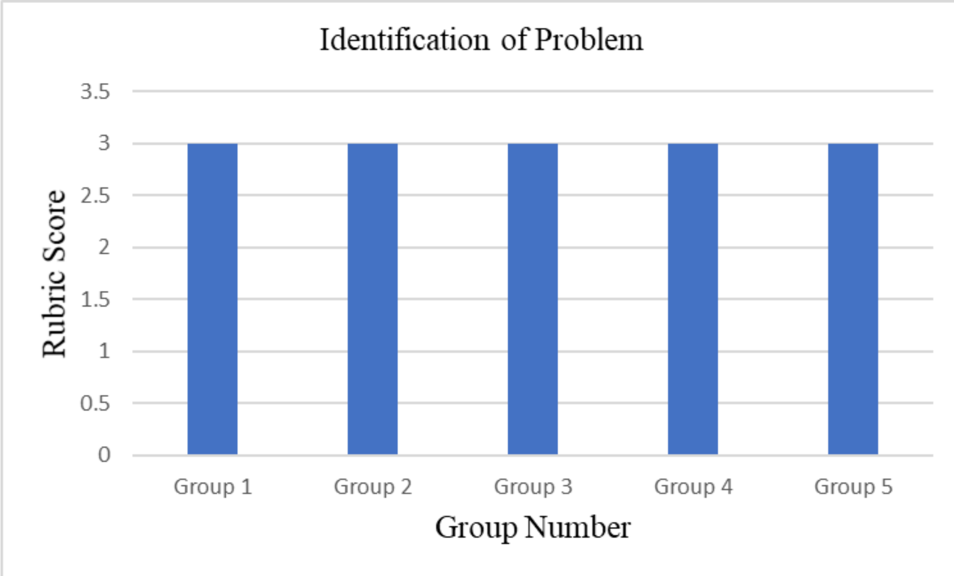

Figure 4.14 Students' Identification of Problem Scores

- Group 1 clearly identified the problem of balls rolling into the street during recess. They also provided extra details as to why this is a problem, and they gave an example of what could happen as a result of balls rolling into the street.
- Group 2 clearly identified the problem of injuries occurring during recess, and they listed examples of types of injuries that occur during recess.
- Group 3 clearly identified the problem of balls rolling into the street during recess.
- Group 4 clearly identified the problem of balls rolling into the street during recess.
- Group 5 clearly identified the problem of balls rolling into the street during recess.

All of the groups scored a three, meaning they clearly identified the problem. Being able to identify a problem is a problem-solving skill, and this activity promoted the use of this skill.

Gathering of Relevant Content Information

Students were asked to gather relevant content information. The information they gathered should have covered their topics in-depth, and their information should have been accurate and relevant to their problems. It was important for students to be able to gather relevant content information because it made them responsible for their own learning, and encouraged them to become active learners. Being able to gather relevant content information also served the purpose of helping students understand how new information aids in understanding the problem. Figure 4.15 below shows the score that was given to each group when identifying the problem.

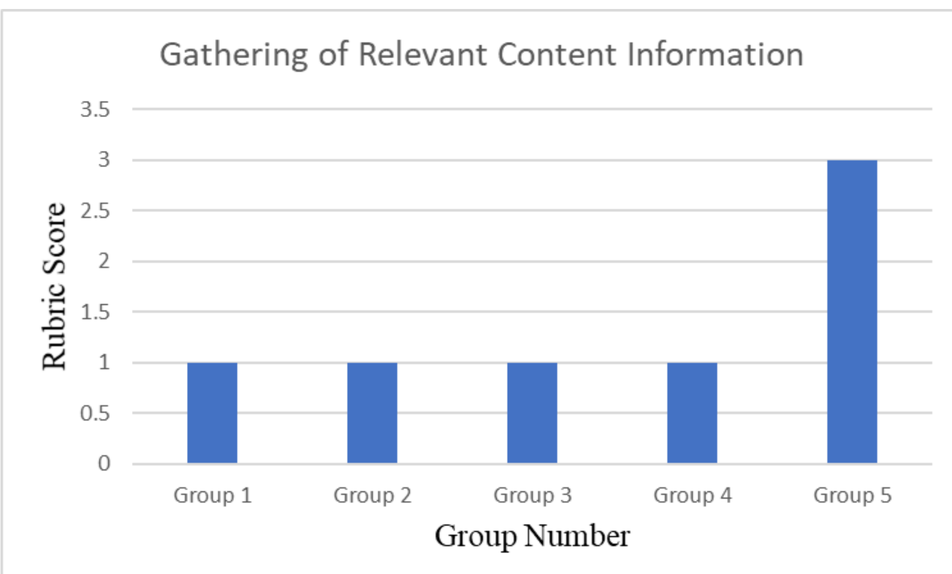

Figure 4.15 Students' Gathering of Relevant Content Information Scores

- Group 1 created one slide for relevant content information. The term speed was mentioned for relevant content, but the topic was not covered in depth.

- Group 2 created one slide for relevant content information. The terms push, unbalanced force, and friction were mentioned, but the topic was not covered in depth.
- Group 3 created one slide for relevant content information. The term force was mentioned, but the topic was not covered in depth. Also, the content this group discussed was not relevant to their problem.
- Group 4 created one slide for relevant content information. The term force was mentioned, but the topic was not covered in depth.
- Group 5 created two slides for relevant content information. The terms gravity, friction, and Newton's Third Law were mentioned, and the topic covered content in depth. Their information was accurate and relevant.

The score of one for Groups 1, 2, 3, and 4 indicates that students in these groups may have struggled with finding relevant content information, and they may have needed additional coaching and guidance. Group 5 received a score of three. This indicates that students in this group were able to find relevant information that addressed their topic, which is an essential PBL skill.

Solutions

Students were asked to provide solutions to their problems and to list the pros, cons, and consequences of their solutions. They were assessed on whether the pros, cons, and consequences were identified and addressed appropriately, which was important because it gave students a chance to analyze different alternatives to address their problem, and a chance to utilize their critical thinking skills. Figure 4.16 below shows the score that was given to each group for identifying solutions and addressing pros, cons, and consequences of the solutions.

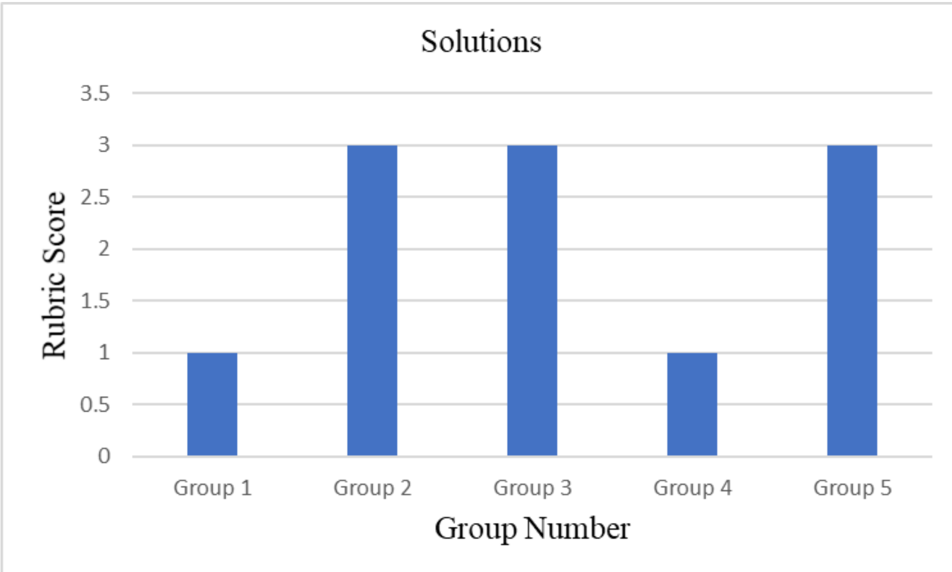

Figure 4.16 Students' Offering of Solutions Scores

- Group 1 discussed a pro to a solution without clearly identifying a solution. As a con to a solution, members of this group actually offered a solution to the problem. They also labeled a slide Consequences, but this slide offered two additional solutions. Students in Group 1 offered solutions to the problem, but they were confused by having to identify pros and cons for each solution. Even though I discussed the differences between solutions, pros, cons, and consequences, these concepts seemed to be challenging to students.
- Group 2 identified one solution, and they discussed two pros, two cons, and two consequences for this solution. The data indicate that students in Group 2 struggled to offer multiple solutions, and they may have needed additional support and coaching. However, because students in Group 2 were able to discuss

multiple pros, cons, and consequences for their identified solution, they were able to demonstrate problem-solving skills.

- Group 3 identified two possible solutions to their problem, and they identified and addressed two pros and two cons for each solution. The data indicate that members of Group 3 were able to demonstrate problem-solving skills.
- Group 4 did not clearly identify a solution. Members of this group created a slide called Pros, but this slide mentioned a possible solution. Their thinking process was not clear because they used incomplete sentences. Group 4 also created a Cons slide; however, this slide actually listed new problems that could possibly occur outside during recess. Members of Group 4 struggled offering solutions, and they struggled to identify pros, cons, and consequences of a solution. The data indicates that members of Group 4 needed additional coaching and support.
- Group 5 clearly identified two solutions to their problem. They also addressed one pro, con, and consequence for each solution. The data indicates that members of Group 5 were able to utilize higher-order thinking skills and problem-solving skills for this activity.

Being able to identify a problem and address the pros, cons, and consequences of a solution to a problem requires higher-order thinking. My students generated solutions to their problems on Day 13 of the intervention, and they used tables to help them organize their ideas. These tables were provided to students while they were creating their presentations, but some groups did not seem to be able to make connections between the assignments because they did not transfer their information to their presentations. The data indicate that students were at varying levels for being able to clearly identify and problem and address pros, cons, and consequences for specific problems. Members of Group 1 and Group 4 struggled with identifying solutions, and they confused the idea of addressing pros, cons, and consequences for a designated solution, which indicates that these students need additional support and guidance for this stage of PBL. Members of Group 2, Group 3, and Group 5 were able to clearly identify solutions and address the pros, cons, and consequences for their solutions; therefore, these students were able to navigate the PBL process. Although one group (Group 4) mislabeled their solution, all groups were able to identify a solution. The presentation gave students an opportunity to utilize problem-solving skills, but additional practice with these skills would be beneficial for students.

