

EFFECTS OF PROJECT-BASED INQUIRY LESSONS INTEGRATED WITH
TECHNOLOGY ON UNDERSTANDING EIGHTH-GRADE PHYSICS CONCEPTS

by

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July 2014

DEDICATION

This paper is dedicated to my husband, Matthew, and my brother, Frank, who watch over me from the heavens. In addition, special thanks to my sister, Carla, who kept me focused and continually inspires me to reach my goals.

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ABSTRACT

The purpose of this project was to identify any effects Project-Based Learning (PBL) that incorporated technology had on student understanding, motivation, and long-term memory in an eighth-grade physical science course. The project was implemented over an eight week period. The first intervention phase was a teacher-oriented lecture-based environment on the topic of motion. No technology was accessible during the first phase. The second phase introduced the students to the PBL model and engaged them in the process of understanding speed through questioning, research and collaboration using Web 2.0 tools. The second phase, also referred to as intervention one, lasted 12 school days. Students had full access to computers and were directed through the stages of inquiry. This intervention phase was both teacher and student-directed with the teacher acting as facilitator for the latter portion of the lessons. The final intervention lasted 14 school days with full use of technology for all aspects of the class. Students studied Newton's laws, completed research, and collaborated on the development of a moving car that modeled Newton's Third Law. Following the PBL model students led the discussions, freely engaged in the learning, openly discussed and argued the points of their project research as well as the models that they created. Students showed improvement in assessments without any negative performance impact and in general responded positively on the Likert surveys that they wanted to continue to help with the project research, continue learning in the PBL inquiry model, and continue to have access to technology as a tool for learning.

INTRODUCTION AND BACKGROUND

With the onset of Common Core State Standards and the Next Generation Science Standards (standards designed to aid students in obtaining skill sets needed for future employment), students will be required to become critical thinkers. The vast majority of science classes are dominated by traditional teacher-centered instruction, contradicting the student-centered recommendation found in research (Tanner, 2009). Students need opportunities to engage in the true nature of science and develop the ability to communicate, argue, and form a deeper understanding of the world around them (Abu Sbeih, Barakat, Boujettif, & Jalil, 2009).

At the beginning of each school year, I ask my students what they like and dislike about science. The general theme is that science is boring and is not relevant to the students' life. My district predominantly utilizes the teacher centered approach, which promotes an apathetic attitude exhibited by the students entering my classroom; therefore, teaching critical thinking poses new challenges. I felt strongly that the current teacher-centered method of cultivating student interest did not properly prepare nor motivate my students to engage in learning. However, if I could implement a Problem/Project-Based Learning (PBL) model, then the students would have an opportunity to be involved in their own learning, making the curriculum more meaningful. Fortunately, my district offered me an opportunity to pilot a one-to-one computer environment that uses blended inquiry where students increase their use of technology via netbook computers and other Web 2.0 tools. According to the Pew Research Center (2013), American adolescents desire to be connected to technology for large portions of their day. Unfortunately, they

then enter the classroom where they are required to disconnect. My goal was to eliminate the boredom of passive lectures to help students construct their learning to become better problem solvers. My aspiration was to teach science in a way that sparked student interest, decreased apathy, and created a link to new understanding of science concepts through a PBL model that incorporated technology into the learning within the classroom.

Over the last four years, I had used computers for labs or had conducted problem-solving activities without technology, but I had not combined the two strategies. I determined that using the technology while implementing PBL would promote student interest and content comprehension (Hmelo-Silver, 2004). For this project, PBL is identified as a means to increase the skills of questioning and observing, as well as collecting and analyzing data on the part of the student. Instead of direct instruction that required rote memorization, pieces of information were given as a means to engage the students allowing them to create questions, or inquire, about their learning. Once engagement had taken place, the students would be guided toward the “problem” with the hope they would research and problem-solve to find the answers. The PBL method provided additional opportunities for the student to have an active role in the learning process and allow the curriculum to have more meaning to the students. The technology and strategies currently available to advance my teaching techniques lend themselves to this blended format. As one of the pilot sites for this technology option, there is a possibility that my capstone results may be used for guiding peers in the classroom use of one-to-one technology.

The study was conducted in one of my physical science classes at the campus of San Elijo Middle School, (SEMS), San Marcos, California. San Marcos is comprised of approximately 87,000 residents with a median household income in the city of \$44,000 (city-data.com, 2012). Due to the districts large size there are three middle schools with a demographics for SEMS of 62% Caucasian, 21% Hispanic, 10% Asian, 4% African American, 2% Other, and a population of 1,750 students.

My focus question for this capstone project was: What are the effects of implementing blended technology- based PBL lessons on my students' understanding of eighth-grade physics concepts? The project subquestions were: What are the effects of instruction that utilizes blended technology-based PBL lessons on my students' motivation and engagement toward science; what are the effects of using blended technology-based PBL lessons on students' long-term memory; and what are the effects of blended technology-based PBL lessons on my attitude and motivation toward teaching eighth-grade physical science?

For this project, Dr. Peggy Taylor, Montana State University Masters of Science in Science Education (MSSE) Program Director served as the Committee Chair; Dr. Jewel Reuter was my Capstone Advisor for this project. Terrill Paterson served as my Montana State project reader. My sister, Dr. Carlotta Rody, Educational Specialist, provided support and feedback throughout this project.

CONCEPTUAL FRAMEWORK

The following conceptual framework includes research on the impact technology and inquiry had on student motivation and critical thinking. This conceptual framework briefly addresses the definitions of constructivism in terms of identifying student

understanding through PBL or inquiry and how PBL is used and implemented with regard to the impact on student motivation, understanding/comprehension, and long-term memory follows. The latter part of the framework focuses on the attitude and role of educators in regards to the blended project-based inquiry lessons in the classroom.

Vygotsky's definition of constructivism, as a learning theory, placed emphasis on learner-based higher-order thinking; whereby knowledge, before becoming an internal process, must first be socially constructed (Reid-Griffin & Carter, 2004; Vygotsky, 1978). To further extend the idea of the student being socially involved in his/her own learning, an article by Martin (2004) analyzed the more recent social cognitive studies of Bandura as they apply to the student as a self-regulated learner in the classroom. The article offered that active engagement and inquiry methods of learning, when facilitated by the teacher, promotes and encourages students to take risks and pursue learning in areas where they may encounter solutions that are incorrect (Martin, 2004).

Within the environment of PBL, the student may or may not encounter a textbook correct answer (Barrows, 1986). The PBL approach was originally introduced and developed in the field of medical education and is currently being used throughout K-12 and higher academic settings (Savery, 2006). Problem-solving skills incorporate subject matter knowledge in addition to general analysis skills where the learner acquires new knowledge by engaging in realistic problem solving. Generally speaking, the learners are gathered in small groups, with the instructor providing resources and appropriate coaching, while acting as a facilitator for the group (Barrows, 1986; Hmelo-Silver & Barrows, 2008; Savery, 2006).

To evaluate the effects of using blended technology-based inquiry lessons on students' understanding of science concepts, a study conducted by Reid-Griffin and Carter (2004) with seventh and eighth-grade students at a magnet school, used data collection for a nine-week, elective class, on exploring various forms of technology for use in math and science. The study found that middle school students were able to use the technology and through data collection developed their own understanding of science topics by manipulating variables, making changes to their experiments, making mistakes, and problem solve in order to become independent learners. The technology provided students with an opportunity to collect high-quality data they could examine for patterns and trends. This could be analyzed immediately to make sense of the data and increase their concept understanding.

In an action research study with sixth-grade earth science students, Wang, Ke, Wu, and Hsu (2011) used student interviews, questionnaires, and self-evaluations to determine whether student understanding of the science concepts were increased. Students were allowed to conduct self-directed investigations with a focus on autonomy. Students were able to create, discuss, peer-review and collaborate with the use of blogs, presentation tools, and the Internet. By incorporating technology as a tool within the PBL environment, students were able to connect their learning to both the social and physical domains and enhance their understanding of the concepts. The study concluded that the experience of collaborating created an atmosphere of learning that promoted value and motivation in the learning process.

As a means to increase motivation, funds and resources are spent on technology with the expectation that learners can explore, experiment, problem solve, and improve

their scientific reasoning. For instance, the case study conducted by Reid-Griffin and Carter (2004), showed that seventh and eighth-grade students using science probes and designing experiments for the nine-week science class were able to engage in discussions, while collecting and analyzing data which aided scientific thinking. The teacher in this case study used the PBL method, created a scaffold of instruction into three tiers, with full responsibility of completing the project placed on the student in the final tier. The release of responsibility by the teacher provided opportunities for the student to interact and collaborate with peers, and ultimately take on the responsibility to complete the task (Reid-Griffin & Carter, 2008). Using student-oriented learning with inquiry and PBL increases motivation according to a study with a college-level biology course conducted by Annerstedt, Garza, Huang-DeVess, Lindh, and Rydmark (2010). In addition, in order to motivate students and engage them in the critical thinking process that promotes active science learning, instruction must tap into prior knowledge and generate questions that the student finds meaningful and engaging (Krajcik & Sutherland, 2010; Singer, Marx, Krajcik, & Chambers 2000).

Student engagement is increased with PBL and technology. According to Harmer and Cates (2007), “inquiry should include the use of technology and allow freedom of exploration within a meaningful assignment” (p. 107). Their research study involved sixth-grade students using an online, PBL method of inquiry to investigate West Nile virus. The goal of the study was to determine to what degree the students would engage in research via a real problem-based inquiry. The results of their study concluded that through ownership, students were provoked to solve or look for solutions to a problem they could relate to. Furthermore, technology allowed students to gain insight and share

their solutions to the problem by connecting with data and sources outside the realm of the classroom (Harmer & Cates, 2007). Blended technology-based inquiry lessons create opportunities for students to become engaged in the process of learning.

As an example, using a blended technology-based inquiry environment with similarities to game playing, a study was conducted with 220 students in a sixth-grade earth science class as they learned about the solar system and the process of scientific inquiry (Liu, Horton, Olmanson, & Toprac, 2011). In their study, students were presented with the task of finding a planetary home for an alien species that had landed on Earth. Through problem solving and information gathering, the students used the media program to learn about the environments of outer space and complete the task of finding a suitable home for the alien to survive. Using an Intrinsic Motivation Inventory and four subscales on a five-point Likert scale, student motivation was assessed. On a scale of 1-5, students scored 3.65 in interest/enjoyment, 3.77 on perceived competence, 4.00 on effort /importance and 3.41 on value/usefulness. Liu et al. (2011) found the various assessment responses led to the conclusions that the PBL process motivated most students and increased student knowledge of the concepts because it was considered *fun*. When the unit concluded, knowledge was measured via a 20 item test that addressed knowledge and application, combined with a motivation questionnaire using a Likert scale and an open-ended survey. The data indicated the word “fun” was mentioned over 100 times.

Further analysis found when motivation scores were high, the posttest knowledge score was also high suggesting motivation and understanding were linked (Liu et al. 2011). When students have an interest in the task, there is a greater chance to complete the work. Motivation is identified as a desire to feel confident in their work and can be

influenced by curiosity, challenges, and a feeling of being in control (Liu et al., 2011; Seifert, 2004). In a PBL environment, students create finished projects and present them as a group, promoting cooperative learning, creativeness, and critical thinking. Being able to present and explain their ideas, serves to increase motivation, understanding, comprehension, and promote recall of the information (Blumenfeld et al., 1991).