Collaboration

Students were asked to work collaboratively on the presentations, and they were assessed on whether the majority of the work was completed by most group members. Students collaborated in groups to decide on the information needed to solve their problems, and the information needed for their presentation. Students are more engaged and active when they collaborate because, as middle schoolers, they enjoy being social. The collaboration score was based on my observations. I moved between the groups to observe students' actions while they were creating the presentations. One of the defining principles of PBL is collaboration (Barrows, 1996) which is why it was important for me to score this. Figure 4.17 below shows the score that was given to each group for collaboration.

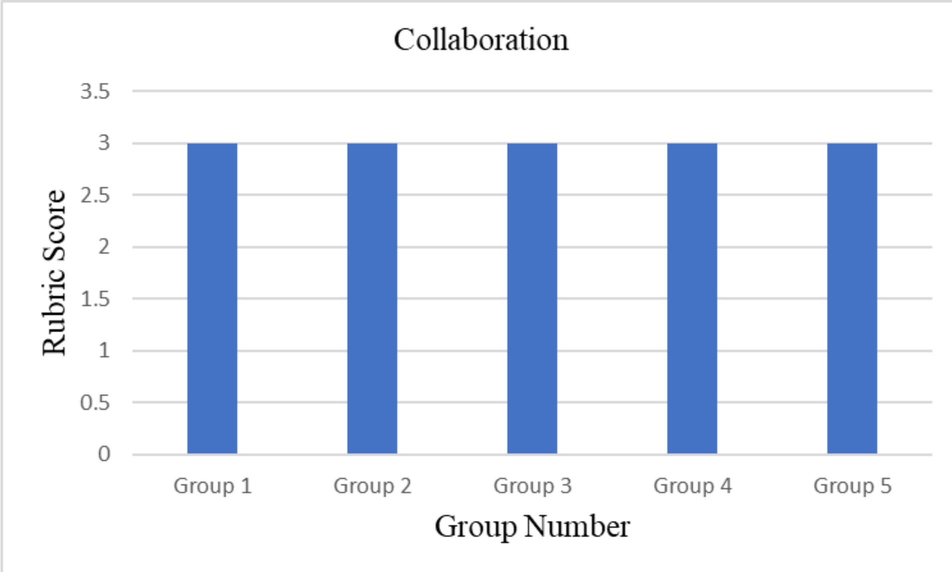

Figure 4.17 Students' Collaboration Scores

- Group 1 consisted of four students. The students shared information and listened to each other's ideas, and they all took part in completing the presentation.
- Group 2 consisted of three students. These students had active discussions about the assignment. One member of this group put his head down on the desk a few times. After redirecting the student with his head down, they all took part in completing the presentation.
- Group 3 consisted of four students. One member of this group asked if she could work alone; however, she cooperated after I reminded her that this was a group effort. The students shared and listened to each other's ideas, and they all took part in completing the presentation.
- Group 4 consisted of four students, but one student was absent on one of the days students worked on the presentation. I had to frequently refocus this group;

however, they had active discussions, they respected each other's thoughts and ideas, and the members present all took part in completing the presentation.

- Group 5 consisted of three students. The students shared and listened to each other's ideas, and they all took part in completing the presentation.

In summary, all of the groups scored a 3 on collaboration, meaning the majority of the work was completed by most group members. This PBL activity allowed students to work in groups and be social. This is important for students' learning because collaborative learning enhances higher-order thinking skills, communication skills, and knowledge acquisition. This instructional activity provided an opportunity for students to collaborate, and they were able to problem-solve together.

Other Skills Addressed by the Presentation

Organization, language, and appearance are not components of PBL; however, these criteria were important. Organization allowed students to present their content in a logical sequence that showed their thinking process better. Language was important because it reflected communication, spelling, and grammar skills. The appearance of the presentations gave students opportunities to be creative, and it also created a classroom environment that promoted discussions on text, fonts, images, and animation.

Organization

Figure 4.18 below shows the score that was given to each group for organization.

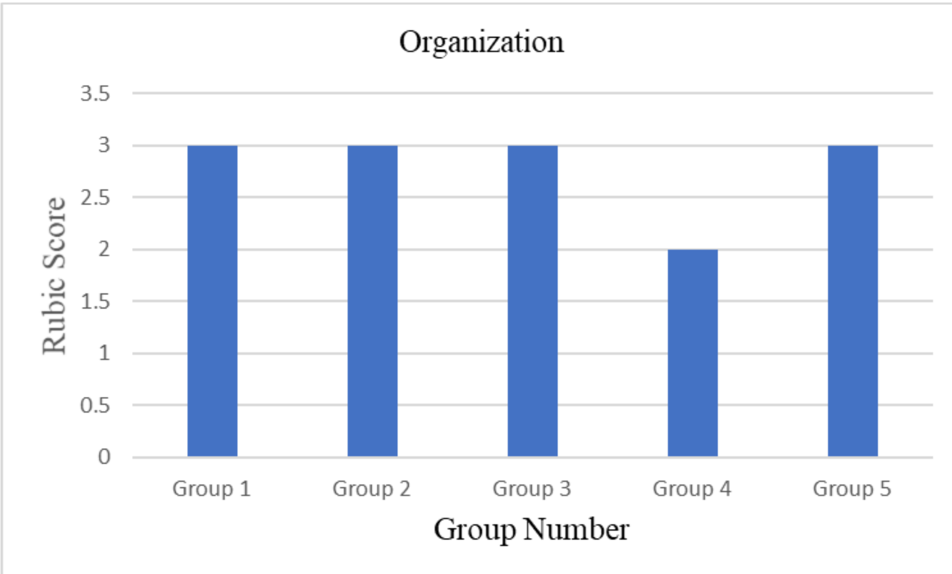

Figure 4.18 Students' Organization Scores

- Group 1 sequenced information in the presentation by first stating the problem, then they discussed relevant content, and they ended with discussing pros, cons, and consequences of the solutions.
- Group 2 sequenced information in the presentation by first stating the problem, then they discussed relevant content, and they ended with discussing pros, cons, and consequences of the solutions.
- Group 3 sequenced information in the presentation by first stating the problem, then they discussed relevant content, and they ended with discussing pros, cons, and consequences of the solutions.
- Group 4 sequenced information in the presentation by first discussing relevant content, they then introduced the problem, and they ended with discussing pros,

cons, and consequences of the solutions. However, their slide labeled Cons actually discussed additional problems.

- Group 5 sequenced information in the presentation by first stating the problem, then they discussed relevant content, and they ended with discussing pros, cons, and consequences of the solutions.

Four out of the five groups received a score of three for organization, which indicates that most students were able to organize their thinking process clearly and logically. Overall, students' presentations were organized, and this gave me insight on how students processed the stages of PBL. I was able see if they presented the problem, discussed relevant content, and discuss pros, cons, and consequences of the solutions in a logical sequence.

Language

Students were asked to create a presentation with correct spelling and grammar, and they were assessed on if there were many, few, or no spelling and grammar errors, which is important for students in conveying their thoughts and ideas using a visual presentation. Figure 4.19 below shows the score that was given to each group for language.

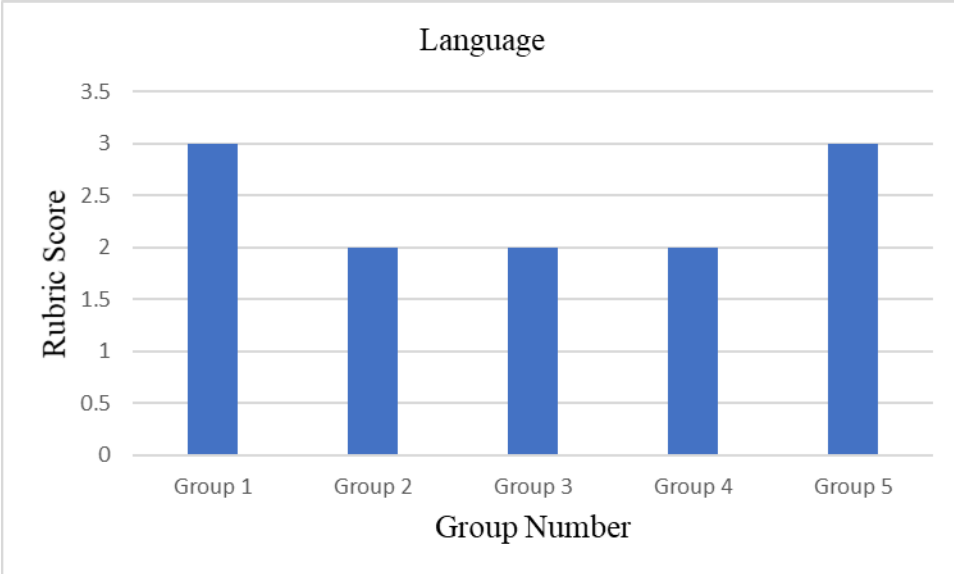

Figure 4.19 Students' Language Scores

- Group 1 had no spelling or grammar errors.
- Group 2 had a few run-on sentences, and some sentences were missing punctuation marks.
- Group 3 had a few spelling errors.
- Group 4 had a few run-on sentences, and some sentences were missing punctuation marks.
- Group 5 had no spelling or grammar errors.

Three groups had a few spelling and grammar errors. Two groups had no spelling or grammar errors. Overall, in terms of spelling and grammar, students were able to express their thoughts correctly.

Appearance

Students were asked to create appealing presentations, and they were assessed on whether or not the presentations were appealing, which gave students a chance to be creative. Being creative gives students an opportunity to take ownership of their own learning which is a benefit of PBL. They were able to show learning from their perspectives with a product they constructed themselves. Figure 4.20 below shows the score that was given to each group for appearance.