PBL projects have the potential to foster students' understanding and interest while providing freedom to construct knowledge, by being involved in the activity, which can result in the long-term retention of the material (Blumenfeld et al., 1991). In a PBL environment, students that are interested and motivated are more likely to internalize the information and add it to their personal knowledge base, which aids in retention and comprehension (Hmelo-Silver, 2004). In an article evaluating data on how students learn in the classroom, Nuthall (2004) stated that students in upper elementary science and social studies classes learn best when they were able to confront new information in different formats and varying manners. In this approach, students were better equipped to transfer the new ideas into their long-term memory. He further added that in order for students to learn, their previous incorrect ideas or misconceptions need to be replaced with new ones and it becomes the job for the educators, not only to teach the content, but also teach the students how to learn as an aid to understanding and retention of information.

If students are engaged in the act of learning, motivation and attitude on the part of the teacher may be affected. When evaluating teacher motivation and attitude toward the PBL method, an article by Harris and Rooks (2010) on classroom management practices, within the K-8 science field, offered that teachers in a technology-based PBL

environment needed to have some expertise in technology to be able to troubleshoot any issues without diminishing the task of leading the students. They further offered that teachers must provide structure to the lesson and for those teachers not familiar with actual research or PBL, the lack of interest and motivation generally resulted in the desire to revert back to the teacher-oriented type of lesson. Bandura (2002) promoted the idea that people contribute, influence, and construct their own circumstances whereby identifying their behavior and motivation. He also stated that if teachers doubt their capability to implement new instructional strategies such as PBL, they will shy away from those approaches, and stay in their teaching comfort zone (Bandura, 2002). Additional issues identified by Harris and Rooks (2010) that may affect attitude and motivation for teachers pertain to the need for technology to be working, support of the school administration, and opportunities to participate in science as a practice.

Oliver and Corn (2008) conducted a study of 300 middle school students at a private school over a two year period and offered that more than a year of training was needed for teachers in the one-to-one environment to implement a student-centered approach, which signifies that teaching in a blended technology-based inquiry environment requires a long-term commitment. In her research study on PBL, Hmelo-Silver (2004) offered that individual teaching style and instructional beliefs can create discomfort on the part of the teacher to attempt any changes in teaching instruction. Additional research studies of middle school and high school teachers working with blended technology-based inquiry instruction found new teachers were less likely to attempt anything new or different when teaching and were more concerned with managing the classroom, planning lessons, and providing assessments (Toolin, 2004).

Her research further indicated that experienced teachers, greater than five years, were more comfortable with new and different approaches, especially if they had prior professional development in the form of one-to-one or project based instruction.

Teaching with PBL creates an environment where students are allowed to embrace problems they may come across in the workplace. By using scenarios as starting points, with student-led groups, the PBL model allows for more self-directed learning. The PBL model provides a more realistic approach to science, but teachers should be aware changes in learning may intimidate some students resulting in a lack of motivation (Blumenfeld et al., 1991).

In summary, Vygotskys' constructivist theory lends itself to this setting of blended technology-based inquiry lessons, as it sets the stage of the student as the learner. Barrow's original work with PBL in the medical field, coupled with the research by Blumenfeld, Krajcik, and Palinscar (1991) are more current due to the increased number of studies that pertain to blending technology with the inquiry methods of learning. These studies provide evidence the PBL model of teaching is in the best interest of students. PBL calls on students to engage in the true aspects of learning, such as creating, while enhancing their skills in public speaking and teamwork. Any negative aspects that may be associated with PBL are minimized by the positive benefits of developing skills that enable students to become life-long learners and by providing safeguards with special teaching strategies to help minimize the negative effects.

METHODOLOGY

Project Intervention

For this study, a nonintervention and two intervention units provided the means to compare and form conclusions regarding the changes made to instruction of teaching physics concepts at the eighth-grade level. The research methodology for this project received an exemption by Montana State University's Institutional Review Board, and compliance for working with human subjects was maintained. The purpose of this project was to utilize blended technology-based PBL lessons to study the impact on my students' understanding of physics concepts. This project consisted of one complete physics unit subdivided into three consecutive subunits. Using traditional teacher-centered methods, a nonintervention unit on motion preceded two intervention units on speed and force incorporating Newton's three laws. The technology-based PBL model utilizing a cycle of questioning, research, discussion, creating, and reflection was used for both intervention units.

The nonintervention unit lasted for 10 instructional days. The topic of motion was introduced by asking the students "how they know an object is moving?" and "how would they know if the object was moving quickly or slowly?" Students were taught through direct instruction and lecture format. On the first day of the unit, students were given direct instruction via lecture format. The second day, students were again guided with direct instruction on the concepts of reference points, distance, and displacement and then completed a set of notes from the textbook used for the class. The third day students completed an activity in class by estimating distance and displacement by making comparisons of the two values. Activities for the remainder of the unit included lectures

on the steps of the scientific method, information on designing experiments, analyzing, and concluding a lab activity. Direct instruction was followed by class discussions with review of the information through a question and answer format. Specific examples of prior year student work were used and modeled during instruction. Students then worked in groups of four to conduct a series of cookbook type labs on motion. One of the labs, in which students were required to create ramps and make observations regarding the distance the object traveled and then graph the resulting data, is included in Appendix A. The nonintervention unit was characterized by teacher-centered instruction and did not use technology or PBL.

Physics concepts are cumulative and required scaffolding past lessons with future content as students worked through each unit. The instructional intervention units included problem-based explorations of phenomena, laboratory experiments, small group, and whole class discussion and design projects. Students were able to collaborate in order to complete lab activities, obtain peer-review of the work before submission for grading, and completed online quizzes from home. Technology was accessible during all portions of the intervention units providing opportunities for students to research, collaborate, and share ideas.

The first intervention unit lasted 12 days and focused on speed and acceleration. To utilize the PBL method of instruction and engage the students into the project, the story of the tortoise and the hare was given. The question of “which one was faster?” was followed by the question “what is speed?” A class dialogue followed, where students generated questions and responded to each other’s inquiries. After the discussion, which included a review of the formula for speed, the students were guided to an online computer simulation that allowed them to experiment with the variables of speed and

acceleration. Upon completion of the simulations, students created groups of three and turned their focus toward the first project/problem for this activity which was researching the three fastest animals known to man. Their objective was to research and then explain how fast their animal choices were, why they chose those three animals, and to defend their choices during group presentations. The final portion of the lesson incorporated their research into creating a Google presentation and a poster. Students presented to a group that had selected different animals and were required to debate and champion their choices by calculating specific speeds for their animals. The final presentations were shared with the teacher for review. Following the group presentations, students reflected upon the choices of each group and challenged to calculate each animal's acceleration based on a specific set of data. The sample lesson can be found in Appendix B.

Based on the student discussions of speed and acceleration, the students were introduced to graphing concepts that are used in physics. Students were directed to an interactive virtual graphing lab that allowed students to see variances in graph shapes when data was altered. Once completed, the students were presented with the next project and question: "How do you create a catapult that can launch marshmallows using only the given materials?" Using only four rubber bands, two Popsicle sticks, one plastic spoon, two marshmallows, six inches of masking tape, and a shoe box, students were left to design a functional catapult. The PBL model incorporated the stages of defining the problem, gathering information/research, planning/discussion, building/creating, testing, evaluating, and then communicating/reflecting. Most students were familiar with the project idea and had seen pictures of catapults or trebuchets and consequently had an idea of what they were building. After a review of the required materials, students were

guided toward a website to research catapults. From that point, the student-centered model replaced the teacher-centered model of instruction as groups began to build and test their catapults. Computers were available for research and information gathering throughout the process, which led to design, creation, and building. In keeping with the PBL model, I moved from group to group questioning designs, asking for clarification, and answering questions when needed acting as a facilitator for the class. Evaluation of the models came into play when students tested for accuracy and competed against other groups. Students used the previously mentioned graphing activity to help calculate angles for launching their marshmallow, which resulted in design and accuracy improvements. Observations of the students as they practiced and competed for distance and accuracy launching marshmallows at the target enabled me to ascertain their level of understanding of the graphing activities. The catapult lab can be found in Appendix C.

To evaluate student understanding of speed, graphing, and acceleration, two additional labs were conducted. In Roller Coaster Design (Appendix D), students used simulations for roller coasters and then designed one. In Parachute Lab (Appendix E) students created parachutes of varying sizes that were then dropped from a set height. Data were collected, graphed, and analyzed from both labs for conceptual understanding.

The second and final intervention unit lasted twelve days and focused on forces and Newton's three laws. To introduce the PBL model of learning, activate prior knowledge, and identify any misconceptions, students were asked, "if both a tennis ball and a basketball were dropped why both balls fall to the floor?" I proceeded to drop a variety of different size balls so students could observe their motion and then explain the force of gravity. To proceed with the questioning phase of PBL, two mini-labs, Free Fall

and Moving Marbles (Appendix F) were introduced. Students were grouped and proceeded to conduct the labs. Small group and whole classroom discussions concluded both activities and paved the way for the final culminating design project. To incorporate the PBL model, the previous activities provided the means to guide instruction toward understanding of Newton's Laws. To then demonstrate Newton's laws, students were given the project of building a Newton's Scooter. Their goal was to build a vehicle that moves without the use of gravity, electricity, or help from any person. The vehicle must travel a minimum of 1.5 meters, move forward by pushing back on something (Newton's third law) and abide by the safety guidelines of the school and classroom. As the Newton Scooter lab was introduced, students were already generating their own questions of how to construct and build the model. In the student-centered model of learning, I took the position of resource/facilitator and answered individual group questions as they occurred moving from group to group. Each group researched ideas, planned their design, and then tested their model. Design changes and suggestions with added resources were provided by me for groups that needed assistance or were in any way challenged with the task. The final phase of the PBL model is reflection and each group was guided through an analysis of the different models that had been built. Students discussed what worked best versus what did not work well for each design, noting changes they could have made to their model. The Newton Scooter lab can be found in Appendix G.

After each activity or lab, students shared their comments, questions, and explanations. Additional math problems were used for filling in data on formulas and then solved to aid students in working through the physics problems. Student sketches for their vehicle allowed assessment to be made in considering the forces that would affect

the vehicle and the planning involved. The culmination of this intervention was the competition of the Newton Scooters. Students had created various shapes and used different models to power their vehicle. Some groups went through five or more different design modifications to achieve success while others “borrowed” ideas from their peers. One group gave up and preferred to watch the other teams and cheer them on to victory.

Incorporating the blended technology-based PBL allowed students to create questions pertaining to everyday occurrences. Students were able to research, collaborate, communicate, take possession of their learning, and help each other learn. Using the tools and technology available increased the level of engagement, provided a means for research and collaboration, making learning relevant, which enhanced concept understanding and motivation.

Data Collection Instruments

I determined that both my sixth and seventh-periods would benefit with interventions in place. My sixth-period class became the trial class to eliminate any technology issues while my seventh-period physical science class was my choice for this project, consisting of 33 students, all at the eighth-grade level.

In this study, there were 12 male students and 21 females with a demographic population of 54% Caucasian and 46% Asian and/or Hispanic descent. They have an academic breakdown of 40% advanced achievement, 40% average achievement, and 21% below average achievement. San Elijo Middle School is located in San Marcos, CA, in an upper middle class neighborhood with fairly affluent families. The school is one of three middle schools within the district with 1,750 students and increasing every day. The students in this study met with me daily for 47 minutes. This class was very energetic

considering they were the last class of the day. They were eager to learn, often volunteering to teach and lead discussions, plus try new ways of learning. When asked if they would be willing to participate in my project, all of the students agreed. I have taught this course for eight years and am very familiar with the content at this grade level. These students openly discussed the projects and assessments and were eager to communicate their likes and/or dislikes concerning school and science.