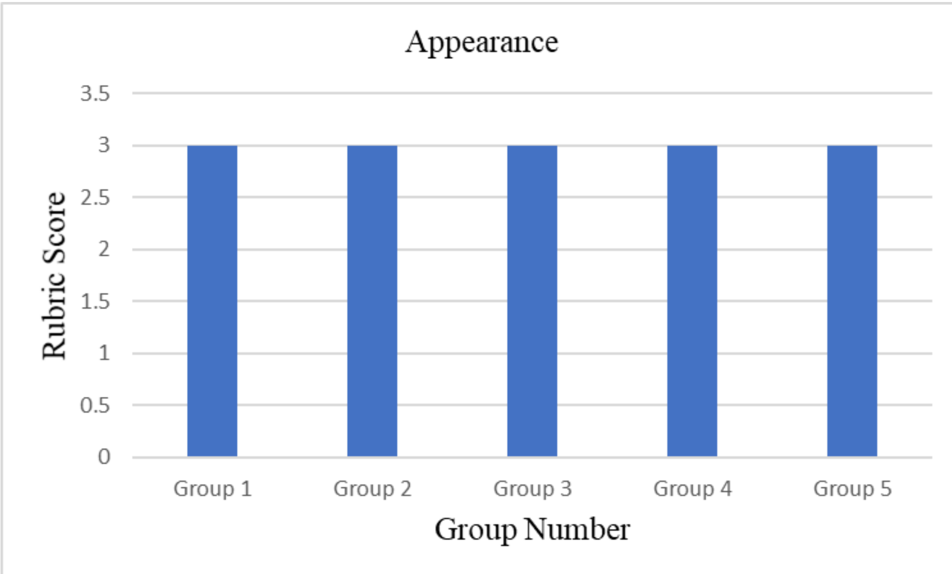

Figure 4.20 Students' Appearance Scores

All groups received a score of three for the appearance of their presentation. All of the presentations were appealing. Students included text, engaging graphics, and videos in their presentations. The data indicate that students were creative, and put forth the effort to create appealing presentations. Figure 4.21, Figure 4.22, and Figure 4.23 below show samples of students' presentations.

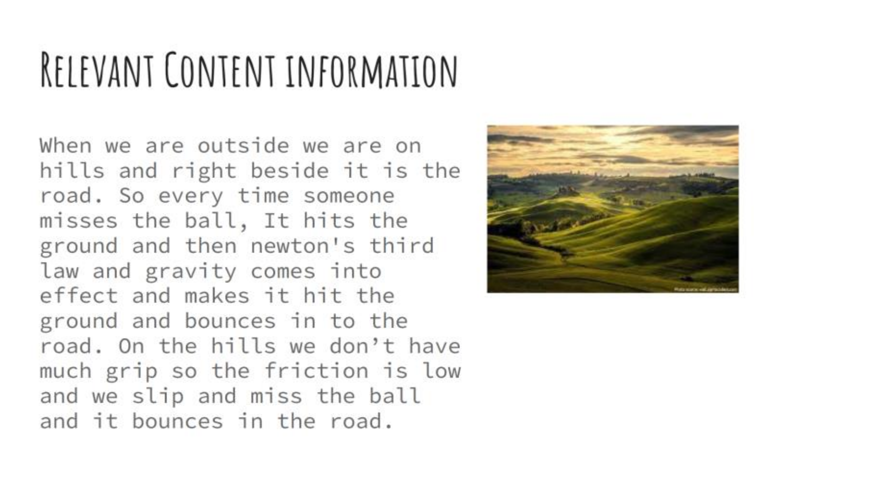

Figure 4.21 Sample of Group 5's Presentation

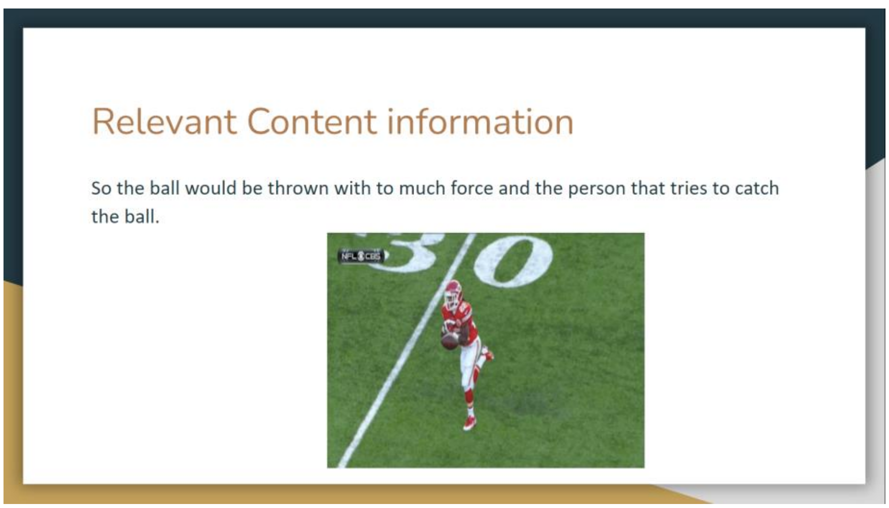

Figure 4.22 Sample of Group 4's Presentation

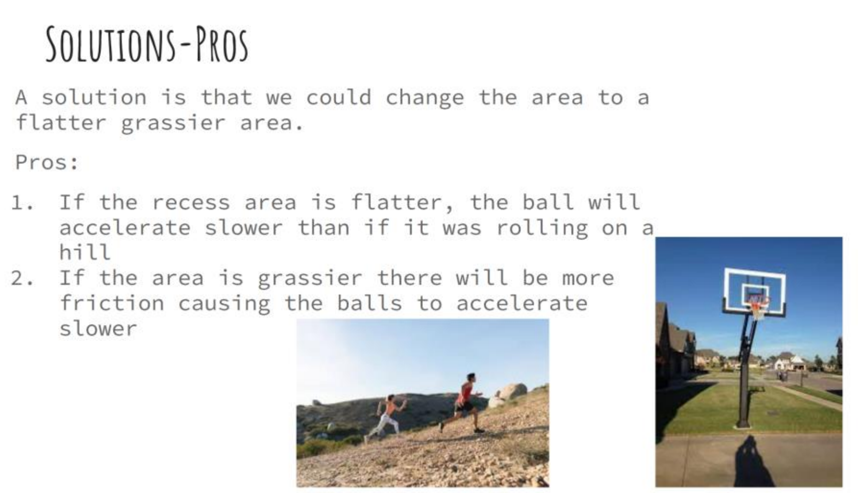

Figure 4.23 Sample of Group 3's Presentation

In summary, the presentations were a student-centered approach to learning. They provided opportunities for students to identify problems, gather relevant content information, identify solutions, and discuss the pros, cons, and consequences of their solutions. The presentations also gave students a chance to collaborate, and students had opportunities to show their learning using different types of multimedia which may have increased their engagement. Although some groups needed additional support and guidance with being able to use research skills, all groups were able to utilize PBL skills that required them to identify problems, gather relevant content information, and identify solutions while creating their presentations.

Triangulation of Students' Presentation Performance and Knowledge Gains

In order to triangulate my findings, I compared students' presentation grades to their posttest scores. The rubric total is the sum of the points given for each criterion listed on the rubric. The presentation grade was calculated by dividing the rubric total by the total points possible (21) on the rubric and then multiplying that number by 100.

Table 4.12 below shows each group's rubric total, their presentation grade, and each student in that group's posttest score.

Table 4.12 Students' Presentation Scores Compared to their Posttest Scores

Group	Rubric Total	Presentation Grade	Students' Posttest Scores
1	17	81	Student 13 (80)
			Student 10 (90)
			Student 3 (100)
			Student 8 (80)
2	18	86	Student 11 (40)
			Student 16 (80)
			Student 1 (70)
3	18	86	Student 17 (40)
			Student 18 (80)
			Student 5 (60)
			Student 12 (80)
4	15	71	Student 6 (90)
			Student 7 (60)
			Student 14 (100)
			Student 15 (100)

Group	Rubric Total	Presentation Grade	Students' Posttest Scores
5	21	100	Student 9 (90) Student 4 (80) Student 2 (100)

Group 1 had a presentation score of 81. This score categorizes students' knowledge level as Close to Proficient. When looking at their posttest scores, all students in this group were either Close to Proficient or at the Proficient knowledge level. Their scores for the presentation and posttest were closely aligned. These students performed well with both the authentic presentation assessment and the traditional multiple-choice assessment.

Group 2 had a presentation score of 86. This score categorizes students' knowledge level as Close to Proficient. When looking at their posttest scores and the corresponding knowledge levels, one student was Close to Proficient, one student was Progressing, and one student Needed Intervention. These students did not perform as well on the multiple-choice assessment as they did on the presentation. Student 11 scored a 40 on the posttest and receive a grade of F; however, this student excelled with the PBL activity and authentic assessment. This student's achievement increased when he was given the chance to experience discovery learning and when provided opportunities to be creative. While completing the presentation, I observed Student 11 searching for information, asking questions, and discussing content with his group members. He was focused and on task. This student was not successful with the multiple-choice assessment, but he was able to experience success with the constructivist approach used by this intervention.

Group 3 had a presentation score of 86. This score categorizes students' knowledge level as Close to Proficient. When looking at their posttest scores and the corresponding knowledge levels, two students were Close to Proficient and this aligned with their presentation score. However, two students' scores did not align. They both were at the Needs Intervention Level on the posttest. While creating the presentations, I observed Student 17 and Student 5 looking for photos and asking their group members about what content should be placed on the slides. I also heard these students discussing the surfaces they played on outside. Although I had to redirect these students a few times for discussions that were off-task, they were easily redirected and contributed to helping create the presentation. These students performed better on the authentic assessment because they were engaged by the activity.

Group 4 had a presentation score of 71. This score categorizes students' knowledge level as Progressing. When looking at their posttest scores and the corresponding knowledge levels, three students were Proficient and one student Needed Intervention. These students had high achievement on the multiple-choice assessment, but they did not perform as well on the presentation. I observed a lot of off-task behaviors from this group while they were creating their presentation. Three of the students in this group are on the same football team, and all four members of this group play together outside during recess each day. While they spent a lot of time discussing football, they struggled to keep their discussions focused. The members of this group wanted to work together while offering solutions to their problem, but this was a distraction. I did not consider the dynamics of this group beforehand, and their social interactions impacted their learning.

Group 5 had a presentation score of 100. This score categorizes students' knowledge level as Proficient. When looking at their posttest scores and the corresponding knowledge levels, two students were Proficient and one student was Close to Proficient. Their presentation score aligns with their posttest scores. These students are high achievers. They perform well with traditional types of teaching and learning like lecture and multiple-choice assessments, and they also do well with constructivists methods like discovery learning and authentic forms of assessments.

In summary, this intervention utilized two different types of assessments. A posttest consisting of multiple-choice questions was used to assess students' gains in achievement. Multiple-choice assessments are commonly used because they can be easily scored with accuracy, but the questions are frequently defective and can lead to ambiguous understandings about students' gains in achievement (Brown & Abdulnabi, 2017). On the other hand, PBL allows learners to demonstrate their knowledge using multiple perspectives (Grant & Tamim, 2019). In this study, students' presentations were used to assess students' problem-solving skills. The students were able to create multimedia presentations that showed their knowledge of identifying a problem, offering solutions, and discussing pros, cons, and consequences of their solutions. The presentations served as an authentic assessment that required students to be active learners. Not only did high-achieving students do well with the authentic assessment, but students who struggled with the multiple-choice assessment were also able to find success with this activity used in the intervention. Overall, PBL was effective in helping students recall and apply scientific concepts. Additionally, the intervention gave students opportunities to utilize their problem-solving skills. Collaboratively, they were able to offer solutions to problems that were relevant to them while learning concepts about forces and motion.

Teacher Observations of Students

During the 20 days of the PBL intervention, I recorded observations of students' actions while they completed activities during the instructional unit. I observed their cognitive engagement, emotional engagement, and behavioral engagement. I also documented observations of students' problem-solving skills. After each class period, I reflected on my observations. I developed codes using my observations and reflections. Cognitive engagement, emotional engagement, and behavioral engagement were three codes that were predetermined because I was specifically looking for those types of engagement. I then organized the codes into categories, and I merged similar categories for patterns and themes. The themes that emerged were positive cognitive engagement when completing PBL activities, varied emotional engagement when completing PBL activities, varied behavioral engagement when completing PBL activities, and learning in a constructivist environment.

Positive Cognitive Engagement when Completing PBL Activities

Observing cognitive engagement allowed me to see the effort students made attempting to complete their activities. Throughout the PBL intervention, students had a variety of assignments to complete that required them to use various levels of thinking. I wrote in my observations that most students attempted the assignments each day. However, I observed that there was a decrease in attempts to complete assignments when students had to create their own knowledge. For example, for one activity students had to define vocabulary words and then restate the definitions using their own words. I noted in my observations that all students attempted to define all of the terms, but some students struggled with restating all of the terms using their own words. Students struggled to complete this assignment because restating and creating their own definitions of the terms required a higher level of thinking.

Although some students made an attempt to restate terms and create their own definitions, some did it incorrectly. For example, I observed that one student wrote that mass is a crowd of people. Another student wrote that mass is how big or small something is, and I wrote in my notes that one student defined mass as Holy Communion. This indicated that I need to support students more in relating terms to physical science. Although these students attempted to complete this assignment, they struggled with understanding this term and creating their own meaning. Overall, most students were engaged, and they made an attempt to complete most of their assignments.

Varied Emotional Engagement when Completing PBL Activities

Observing students' emotional engagement allowed me to see how students felt about their learning. This was important because PBL was a new way of learning for students in this class. I wrote in my observations "All seem happy." or "All students seem calm." for most days during the intervention. Students were actively engaged, and they seemed to be enjoying the activities.

There were only three instances when I observed students being nervous or anxious. The first occurrence was on Day 3 of the intervention. I asked students to participate in a class discussion and come to a consensus on how the key terms should be defined. I wrote in my observations that eight students contributed to the discussion, but 10 students just listened. Even when I called on them, they would not provide feedback. Students were not used to creating their own definitions, and having to discuss their thoughts may have given them some anxiety. The second occurrence was on Day 6 of the intervention. I wrote in my notes that one student verbalized that he did not want to complete the assignment with a partner. Then he stated he did not want to complete the assignment at all. Before the intervention, this student usually worked alone on all assignments. So being placed with a partner or in a group may have made him anxious, and he refused to complete the assignment. However, this is the only day that this student refused to work with a partner or group during the intervention. The third occurrence was on Day 8 of the intervention. I could tell that some students were nervous or anxious about working with a group because I wrote in my observations that some of them rolled their eyes when the groups formed. However, once the groups gelled together, students no longer seemed to be anxious. I did not observe any other emotions during the intervention that indicated students were sad or anxious. Overall, most students showed positive emotional engagement when completing the activities in this unit.

Varied Behavioral Engagement when Completing PBL Activities

Observing students' behavioral engagement allowed me to see if they had a positive or negative behavioral response to learning. I observed students' behaviors while they completed the PBL activities, and I observed how students collaborated and interacted with their group members.

Throughout the intervention, I observed many on-task behaviors. For example, I wrote in my observations that students were listening to each other and discussing problems that occurred during recess on Day 4 of the intervention. I also wrote that students were attentive while their classmates were presenting on Day 16 and Day 17 of the intervention. They asked questions about the content and images their classmates used. I documented in my observations that one student pointed out that a group discussed solutions on a slide that was labeled relevant content. Students' positive behaviors showed that they were engaged while completing the PBL activities.

Although many on-task behaviors were observed, many off-task behaviors were also observed. I wrote in my observations that there was a lot of off-task talking, students were on inappropriate websites when they were supposed to be researching relevant content information about their problems, and there was horse-playing when students conducted observations and completed the mini-experiments outside.

The off-task behaviors required me to redirect students on several occasions. I wrote in my observations that I redirected students for putting their heads down on a few days, but this could also indicate that they were bored. I observed students arguing about their group roles and having discussions that were off-topic for extended periods of time. I also observed off-task behaviors occurring during the mini-experiments that were conducted outside. For example, I observed students dancing, looking at their cell phones, and playing with a football. I tried to redirect students when I observed these behaviors. It is important to note that students in this class required a lot of redirecting while completing activities, even before the implementation of the intervention.

Learning in a Constructivist Environment

PBL promotes an active learning environment in which students actively participate in the learning process. The activities utilized throughout this instructional unit allowed students to create their own understanding. Four subthemes emerged related to learning in a constructivist environment: the need for scaffolding, needed support with research skills, the need to enhance communication skills, and lack of time.

The Need for Scaffolding. On several days I observed that students needed scaffolding while completing PBL activities. For example, students struggled to complete concept maps. Several students asked, "What does indicator mean?" I explained the term several times and provided examples, but some students did not seem to understand the meaning of this word. Before the intervention, I often used concept maps in my class. However, this concept map required higher-order thinking because students had to describe ideas related to their problems and make connections to forces and motion. Also, this activity required students to research and discuss causes, indicators, solutions, and consequences of their problems. I should have broken this lesson down to make sure students understood the nature of their problems better.

Another example where scaffolding was needed was during the mini-experiments. I observed students struggling to create organized procedures for their experiments. Before the intervention, I always provided procedures for experiments with very specific instructions that students had to follow. In this PBL intervention, I allowed students to develop their own procedures, but they needed more guidance with this process.

Needed Support with Research Skills. Students needed additional support with their research skills. Chromebooks served as a resource for students to use to help them gather information about their problems. However, after reminding students to use their computers during several days of the intervention, I observed that many choose not to. Students asked me to provide them with information while I observed their Chromebooks sitting on their desks. Before the intervention, I usually provided students with specific sites they needed in order to research topics. For this PBL activity, students seemed to need support in the development of these skills by explaining how to research topics effectively, and providing opportunities to practice these skills before the start of the intervention.

Need to Enhance Communication Skills. Learning in a PBL environment requires students to have effective communication skills. I observed students demonstrate these skills while completing activities during the intervention. For example, I observed students asking questions, listening to each other, and having discussions. However, I observed that on some days students struggle to communicate effectively. For example, on Day 4 of the intervention, I asked students to share their ideas about problems occurring during recess. Students were hesitant to respond, and some students refused to respond when I called on them. On other days, I had to address students yelling, talking over each other, and being rude to each other. For example, one student yelled “Shut up!” after another student commented that content on a slide made for the presentations was incorrect. Students were used to lecturing strategies before the intervention, and they did not get to practice speaking their thoughts in an effective and appropriate manner.

Lack of Time. PBL promotes the development of problem-solving skills, research skills, and communication skills. These skills need to be developed, and this takes time. Throughout the intervention, I felt there was a lack of time for students to think and process their thoughts. I observed students needing more time to generate ideas and reflect on their problems. There was also a lack of time to complete activities that required students to create their own meaning. For example, more time was needed to create and conduct the mini-experiments. When I announced that it was time to go outside to perform the mini-experiments, a student responded, “We need more time!” I rushed this student while he was trying to develop procedures for his experiments.

PBL was fundamental to this action research study. It encouraged students to become active learners while constructing their own knowledge about scientific concepts. Several students commented that they enjoyed the instructional model while reflecting on the intervention. I wrote in my observations that one student commented, “I liked that we could do hands-on activities.” Another student responded, “I like trying to solve a problem and not just listen to the teacher.”

Triangulation

PBL was effective in helping students recall and apply abstract scientific concepts. Quantitative data from the pretest and posttest showed when students had prior knowledge about a concept, their scores were higher as compared to concepts where students had little prior knowledge. Quantitative data from the pretest and posttest also showed that there were more gains in achievement when concepts being taught had a heavy PBL influence. Students improved their scores more compared to previous years using this instructional model.

PBL improved students problem-solving skills, but students still needed scaffolding. Quantitative data from students’ presentations showed that students utilized skills like being able to identify problems, offering solutions, and communication. However, quantitative data from students’ presentations also showed that students needed additional support with gathering relevant content information and being able to offer solutions. Qualitative data from my observations also showed that students needed additional support with being able to gather relevant content information. The qualitative data from my observations specifically identified students' needs to enhance their research skills.

The activities used for this PBL intervention were engaging to students. Quantitative data from student engagement surveys and qualitative data from my observations showed that students were mostly happy while completing the activities. Quantitative data from student engagement surveys and qualitative data from my observations also showed that most students were on-task during the intervention, and most students attempted to complete all the activities. Although both types of data showed that most students were engaged, qualitative data from my observations showed that students needed frequent redirection.

Summary

Chapter 4 provided an analysis of the findings for the data collection instruments used in this study. I used quantitative and qualitative instruments in this study because I wanted to gain a better understanding of the PBL experience. The quantitative instruments used in this study included a pretest and posttest, student engagement surveys, and student presentations. The qualitative instrument consisted of teacher observations. The quantitative instruments provided data on students' academic growth, students' problem-solving skills, and students' perceptions and engagement toward PBL. The qualitative instrument provided data on students' cognitive engagement, emotional engagement, and behavioral engagement. It also provided data on students' problem-solving skills. Chapter 5 follows, where the implications of these findings will be discussed.