Varying forms of data were collected and Table 1, below, is the data triangulation matrix used for this study. No tool used alone provides an accurate picture of data. To investigate the project questions related to technology use within the PBL model, a variety of data collection instruments was used to obtain qualitative and quantitative data.

Table 1
Triangulation Matrix

Focus Questions	Data Source		
	1	2	3
<i>Primary Question:</i>			
What are the effects of implementing blended technology PBL lessons on my students' understanding of eighth-grade physics concepts?	Preunit and postunit student assessments	Preintervention and postintervention student surveys	Preunit and postunit student interviews with concept maps
<i>Secondary Questions:</i>			
1. What are the effects of blended technology-based PBL lessons on student motivation and engagement toward science?	Teacher weekly reflection journals with prompts	Preintervention and postintervention student surveys	Preintervention and Post Nonintervention and intervention peer observation
2. What are the effects of blended technology-based PBL lessons on students' long-term memory?	Postunit and delayed unit student surveys	Postunit and delayed unit assessments	Postunit and Delayed unit student interviews with concept maps
3. What are the effects of blended technology-based PBL lessons on my attitude and motivation toward teaching eighth-grade physical science?	Preintervention and postintervention teacher surveys	Teacher weekly reflection journal with prompts	Nonintervention and intervention peer observation

The primary project question and the second subquestion focused on the effect blended technology-based PBL lessons had on my students understanding of physics concepts. Short preunit and postunit assessments in the form of five question quizzes were given before and after each unit to assess changes in understanding of the physics concepts. The assessment questions are included in Appendix H. A similar assessment was given approximately 14 days after the postunit assessment. The percent change from postunit to delayed unit was calculated to assess long-term memory of those concepts.

A student survey (Likert scale) was conducted within the first week of the nonintervention unit and again at the middle of intervention unit two. The survey was used to gauge initial impressions of science class, technology use and learning styles, plus assess students' perception of their understanding of physics concepts before and after the intervention. Some of the survey questions had follow-up open-ended prompts which provided an opportunity for more detailed explanation of a student's Likert scale choice. A student survey is located in Appendix I.

Student interviews with concept maps were also conducted to assess understanding and long-term memory. Students in the study were asked if they would be interested in openly discussing physical science topics with me. Upon their agreement, the students were divided into academic levels of low, middle, and high. One male and one female student from the high academic level were selected. The middle level of students contained only two male students and neither could commit to the interview process. Furthermore, in the low academic level there was only one female student and she was unable to commit to interviews either. As a result, two females were selected

from the middle academic level and two males were selected from the low academic level. This selection allowed me to have three females and three males as participants in structured interviews before, after, and two weeks following each unit. Notes were taken during the concept interviews as students created concept maps and linked ideas from vocabulary within the unit. The concept maps were scored using a rubric that focused on hierarchy and links between concepts. The same students participated in all interviews and the terms for the concept maps are identified in Appendix J.

To assess the effects of technology blended PBL on student and teacher motivation and engagement, I completed a weekly journal reflection. My weekly journal entries and prompts incorporated both student and teacher observations, as well as personal journaling pertained to student engagement, teacher attitude and motivation. The journal prompts are located in Appendix K. The Observer Feedback form, included in Appendix L, was used to assess the effects of blended technology-based PBL lessons on student motivation and engagement as well as teacher attitude and motivation. The assistant principal at SEMS, Patricia Kurylo, observed lessons during the nonintervention and the intervention unit and completed the observer feedback forms. A similar survey where I explained and ranked aspects of my attitude and engagement was completed pre and postintervention and is included in Appendix M.

The surveys and concept interviews scored using the rubric located in Appendix N, provided data that could be evaluated both quantitative and qualitatively. Both were used to evaluate the effect of technology based PBL on student understanding of physics concepts. Those items, in conjunction with the assessments, were used to analyze long-term memory. Changes in motivation, engagement, and attitude, on the part of the

students as well as the teacher, as a result of the technology based PBL model were assessed through preintervention and postintervention teacher journal entries, observer ratings and surveys.

The physics unit was introduced after our winter break and my study began mid-January and completed in March with the delayed assessment conducted 14 days after the Unit 2 Intervention ended. The timeline for the study is located in Appendix O.

DATA AND ANALYSIS

In an effort to gain insight about understanding eighth-grade physics concepts, data were collected using both quantitative and qualitative methods.

To assess the change in student understanding during nonintervention and intervention units, percent change was calculated between preunit and postunit assessment scores. The values are included in Table 2. There was a much higher percent change in student understanding in the second intervention as compared to the other two units. On average, high-achieving students had the greatest percentage of change in all three units. The percentage of change in assessment scores for the high and middle-achieving students on intervention unit two was almost equal.

In order to create a better comparison of the data, an average normalized gain of the postunit score was calculated and is included within Table 2. The average normalized gain for intervention 2 is much higher than the nonintervention unit, and slightly higher than the first intervention unit gain. High-achieving students had larger normalized gains in the intervention units compared to the nonintervention unit. Middle and low-achieving students had the largest normalized gain in the second intervention unit compared to the nonintervention and the first intervention units. Overall, the percentage of change and the

normalized gain show similar results in that both increased within each academic level from unit to unit.

Table 2
Average Pre and Postunit Assessment Scores with Percent Change and Normalized Gain

Nonintervention Unit				
Assessment Scores	Student Achievement Level			
	All (N=33)	High (n=13)	Middle (n=13)	Low (n=7)
Preassessment	4.8	4.2	5.4	4.9
Postassessment	6.2	6.7	6.3	5.3
% Change	29.6	58.0	17.1	8.8
Normalized Gain	0.27	0.43	0.2	.08
Intervention Unit 1				
Assessment Scores	Student Achievement Level			
	All (N=31)	High (n=13)	Middle (n=12)	Low (n=6)
Preassessment	3.1	3.1	3.3	3.0
Postassessment	6.7	8.1	5.8	5.3
% Change	102	164	77	78
Normalized Gain	0.52	0.73	0.37	0.33
Intervention Unit 2				
Assessment Scores	Student Achievement Level			
	All (N=29)	High (n=12)	Middle (n=11)	Low (n=6)
Preassessment	1.0	1.0	1.0	.86
Postassessment	8.17	8.2	8.1	6.83
% Change	690	723	709	695
Normalized Gain	0.79	0.80	0.79	0.65

Note. Maximum score out of 10.

To continue to assess student understanding, a small group of students were interviewed before and after each unit. The criteria for selecting students is described within the data collection instrument portion of this paper. Two students from each academic level met with me and created concept maps using a set of given terms for each

of the units. Utilizing a scoring rubric, each map component was evaluated. Links between two concepts that were clear and meaningful (propositions), levels of hierarchy, cross-links that connect concepts, and examples or ideas beyond the given set of terms were awarded points. There was no maximum amount of points that could be awarded, but a higher score was considered an indication of more detail and greater understanding of the concept through the linking of ideas and terms. Table 3 provides a summary of the preunit and postunit concept map scores with percentage of change.

Table 3
Average Preunit and Postunit Concept Map Scores during Interviews and Percent Change

Students	Nonintervention Unit Scores			Intervention Unit 1 Scores			Intervention Unit 2 Scores		
	Pre	Post	% Change	Pre	Post	% Change	Pre	Post	% Change
High 1	33	36	9	36	46	28	45	48	6.7
High 2	36	69	92	56	83	48	69	78	13
Average High	34.5	52.5	52	46	64.5	40	57	63	11
Middle 1	29	35	21	NA	NA	NA	37	37	0
Middle 2	37	66	78	52	92	77	52	68	31
Average Middle	33	50.5	53	--	--	--	44.5	52.5	18
Low 1	23	32	39	22	78	255	48	55	14
Low 2	22	40	82	NA	NA	NA	28	79	216
Average Low	22.5	36	60	--	--	--	36.5	67	42
Average	30	46	54	41	75	--	46	61	32

Note. NA = student was not interviewed. Pre is preunit and post is postunit.

The greatest percentage of change occurred with my lower-achieving student in Intervention Unit 1. Within each academic level there was one of the two students interviewed that showed much change in their score. No instruction was given prior to the nonintervention interview and because the concepts were significantly different for each unit the preunit concept interviews generally resulted in fairly low scores. Upon completion of the unit each student interviewed was able to make more connections, add levels of hierarchy, and provide additional examples suggesting an increase in knowledge and understanding of the concepts of force, motion and speed. The percent change was positive for all students interviewed, which could reflect that either the students became more comfortable with the process of concept mapping or their understanding did increase, or both. It should be noted the only time these students were exposed to or used concept maps for science was during these interviews. Two students, one middle and one low-achieving level, were unable to be interviewed due to illness and or absences during the preintervention interviews and the delayed interviews for the first intervention unit; consequently, eliminating an opportunity to calculate a meaningful average for that unit.

A survey given one week into the nonintervention unit and again midway through the second intervention unit was used to assess student perception of understanding. Student responses to the statement, "I have a good understanding of how the main objectives for this chapter are important to the current unit that we are studying," are shown in Figure 1. The median response for both surveys was "Agree." There was a decrease in the number of "No opinion" responses and an increase in the number of responses for "Strongly Agree" for the intervention unit. Overall, the distribution of responses shows only minor changes from the nonintervention unit to the intervention

units of study suggesting no significant change in student perception of understanding of the topics.

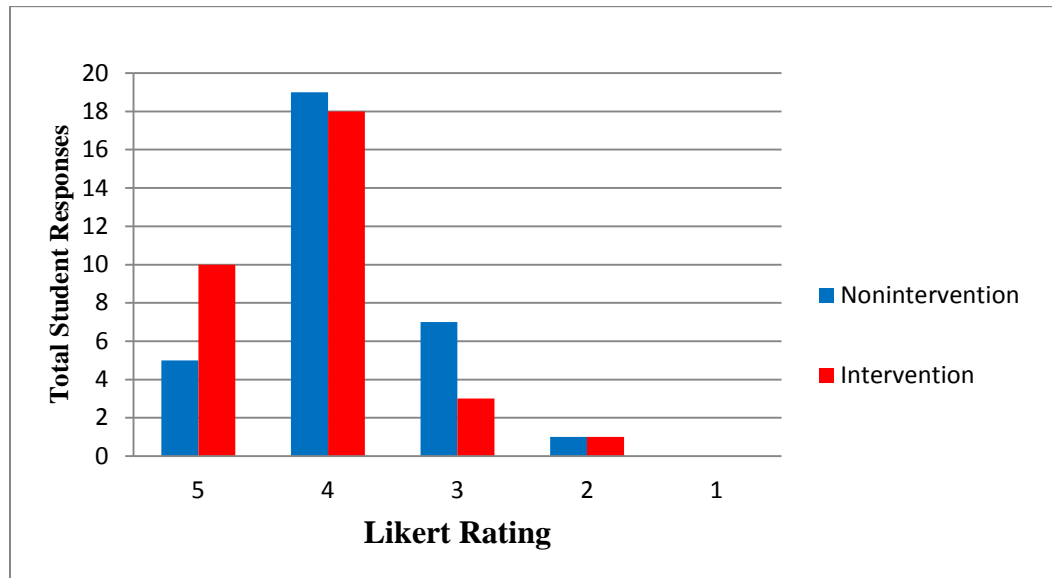


Figure 1. Distribution of student rating of understanding of the importance of objectives as measured according to surveys, ($N=32$). *Note.* Likert scale 5 = Strongly Agree, 4 = Agree, 3 = No Opinion, 2 = Disagree, 1 = Strongly Disagree.