CHAPTER 5

IMPLICATIONS AND RECOMMENDATIONS

This chapter begins with an overview of the study that includes a description of the problem of practice, a summary of the intervention, and a discussion of the research questions and findings. An action plan will be presented followed by implications for classroom practices and further research. The chapter will conclude with a reflection on the research process.

Overview of the Study

Science concepts taught in middle school are very abstract, and students sometimes struggle with learning and applying the information. The traditional methods that I have used to teach science are not engaging for students. Instructional strategies I have used in class have not been effective in helping students to recall and apply the information they learn.

The intervention used for this study utilized PBL as an instructional model. PBL is a student-centered instructional model in which students learn about content by solving real-world problems. The purpose of this study was to research the impact of PBL on eighth-grade college prep students' science achievement, student engagement, and students' problem-solving skills.

I collected quantitative and qualitative data for this study. Pretest and posttest, student engagement surveys, and student presentations were used as my quantitative instruments. Teacher observations were used as my qualitative instrument. The findings gave insight into students' cognitive engagement, emotional engagement, and behavioral engagement. The findings also provided insight into students' knowledge construction and problem-solving skills. This chapter will discuss an action plan for my teaching and classroom practice, a reflection on my research process, and recommendations for further research.

Findings as it Relates to the Literature

The goal of the research questions was to measure the impact of PBL on students' science academic achievement and engagement towards science and learning. Also, the goal was to measure how PBL impact students' problem-solving skills. The findings from chapter 4 will be used to answer each research question.

Research Question #1: What is the impact of problem-based learning on students' achievement?

Using PBL, students worked to offer solutions to problems that occurred during recess. The activities used to aid students in offering solutions led to an engaging, student-centered classroom, and the increase in students' knowledge levels on the posttest showed that the activities were successful in aiding students to learn the content. Muniz (2019) observed that the activities used to help students create knowledge using PBL leads to increased achievement, and I found similar results with my study. Quantitative data from the pretest and posttest showed that students increased their science achievement, and they made gains on all questions. Students' achievement increased on some concepts more than others. The more abstract the concept, the harder it was for students to make gains. However, the gains students made were an improvement from last year.

Constructivist teaching allows students' knowledge to build from their previous experiences (Shah, 2019). My findings were consistent with this idea. Students' knowledge levels were Proficient or Close to Proficient when they had prior knowledge about a concept. For example, students had prior experiences with forces, and their knowledge level was Proficient when being asked to define a force. Moreover, Vygotsky (1978) believed that knowledge is constructed in a discovery environment. The activities used in this intervention allowed students to experience discovery learning. As students observed, explored, created, and performed experiments their knowledge was constructed. Overall, PBL had a positive impact on students' achievement.

Research Question #2: How does problem-based learning impact students' engagement towards science and learning?

A principle of constructivism is that students are engaged when problems are meaningful and relevant to them (Mohammed & Kinyo, 2020). My findings were consistent with this principle. My observations and the student engagement surveys revealed that students were engaged while using PBL. According to Rotgans and Schmidt (2011), engagement increases as students depend less on the teacher and become more active learners. Throughout the intervention, the majority of students agreed that they worked hard while completing the activities for the unit. I observed students being happy and calm while completing their assignments, and I also observed most students being on-task. Some students needed redirecting, but their engagement was improved from when I have used direct instruction.

Vygotsky (1978) believed that knowledge is constructed when students have meaningful social interactions. My study found similar results. The student engagement surveys showed that most students showed positive behaviors when using PBL. The majority of students felt like they had a chance to interact with their group, and most students enjoyed talking with their groups. PBL provided opportunities for students to interact each day, and these types of interactions did not occur daily before the intervention. Although I did observe some negative behaviors like excessive, off-task talking, I was able to redirect students as needed. Being able to interact and discuss content had a positive impact on students’ engagement towards learning and science.

Research Question #3: How does implementing problem-based learning impact students’ problem-solving skills?

According to Müller et al. (2017) problem-solving skills develop when using PBL. This study showed similar findings. Based on students’ presentations and teacher observations, I was able to observe the impact PBL has on students’ problem-solving skills. Students were able to identify problems, gather relevant content information, and suggest solutions. However, when finding relevant content information, some students struggled. I observed students not using their Chromebooks to research information when they had opportunities to do so. They were not taught research skills before the intervention, so students needed additional support and guidance with these skills.

Students varied in their success with being able to offer solutions to problems. I observed students struggling to complete activities that required higher-order thinking. The instruction I provided to students before the intervention did not prepare them for this type of thinking. Students need additional practice with this problem-solving skill.

Also, collaboration is one of the major components of PBL (Savery, 2006). Students were able to work together to construct a presentation. During my teacher observations, I observed student discussing content, working together to find relevant images and videos, and creating the presentations. They all took part in working on the assignment. Overall, implementing PBL promoted the use of students' problem-solving skills.

Action Plan

Similar to the scientific method that I teach my students, action research is cyclic and occurs in many phases. It allows one to be responsive after reflecting on knowledge gained from the research (Efron & Ravid, 2013). After completing this study, I reflected on my findings and developed an action plan for future steps I would like to take. The details of the action plan are discussed in the following section. The steps of are organized in chronological order.

July 2023

To begin this action plan, I will meet with my principal and assistant principal of instruction to update them on my findings. I want them to know about the benefits of using PBL to increase students' achievement, engagement, and problem-solving skills. They were both aware of my research, and they frequently asked me to provide updates. After sharing my findings with my administrators, I will ask for permission to share my findings with the science department and provide professional development to the department.

One of my roles as department head is to lead and train staff members on best practices for instruction. We are encouraged to facilitate professional development that uses researched-based strategies to improve student achievement. Department heads are allowed to prepare curriculum and professional development during summer curriculum writing, so I will need to meet with my principals in early July to make sure they are on board with me sharing my findings about the benefits of using PBL with the department. It is important for me to share my research with the department because the science department is a professional learning community. Our principal likes for us to be "like-minded" and on the same page. The department meets on a weekly basis, and our overarching goal is to improve achievement for all students.

During summer curriculum writing, I will work on a modification to the unit of study that was used during the intervention. I need to align the timing of the intervention with our second unit of study which is Waves. The Forces and Motion unit occurs at the beginning of the school year, so this does not give me enough time to provide the needed professional development to the department.

August – September 2023

Beginning in August, I will prepare the professional development that I will facilitate during our weekly department meetings. I do not want to overload teachers with information and instructional models they may not be familiar with, so I will share information about my research for four consecutive weeks on the following topics: teaching in a constructivist environment, PBL, professional readings and research, and the design and findings of my study. The professional development sessions will occur during our normal planning time during the school day.

October 2023

During the next step of this action plan, I will begin the new study. I will prepare to conduct the intervention with any other teachers who are interested in trying this PBL instructional model in their classroom. I have different students each year, so a different group of students will take part in the study. It will be interesting to see if I find similar results when focusing on different standards and concepts. I would also like to give the students more ownership in developing the problems, and I am excited to see what they will come up with.

November 2023

After the completion of this new study, I will share the results with the science department and the principals. I want my instructional partners to be aware of how PBL can impact students' success. For many teachers, this will be a new way of providing instruction. If the results are positive, this may help to decrease the anxiety with trying something new (Evans, 2001).

December 2023

Following the intervention, teachers that participated will share their results with the instructional staff. This is beneficial because our school is a STEAM School. The following is our mission.

The mission of Silver Fox School (pseudonym) is to:

Strategically implement an engaging and challenging curriculum that will integrate

Technology while encouraging students to

Effectively communicate, critically think, collaborate, and be creative. By partnering with our community, students will be

Accountable for their learning as they are

Mentored to be successful contributors to a global society.

Our school's mission aligns with the goals of PBL. Unfortunately, due to COVID, our school's STEAM initiatives have slowed tremendously, and we have not had any schoolwide strategies to address ways to improve student achievement in the last few years. The benefits of implementing PBL schoolwide "extend to all students, regardless of socioeconomic or linguistic status, or special learning needs" (Sutton & Knuth, 2017).

Also, students will prepare multimedia presentations to share with the school. The presentations will be similar to what was completed during the initial intervention. These presentations will allow others to see their problem-solving skills, and I would also like for students to include information about their thoughts and feelings when using PBL.

January 2024

After sharing results with the instructional staff, I will form a PBL subcommittee under the STEAM committee to implement PBL school-wide. All teachers are required to serve on a school committee. I would hope to receive participation from at least one teacher from each core content taught at our school, and participation will also be needed from Fine Arts and Exploratory teachers. This is important because it allows other teachers to take ownership in this process.

February – March 2024

Members of this committee will be expected to share their thoughts and expertise, and identify community resources that can develop one cross-curricular unit utilizing PBL. Our school-based committees only meet twice a month, so planning for the instructional unit will take a couple of months.

April 2024

The committee will then present the instructional unit to the faculty during a staff meeting, and school-wide implementation of the PBL unit will then occur. After the completion of the intervention, a survey will be given to staff members to obtain their feedback on their perceptions of the intervention. We will create a final report to give to the principal at the end of the school year that discusses findings from implementing an instructional unit based on PBL. The committee will also share recommendations for the following school year. The timeline and details of the action plan are shown in Table 5.1 below.

Table 5.1 Action Plan

Date	Activities	Expected Outcomes
July 2023	Meet with the principal and assistant principal of instruction.	Meeting with the principles will give me an opportunity to share my findings so administrations will know the possible benefits of using PBL. I hope to gain their support to implement PBL with other teachers.
July 2023	Participate in summer curriculum writing.	During summer curriculum writing, I will update the instructional unit that will be used for the intervention.
August 2023	Prepare professional development for the science department.	I will prepare presentations and gather materials to distribute that will make my professional development engaging.
September 2023	Conduct professional development sessions. Week 1: Constructivist Teaching	The goals of the professional development are for teachers to learn about constructivist teaching methods and

	Week 2: PBL Week 3: Professional readings/research Week 4: Present research to the department.	problem-based learning. Teachers will have opportunities to read professional literature, have discussions, and ask questions about this instructional model.
October 2023	Prepare to conduct the intervention with other teachers.	Teachers will see the benefits of using PBL with their students.
	Repeat the intervention.	Students will have opportunities to become active learners.
November 2023	Share the results with the department and principals.	Teachers and administrators will see the benefits of using PBL from other teachers.
December 2023	Present findings to the instructional staff (teachers).	Teachers presenting their findings to the instructional staff will give staff members to reflect on the intervention. Teachers will be able to modeling of the PBL process, and they will be able make suggestions on what aspects can be improved.
	Prepare a presentation to present to the school (students).	Students preparing a presentation for the school will give them a chance to show others their work. It will also give teachers a chance to see students taking ownership of their learning. By having teachers and students present to the staff, I hope to motivate others to be active participants when trying to implement PBL schoolwide.