The distribution of student Likert responses to the statement, “I feel confident that I can learn about motion, speed, and force in this class,” is shown in Figure 2. The distribution of responses shows a decrease in the number of responses of “No Opinion” in the nonintervention survey and an increase in the number of responses of “Strongly Agree” in the intervention unit. When comparing the responses from Figure 1 to those in Figure 2, there is a decrease in the number of “No Opinion” and an increase in the number of “Strongly Agree” responses suggesting that students may not have a good understanding of the objectives but they are confident, as evidenced in Figure 2, that they can learn the material. All survey questions included an option for students to explain their Likert rating and two middle-achieving students that responded with, “Strongly

Disagree” opted to share their concerns. These two students were struggling with the concepts as indicated by their written response, “I have a hard time grasping info,” and “some concepts are a challenge for me to wrap my brain around and remember.”

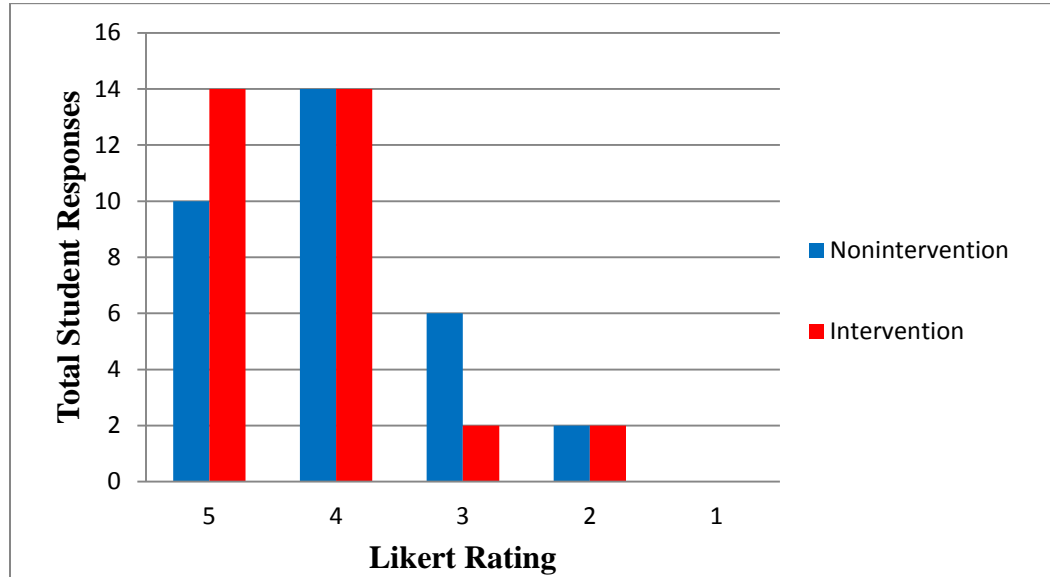


Figure 2. Distribution of student rating of confidence in learning as measured according to surveys, ($N=32$). *Note.* Likert scale 5 = Strongly Agree, 4 = Agree, 3 = No Opinion, 2 = Disagree, 1 = Strongly Disagree.

To address the technology component for student learning, the survey question, “does technology help you in the classroom,” was given. Even though technology was not used in the nonintervention unit, the majority of the students responded with “Agree” that the computers help their understanding through the research, collaboration, visuals, animations, and tutorials. Two students had no opinion on the matter and two high-achieving students were extremely against the use of technology. The comment, “I dislike using technology as it gets in the way of my learning,” was offered.

When triangulating the data, student assessments and concept interviews show mixed results for the effect of the PBL model on student understanding of physics concepts. There was an increase in learning as each unit progressed. The nonintervention

unit had required no PBL instruction or technology use and yet there were gains in understanding as evidenced by the percentage of change and the normalized gain for all academic levels. The two intervention units incorporated technology use into the instruction through the PBL model and based on student surveys the student perception of confidence and understanding increased in all academic levels. In addition, the average normalized gains on postunit assessments for the second intervention unit which provided PBL instruction with full technology access was higher for all students compared to the nonintervention unit. These data suggest the possibility that the PBL model pushed the students to interact with the material and content, perhaps aided by the technology, and created a higher level of understanding.

The secondary emphasis of this project was to assess student motivation and engagement with the concepts using both traditional versus PBL methods of teaching. In a lecture-oriented environment the focus is on teacher-led instruction with little interaction among peers. The PBL method of instruction allows for more group work and student interaction. Throughout the project I completed weekly journal entries regarding student engagement, interest, motivation, and frustrations along with a teacher survey rating statements about student engagement, motivation and attitude using the same Likert scale. Figure 3 below shows the results from the teacher survey prompts “students appeared engaged in the lesson,” and “students were showing motivation to solve problems.”