January 2024	Form a subcommittee under the school's STEAM committee.	The school's STEAM focus aligns with the goals of PBL. The subcommittee will provide opportunities for teachers to communicate and collaborate their thoughts and ideas about implementing PBL school-wide.
February/March 2024	Develop a school-wide PBL unit.	A school-wide PBL unit will build community in the school. Everyone will work towards a common goal of helping students enhance their problem-solving skills.
April 2024	Present the instructional unit to the instructional staff.	Presenting the instructional unit will make everyone aware of the goals and expectations for the instructional unit. The specific activities that students will complete will be discussed. Teachers will be allowed to ask questions and share their concerns.
	Conduct school-wide implementation of the instructional PBL unit.	During the implementation of the instructional unit, students will collaborate to offer a solution to a real-world problem.
April 2024	Survey the staff.	The survey will give staff members an opportunity to express their views and experiences using PBL. They will also be able to suggests improvements that may be needed.
May 2024	Present the final results to the principal and staff.	A final summary will be presented so adjustments can be made to improve the

	implementation of PBL for the next school year.

Limitations

There are some limitations and suggestions related to classroom practices. I frequently thought about time while I was conducting this study. I learned from this study that there are skills students need when they participate in PBL activities that require scaffolding. Communication skills have to modeled and practiced. Research skills have to be taught and practiced. Students may not be used to collaborating in groups. My district uses a pacing guide. There are strict timing guidelines that must be followed in order to cover content and prepare students for district and state assessments. The time needed to provide students with support and opportunities to practice these skills is not accounted for in a pacing guide.

Time is also a limiting factor because the activities used for PBL require higher-order thinking. When students are using critical thinking skills and creating knowledge, it takes more time to process these thoughts.

Recommendations for Practice

Suggestions for classroom practice that may improve the results after implementing PBL relates to assessment questions. First, the multiple-choice pre- and posttest questions can be improved by making them more relevant to students' experiences. For example, students' had to analyze a scenario relevant to friction and driving for question 5. My students are not old enough to have their driving license, so they may not have had any prior knowledge or experience with this concept. Also, several of the questions used for my pre- and posttest required higher-order thinking.

These types of questions are great because they challenge students. However, if students are already struggling with concepts, it may not be necessary to use complex questions on an assessment when a new instructional strategy is being implemented. If students struggle with activities that require them to use higher-order thinking skills, they will not be ready for this level of thinking on an assessment.

Another suggestion for classroom practice is to improve upon the authentic learning environment by expanding ideas for problems to issues that are important in the community. For this research study, students addressed problems occurring during recess. However, addressing community issues may provide opportunities for students' families to become involved with the learning. Getting to know students' families can help teachers become more aware of students' needs. Also, PBL recognizes students' diverse backgrounds, and working with the community helps to build diverse relationships (Lee & Blanchard, 2019).

A third suggestion for classroom practice is to have a plan that addresses student absenteeism. Several students missed instruction during this research study, and I sometimes struggled with holding them accountable for their learning when they were not present. It may be useful to provide all students with an outline for the unit so they are aware of the instructional goals that will be covered each day during the unit. Also, creating some type of student accountability worksheet may help teachers and students set goals and discuss expectations for learning when students are absent.

A fourth suggestion is to try to engage students that did not find the learning interesting. This can possibly be accomplished by giving students more options for problems to solve and letting them choose the problem they would like to offer solutions to. Also, offering problems that are culturally relevant to students may increase their engagement (Samuels, 2018).

Finally, instead of using a teacher-created instrument to record my observations of student engagement and problem-solving skills, I would like to use an observation checklist for PBL that is already documented. It was overwhelming trying to record observations while facilitating lessons simultaneously. I would suggest videotaping the lessons and using a tool that has been tested and used in the literature that relates to problem-based learning. Specific rubrics that help capture different types of behaviors and problem-solving skills are offered by pblworks.org.

Recommendations for Future Research

Improving my students' achievement and success in the classroom is something I will always reflect on. For future research, I would like to continue to investigate how PBL increases students' academic achievement. As stated in my action plan, I will continue this research with some modifications. First, I will have a different group of students next year. Second, I will implement PBL using a different unit of instruction. Third, now that I am knowledgeable about this instructional design, I would like to implement the intervention with all of my students. I teach college prep students and honors students. I want to improve the achievement of all of my students. PBL enhances skills that all students need to learn in order for them to be successful in life.

An area of interest that came to mind while conducting this study was group dynamics. For this research study, I allowed students to choose their groups. However, this may have caused more distractions because students wanted to socialize with their friends and have discussions not relevant to the content. Also, one of my students always wants to work alone. He does not speak much during class, but he socializes with his friends when we are outside during recess. This student told me he did not wish to work with a group, but he only refused to do this one day during the intervention. Future studies could investigate how group dynamics and learning preferences impact the effectiveness of PBL.

Another area of interest for future research is to compare learning gains using traditional teaching to learning gains using PBL. In previous years, students built prior knowledge and learned content using direct instruction. For example, modeling, demonstrations, and guided lessons helped students learn scientific concepts, and they were able to make gains in their achievement. Students can learn from traditional and constructivist teaching methods, and it may be beneficial to investigate which method has the greater impact on students' academic achievement.

Reflection

I truly enjoyed the nature of action research. The students in this class and I were all learners throughout this process. I was able to study an area of weakness in my instruction and implement a research-based instructional design to improve my students' growth in their knowledge and skills. The research I conducted to learn about action research, constructivism, and PBL all gave me insight to what professionals are doing to improve the learning environment and increase achievement for all students.

The methods used for this study did come with some difficulties. It was hard being the teacher and the researcher. On many days, I struggled with trying to manage teaching, recording observations, and having to reflect on my intervention. Many observations were overlooked because I was trying to answer questions or redirect students. However, I have been able to reflect on ways to improve my methods for data collection in the future.

There are a few changes I would make to the methods I used in this study. First, I would give students more choice in deciding on what problem they would like to solve. For this study, I gave them two options. However, it probably would be more engaging for students if they had more of a voice in deciding this. Second, I would use a shorter unit or have fewer concepts to cover. The forces and motion unit had several abstract concepts, and trying to problem-solve and think about an enormous amount of information was a challenge for me and my students. The final change I would make would be to consider the grouping of students more. PBL requires students to be social (Vygotsky, 1978) and middle school love to socialize. I let several students work with their friends because I wanted them to be comfortable. However, this may had led to students being more distracted.

Summary

Chapter 5 answered the research questions and provided details for my action plan. It also discussed implications for classroom practice and recommendations for future research.

This action research study investigated how a constructivist teaching design impacts eighth-grade students' achievement, engagement, and problem-solving skills. Although some students struggled with learning complex scientific concepts, I found that PBL did improve students achievement in science. Most students were engaged while using PBL, and the activities used during the intervention allowed students to enhance their problem-solving skills. It can be concluded that PBL is an effective instructional model.

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APPENDIX A

PRE- POSTTEST

1. A force can be defined as a ____________________
A. decrease in speed.
B. distance traveled.
C. push or a pull.
D. speed of an object.

2. Gravity can be defined as ____________________
A. a force that attracts or pulls objects toward each other without direct contact.
B. a force that attracts or pulls objects toward each other with direct contact.
C. the resistance between objects that are in contact with each other.
D. the tendency of objects to resist a change in motion.

3. A ball is kicked into the air. The student is watching the path of the ball. Why will the ball fall down?

A. A reaction force is not acting on the ball.
B. Friction has no effect on the ball.
C. Gravity is balanced by the force of the air.
D. Gravity is the unbalanced force pulling it down.

4. Friction is a force that occurs when one object rubs against another object. Friction depends on what 2 factors?
A. mass and distance

B. force and surface type
C. speed and momentum
D. force and distance

5. If you were driving in a severe thunderstorm and your car started to swerve, which of the following would need to occur in order to gain control of your car again?

A. Increase the friction between the tires on the car and the road.

B. Decrease the friction between the tires on the car and the road.

C. Decrease the friction between the tires on the car and the water on the road.

D. Increase the friction between the car and the falling rain.

6. If a body is at rest or moving at a constant speed in a straight line, it will remain at rest or moving at a constant speed unless it is acted upon by an unbalanced force. This describes which one of Newton's Laws?
A. Newton's First Law
B. Newton's Second Law
C. Newton's Third Law
D. Newton's Fourth Law

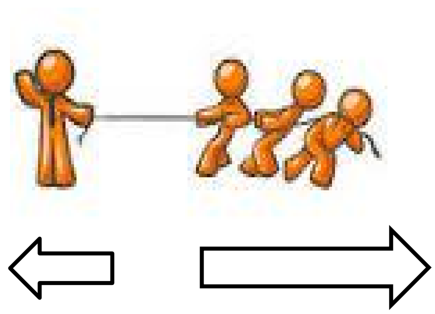
7. Review the data in the table below.

Ball	Mass
Ball 1	410 grams
Ball 2	420 grams
Ball 3	430 grams
Ball 4	440 grams

Which ball will travel the greatest distance if all the balls are kicked with the same force?
A. Ball 1
B. Ball 2
C. Ball 3
D. Ball 4

8. Newton's Third Law of Motion states that every force is accompanied by an equal but opposite force. This is best illustrated by which of the following?
A. A book sliding off the car seat when the car turns a corner.
B. A lunch bag falling off the desk.
C. A planet orbiting a star.
D. A rocket being launched into space.

9. Use the diagram to analyze what will happen in the tug-of-war example below?



50N 150N

A. The forces are unbalanced, and the rope will move to the right.
B. The forces are unbalanced, and the rope will move to the left.
C. The forces are balanced, and there will be no change in motion.
D. The forces are balanced, and the rope will move to the right.

10. Students normally play with footballs and soccer balls outside during recess. Why might students not play with bowling balls during recess?

A. Bowling balls would be harder to throw because they have less inertia.

B. Bowling balls would be easier to throw because they have more inertia.

C. Bowling balls would be harder to throw because they have more inertia.

D. Bowling balls would be easier to throw because they have less inertia.

APPENDIX B

THE INTERVENTION

Step One: Prepare the Learners

This step provides a foundation for the learners (Torp & Sage, 2002).

Role as a Facilitator

I will serve as a facilitator during Step One by scaffolding learning. My students will activate prior knowledge about their experiences with forces and motion. Specific vocabulary will be given to them so they know the scientific language they need to understand and use during this instructional unit. I will monitor students as they develop their own definitions of key terms, and encouragement will be provided if they struggle with creating their own definitions.

Day 1

Objective: Learners will be able to identify how forces and motion impacts their lives.

To motivate students, I will ask students to brainstorm any experiences they have encountered with forces and motion. This will allow my students to make relevant connections with the content because they will list experiences that they can personally relate to. My students' responses will be placed around the room, and they will perform a gallery walk to view other's work.

Day 2

Objective: Learners will be able to define key terms related to Forces and Motion.

My students will be given terms to begin constructing knowledge about key vocabulary used in the Forces and Motion unit. Students will research specified terms using their Chromebooks. This will allow students to be active learners because they will have to define terms and then create definitions for those terms using their own words. This activity will allow students to create definitions they are familiar with, and they will have a better understanding of what they have written.

Day 3

Objective: Learners will be able to communicate appropriate definitions for key terms related to forces and motion.

Day 3 will require my students to participate in a class discussion. For each term, I will select three students to read the definitions they have created. Then as a class, we will come to a consensus about how each term should be defined. As a class, this will give us an opportunity to speak, listen to others, and come to an agreement about final definitions. Students will have additional practice with communicating with each other.

Handout Used for Day 2-3

Forces and Motion

Directions: The following is a list of terms that will be used in the Forces and Motion unit. Use your Chromebook to define each term. It may be helpful to also view images of the terms. Next, try to write a definition for each term using your own words. Try to use words that your classmates are familiar with when defining the terms in your own words. During the next class period, we will have a discussion and choose definitions to use that are suitable for this class.

Term	Definition	Define Using Your Own Words	Class Definition
Force			
Balanced forces			
Unbalanced forces			
Gravity			
Friction			
Mass			
Inertia			
Newton’s First Law			
Newton’s Second Law			
Newton’s Third Law			

Step Two: Meet the Problem

This step motivates the learners by making the content relevant to their lives (Torp & Sage, 2002).

Role as a Facilitator

During this step, I will shift from the norm of giving a lecture to being a facilitator by providing a resource to students. The assistant principal will serve as a resource by introducing the problems to the students, and I will observe how students respond.

Day 4

Objective: Learners will be able to identify dangerous issues occurring during recess.

I will ask the assistant principal to visit our class to ask students to help solve problems that are occurring while the students are at recess. The assistant principal introducing the problems will be more authentic because students feel that situations are more serious when an administrator is in the room asking them questions.

Problem 1

Too many injuries are occurring during recess. The school nurse is requesting that balls are no longer allowed outside. Determine the cause of these injuries and recommend appropriate solutions.

Problem 2

Our recess area is located alongside a road where buses and cars travel. Footballs thrown by students enter the street more frequently than the soccer balls students play with. This can lead to an unsafe playing area. Students do not want to stop playing with the balls during recess. Determine why the football enters the street more often than the soccer ball. Recommend appropriate solutions.

Step Three: Identify What We Know, What We Need to Know, and Our Ideas

This step activates students' prior knowledge and helps them to comprehend the problem (Torp & Sage, 2002).

Role as a Facilitator

I will serve as a facilitator by observing students' ideas about the problem. I will monitor students' progress and ask them to share their ideas with me. I will listen and provide encouragement for students to offer multiple ideas. I will monitor students to make sure they stay on task and redirect them when needed.

Day 5

Objective: Learners will be able to recognize what they know about the problem and list any thoughts they have about the problem.

Students will complete a chart to record their ideas about the problem. The “know” are things students are knowledgeable about and have experience with, the “needs to know” are things students feel they need more information about, and the “ideas” are any relevant thoughts or initial solutions students may have about the problem (Torp & Sage, 2002). Students will complete this chart for both problems, and this will give students time to think about the problem that is most relevant to them.

Problem:		
What I Know	**Information Needed**	**Thoughts I Have**
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.

Step Four: Define the Problem Statement

This step aids students in making connections to the problem and the conditions needed to solve it (Torp & Sage, 2002).

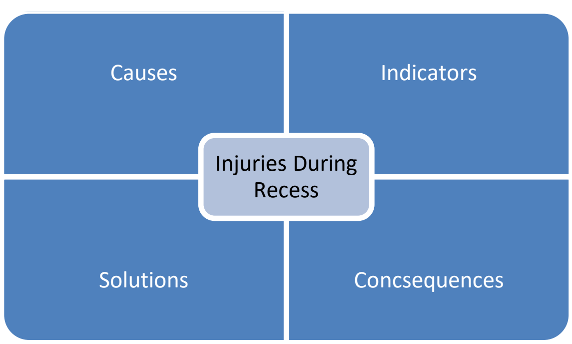
Role as a Facilitator

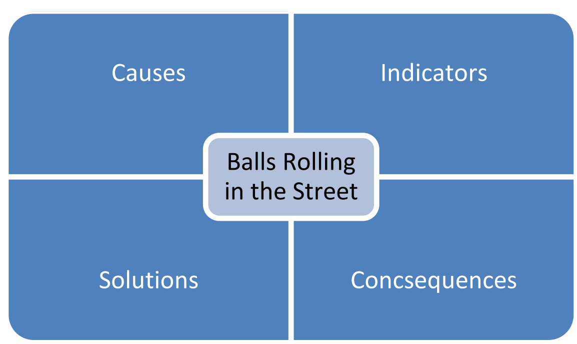
Students will work with a partner to seek answers, and this will give students an opportunity to articulate their ideas with each other. I will monitor students and facilitate discussions by asking them questions about the problem if they have trouble completing a concept map.

Day 6 and Day 7

Objective: Learners will be able to describe their ideas about the causes, indicators, solutions, and consequences of the problems (Torp & Sage, 2002), and explain how their ideas are connected to forces and motion.

Students will refer to their forces and motions terms (completed on Day 2) while completing a concept map. I will ask students to try to use some of the terms while discussing and listing their ideas on the concept maps. Using the terms in their responses will help students practice the vocabulary, recall the definitions of the terms, and relate the forces and motion concepts to their lives. This activity will be completed with a partner so that students can listen to others' ideas and share their ideas. Based on the students' responses and interests in the problems, I will use the maps and teacher observations to place the students in groups for the next activity. Students will complete a concept map for problem 1 on Day 6, and they will complete a concept map for problem 2 on Day 7. As suggested by Torp and Sage (2002), the concept maps will have the following central ideas:





After completing the concepts maps about the problem, students will then develop a problem statement. Torp and Sage (2002) suggest using the format, “How can we … in such a way that …?” (p. 39). This format for defining the problem statement helps students focus on the key issues and circumstances for solving the problem (Torp & Sage, 2002).

Step Five: Gathering and Sharing Information

This step requires students to work in groups to gather and share information that is most useful for identifying solutions to the problem (Torp & Sage, 2002).

Role as a Facilitator

I will allow students to work collaboratively so they have a chance to listen and discuss their ideas with each other. Instead of me providing information to students, they will use the Internet to research and gather information. If needed, I will guide students to appropriate websites, and I will monitor their progress throughout the class periods. I will also be able to monitor their progress by reviewing their exit slips. Students will be presenting their findings to the class. They will be active learners.

Day 8 – Day 10

Students will work collaboratively in groups with each group having a facilitator, recorder, timekeeper, and spokesperson. Students will view and discuss BrainPOP videos about Newton’s Laws of Motion. BrainPOP videos shown each day during the Gathering and Sharing Information stage aim to focus students on the science content. It uses short, animated videos that are standards-based to engage learners. After discussing the video, students will perform Internet searches to gather information. Students’ searches will be guided by the Need to Know section from the activity on Day 5. Students will complete an exit slip that will access their knowledge of the forces and motion concepts as it relates to the problem at hand. This will allow me to monitor and adjust instruction as needed.

Intervention Day	Objective(s)	Video Clip	Exit Slip
Day 8	The learner will be able to: 1. Describe Newton's First Law of Motion. 2. Give examples of Newton's First Law of Motion. 3. Define inertia.	BrainPOP- Newton's Laws of Motion https://www.brainpop.com/science/motionsforcesandtime/newtonslawsofmotion/	Based on your research, how can you define Newton's First Law? Diagram an example of Newton's First Law. Explain how this law is related to the problem you have chosen to offer solutions to.
Day 9	The learner will be able to: 1. Describe Newton's Second Law of Motion. 2. Give examples of Newton's Second Law of Motion. 3. Define force. 4. Define mass.	BrainPOP- Forces https://www.brainpop.com/science/motionsforcesandtime/acceleration/	Based on your research, how can you define Newton's Second Law? Diagram an example of Newton's Second Law. Explain how this law is related to the problem you have chosen to offer solutions to.
Day 10	The learner will be able to: 1. Describe Newton's Third Law of Motion. 2. Give examples of Newton's Third Law of Motion.	BrainPOP- Forces https://www.brainpop.com/science/motionsforcesandtime/forces	Based on your research, how can you define Newton's Third Law? Explain how this law is related to the problem you have chosen to offer solutions to.

			Diagram an example of Newton's Third Law.

Instruction for middle-school students needs to be engaging. Students in my college preparatory classes may have difficulties conducting research that involves a lot of reading for extended periods of time. The gathering of information for the next two days will allow students to make direct observations in order to keep them from becoming inattentive.

Day 11

Objective: Learners will be able to describe how forces impact the motion of objects.

On Day 11 of the intervention, students will first watch a BrainPOP about gravity and friction. Students will then travel outside to record observations of other students at recess. They will record their observations in a journal. Upon returning to class, students will share and discuss their observations with other group members. Each group will then have the designated spokesperson share their findings with the class.

Day 12

Objective: Learners will be able to describe how forces impact the motion of objects.

On Day 12 of the intervention, a variety of balls will be given to students. Each group will develop mini experiments they can perform to test how different forces impact the motion of the balls. The class will return to the recess area to conduct these experiments and make observations with their groups. Upon returning to class, each group will share their findings with the class. Students' observations will be recorded on a handout I have created in order to guide the students and keep them focused.

Description Describe what you are doing to test how forces impact the motion of objects.	**Observations** Note: Your observations must include vocabulary from the Forces and Motion unit of study.	**Connections** What connection can be made to the problem you are trying to find solutions to?
Mini-experiment #1		
Mini-experiment #2		
Mini-experiment #3		

Step Six: Generate Possible Solutions

This step requires students to return to the problem statement and offer solutions based on knowledge they have gathered (Torp & Sage, 2002).

Role as a Facilitator

During Step Six, I will continue to guide and coach students. I will accomplish this by monitoring what students need by questioning responses that need clarification or more details. I will continue to offer encouragement as they develop solutions to the problems.

Day 13

Objective: Learners will be able to generate solutions to problems based on information they have gathered.

In their collaborative groups, students will list strategies to solve their chosen problem. For each strategy, students will list and discuss the positives, negatives, and consequences for their suggested solutions (Torp & Sage, 2002). Students will use the table below to help them organize their ideas.

Strategy	Positives	Negatives	Consequences

Step Seven: Determine the Best Fit of Solutions

This step requires students to think critically about their solutions by evaluating each conclusion and reflecting on their reasoning (Torp & Sage, 2002).

Role as a Facilitator

I will observe each group to make sure they are on task. I will offer support to students by asking clarifying questions if groups need help reaching a consensus.

Day 14

Objective: Learners will be able to communicate what they have learned to their classmates.

Students will work in their groups and discuss their solutions to the problem. They will use the activity from Day 13 to guide their discussion, explaining the pros, cons, and consequences for each solution. Each group will come to a consensus about the best solution. Each student will write a journal entry about the best solution their group has decided upon. The journal entry will allow me to access students' progress individually.

Step Eight: Present the Solutions

This step allows students to show what information they know by presenting their findings to others (Torp & Sage, 2002).

Role as a Facilitator

I will provide an active learning opportunity for students. They will demonstrate what they know by listening to the ideas of other groups, and they will be able to ask questions and make comments about the presentations.

Day 15 – Day 17

Students will use Google Slides to create a presentation that will be shared with the class. Using Google Slides, students will be able to collaborate on the presentation, therefore each group will be responsible for creating one presentation. During Day 16 and Day 17, students will present their findings to the class. This will give students an opportunity to hear and respond to their classmates' perspectives. Details about the rubric used for grading the presentations are found under Data Collection Instruments.

Step Nine: Debrief the Problem

This step allows students to reflect on their learning (Torp & Sage, 2002).

Role as a Facilitator

Students will again be active learners by thinking about the process used to solve the problem. I will listen to their discussions and ask clarifying questions if needed.

Day 18

Objective: Learners will reflect on the intervention and strategies used to implement the intervention.

Students will reflect on the intervention using whole-class discussion. Students will be able to discuss any changes they would make in solving different problems. This will allow students to think about their own learning.

Day 19

Review for the post-test.

Day 20

Students will complete the post-test.

This timeline allows for flexibility if students need additional time to complete the intervention.

APPENDIX C

TEACHER OBSERVATIONS OF STUDENTS TEMPLATE

<table>
<tr><td colspan="3">Teacher Classroom Observations</td></tr>
<tr><td>Date:</td><td>Day of Intervention:</td><td>Participants:</td></tr>
<tr><td colspan="3">Types of Engagement Being Observed</td></tr>
<tr><td><u>Cognitive Engagement</u>
-Assignment completion
-Attempt</td><td colspan="2"></td></tr>
<tr><td><u>Emotional Engagement</u>
-Happy/Sad
-Interested/Bored
-Calm/Anxious</td><td colspan="2"></td></tr>
<tr><td><u>Behavioral Engagement</u>
-Positive
(Collaborating/Interacting/On-task communication

-Negative
(Off-task, causing classroom disruptions, presence in the classroom)</td><td colspan="2"></td></tr>
</table>

Problem-solving Skills Observed
Observation Skills (gathering information, understanding meaning by identifying key points)   Critical thinking skills (identifying problems, making inferences, identifying solutions)
Teacher Reflections:

APPENDIX D

STUDENT ENGAGEMENT SURVEY

Student Engagement Survey

Directions: Please read each statement and select the answer that best represents the degree of your agreement or disagreement.

Question	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
I feel like I am working hard while completing the activities for this unit.					
I made an attempt to complete all of the activities for this unit.					
While completing the activities for this unit, I try to understand content more by relating it to things I already know.					

While completing the activities for this unit, I make an effort to think about how the information is useful in the real world.					
I think what we are learning about is interesting.					
I think what we are learning about is boring.					
I feel happy working with my group when trying to solve problems.					
I feel sad working with my group when trying to solve problems.					
I feel like I have a chance to interact with my group members.					
I enjoy talking with my group members.					
My mind wanders while working with my group.					
I am an active participant in my group.					

APPENDIX E

TEACHER-CREATED RUBRIC

Criteria	3	2	1	Score	Comments
Organization	Presentation has a logical sequence of information	Presentation has some logical sequence of information	Presentation has no logical sequence of information		
Language	Spelling and grammar are correct	There are few spelling and grammar errors	There are many spelling and grammar errors		
Appearance (Text, graphics, video)	Presentation is appealing	Presentation is somewhat appealing	Presentation is not appealing		
Identification of problem	Problem clearly identified	Problem somewhat identified	Problem not identified		
Gathering of relevant content information	Topics cover content in depth, and information is accurate and relevant	Topics cover some content, and some information is accurate and relevant	Topics cover little content, and information is not accurate or relevant		
Solutions	Pros, cons, and consequences are identified and addressed appropriately	Pros, cons, and consequences are identified and somewhat addressed	Pros, cons, and consequences are not addressed appropriately		

APPENDIX F

INFORMED CONSENT FORM

<u>Informed Consent Form</u>

UNIVERSITY OF SOUTH CAROLINA

CONSENT For Your Child (Student) TO BE A RESEARCH SUBJECT

Implementing Meaningful Problem-Based Learning in a Middle School Science Classroom

Dear Parent/Guardian: I am inviting your child to participate in a research study.

KEY INFORMATION ABOUT THIS RESEARCH STUDY:

You (your child) is invited to volunteer for a research study conducted by Celestine Pough. I am a doctoral candidate in the Department of Education, at the University of South Carolina. The purpose of this study is to explore the impact of a problem-based learning instructional approach in an eighth-grade college preparatory science classroom. This study is being done at S. Fox School (pseudonym) and your child is being asked to participate due to their grade and grade level placement.

The following is a short summary of this study to help you decide if your child would like to be a part of this study. More detailed information is listed later in this form.

The purpose of this study is to investigate the impact of a problem-based learning instructional approach in a middle school science college preparatory class. The problem-based learning instructional model will be implemented for 20 days during the Forces and Motion unit of study. Participants will be presented with an ill-structured problem and asked to identify solutions for the problem. Ill-structured problems lack a clear solution, and they can also have multiple solutions. Using problem-based learning, students will be asked to work collaboratively and communicate their ideas. All information collected or revealed will be kept confidential, and only pseudonyms will be used for students' names and the school's location. There are no foreseeable risks or discomforts to students.

PROCEDURES:

If you agree to have your child participate in this study, your child will work collaboratively to offer solutions to an ill-structured problem that will be presented to the class.

DURATION:

Participation in the study involves 20 days to work through the steps of problem-based learning, a total of a 4-week duration.

RISKS/DISCOMFORTS:

There are no identifiable risks other than a potential loss of confidentiality. There is always a risk of a breach of confidentiality, despite the steps that will be taken to protect your child's identity. Specific safeguards to protect confidentiality are described in a separate section of this document.

BENEFITS:

This study will likely benefit the participants by learning skills using problem-based learning to help students learn science content. The responses and analysis from the study will help future students who are in similar circumstances.

COSTS:

There will be no costs to you for your child participating in this study.

PAYMENT TO PARTICIPANTS:

You will not be paid for your child participating in this study.

STUDENT PARTICIPATION:

Participation in this study is voluntary for your child. **You are free to not have your child participate, or to stop your child from participating at any time, for any reason without negative consequences.** Your child's participation, non-participation, and/or withdrawal will not affect your child's progress, grades, or his/her relationship with his/her teachers or S. Fox School.

CONFIDENTIALITY OF RECORDS:

Information obtained about your child during this research may be published, but your child will not be identified. Information that is obtained concerning this research that can be identified with your child will remain confidential to the extent possible within State and Federal law. The investigators associated with this study, the sponsor, and the Institutional Review Board will have access to identifying information. Study information will be securely stored in locked files and on password-protected computers.

VOLUNTARY PARTICIPATION:

The school district is neither sponsoring nor conducting this research. There is no penalty for not participating. Participants may withdraw from the study at any time without penalty.

Participation in this research study is voluntary. You are free to not have your child participate, or to stop your child from participating at any time, for any reason without negative consequences. In the event that you do withdraw your child from this study, the information you have already provided will be kept in a confidential manner. If you wish to withdraw your child from the study, please call or email Celestine Pough.

I have been given a chance to ask questions about this research study. These questions have been answered to my satisfaction. **If I have any more questions about my child's participation in this study, I am to contact Celestine Pough at (803) 917-3267 or email BANKSCR@email.sc.edu.**

Concerns about your rights as a research subject are to be directed to, Lisa Johnson, Assistant Director, Office of Research Compliance, University of South Carolina, 1600 Hampton Street, Suite 414D, Columbia, SC 29208, phone: (803) 777-6670 or email: LisaJ@mailbox.sc.edu.

Informed Consent Form

UNIVERSITY OF SOUTH CAROLINA

CONSENT For Your Child (Student) TO BE A RESEARCH SUBJECT

Implementing Meaningful Problem-Based Learning in a Middle School Science Classroom

Dear Parent/Guardian: I am inviting your child to participate in a research study.

Student's Name: ___________________________

School's Name: ___________________________

Teacher's Name: ___________________________

Please check one of the boxes below.

☐ I **agree** (for my child) to participate in this study. I have been given a copy of this form for my own records. The copy provides details about the procedures that will be used in this research study.

☐ I **do not** wish (for my child) to participate.

If you (your child) wish to participate, you should sign below.

______________________________ ___________________________

Signature of Parent/Guardian Date