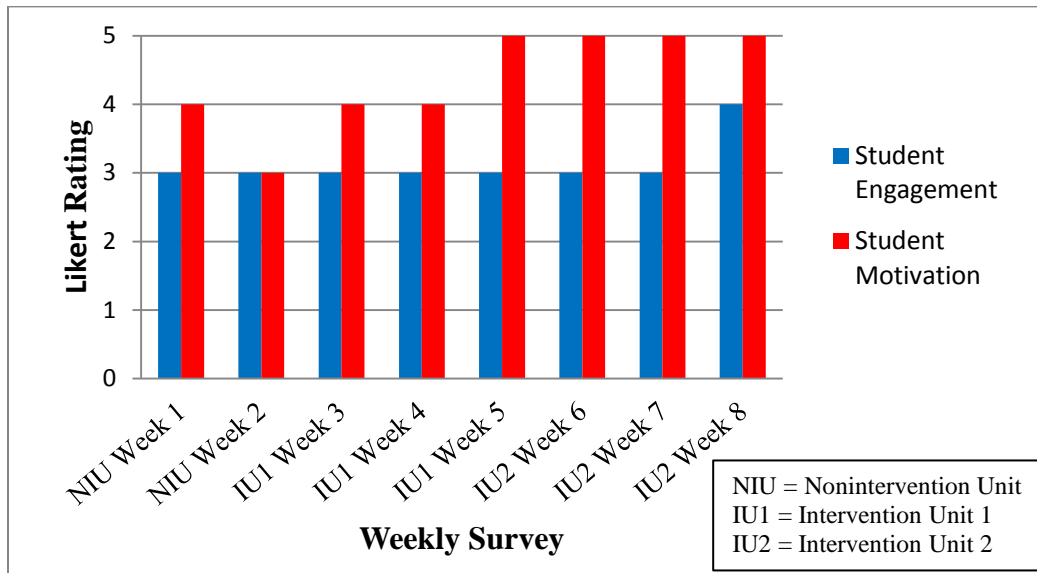


Figure 3: Distribution of teacher rating for motivation and engagement as measured according to weekly journal prompts. *Note.* Likert scale 5 = Strongly Agree, 4 = Agree, 3 = No Opinion, 2 = Disagree, 1 = Strongly Disagree.

Through my weekly observations I noted that engagement stayed about the same throughout the units, but it appeared that students pushed each other to accomplish the tasks as the weeks progressed. As the intervention unit began, the added component of having a laptop for research, visuals, collaboration, and online activities helped the classroom climate become more student-centered and less teacher-oriented. One comment, “why didn’t we get to use the computers before, this is much easier,” was made by a low-achieving student. Other students made similar comments as they worked within their groups to create roller coasters and research information for various projects.

Not everything was positive. Although not evidenced within the weekly rating, one of my weekly journal prompts was to identify “what if anything created frustration in class today?” I noted in my journal that motivation dropped as students became frustrated with the preassessments, especially in the second intervention unit. Being tested on concepts they had not reviewed and had no familiarity bothered some of them in as much

as they stated, “I feel stupid.” In addition, issues with internet connection and bandwidth not being strong enough to maintain all the computer connections created disengagement with the technology and supported the students that stated “technology is overrated and not necessary.” I noted in my journal that higher-achieving students appeared to stay engaged, while lower-achieving students connected much more with the technology option and the assistance of peer groups in the PBL model.

Student engagement and motivation was investigated through two student surveys that asked the same questions for both the nonintervention and intervention unit. The first survey was administered one week into the nonintervention unit and the second given midway through the second intervention unit. Likert ratings were recorded for four questions, with the responses for both nonintervention and intervention surveys broken down by academic level. The distribution of responses to the first two questions, “I am interested in the science topics I am learning this year,” and “I enjoy coming to science class,” were compared to obtain an overall sense of engagement and motivation. In Figure 4 and Figure 5 below, student interest changed slightly from the nonintervention to the intervention unit, with the median-academic level students showing the most change. In Figure 6 and 7, student enjoyment at the medium-academic level once again showed the most change from nonintervention to the intervention unit as student rating changed from “No Opinion” to “Agree.” When comparing the overall distribution of responses for interest and enjoyment for the nonintervention and intervention surveys the data sets were similar, with enjoyment ranking slightly higher in the “Agree” response. Students with “No Opinion” were mainly at the middle and higher-academic level while the lower-academic group median response was “Strongly Agree.” Although useful for

comparison, these results are somewhat inconclusive as the students may just like the class and may or may not like science.

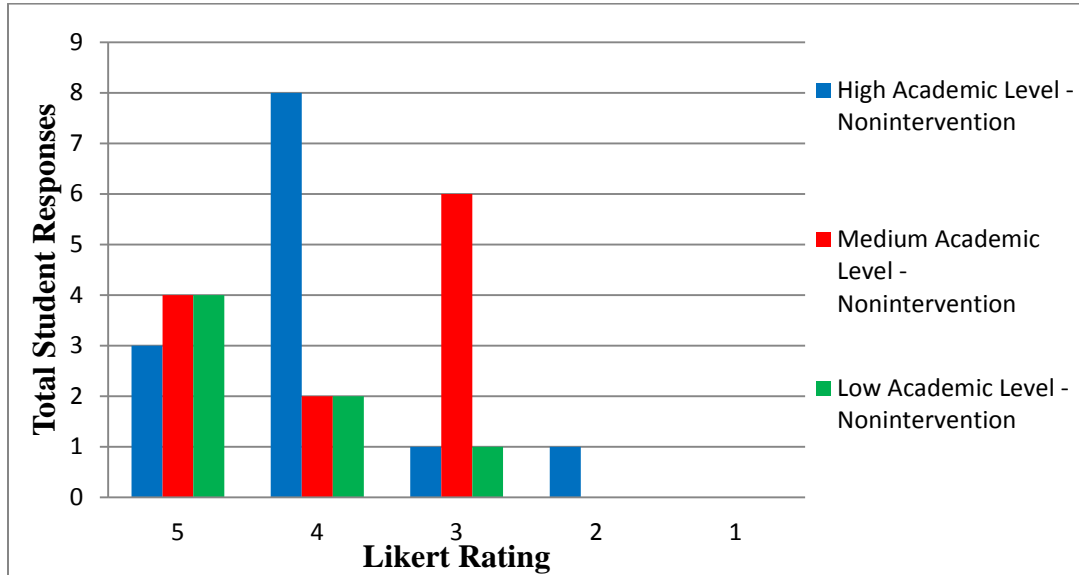


Figure 4: Distribution of student responses pertaining to interest by academic level for the nonintervention unit as measured according to surveys, (N=32). Note. Likert scale 5 = Strongly Agree, 4 = Agree, 3 = No Opinion, 2 = Disagree, 1 = Strongly Disagree.

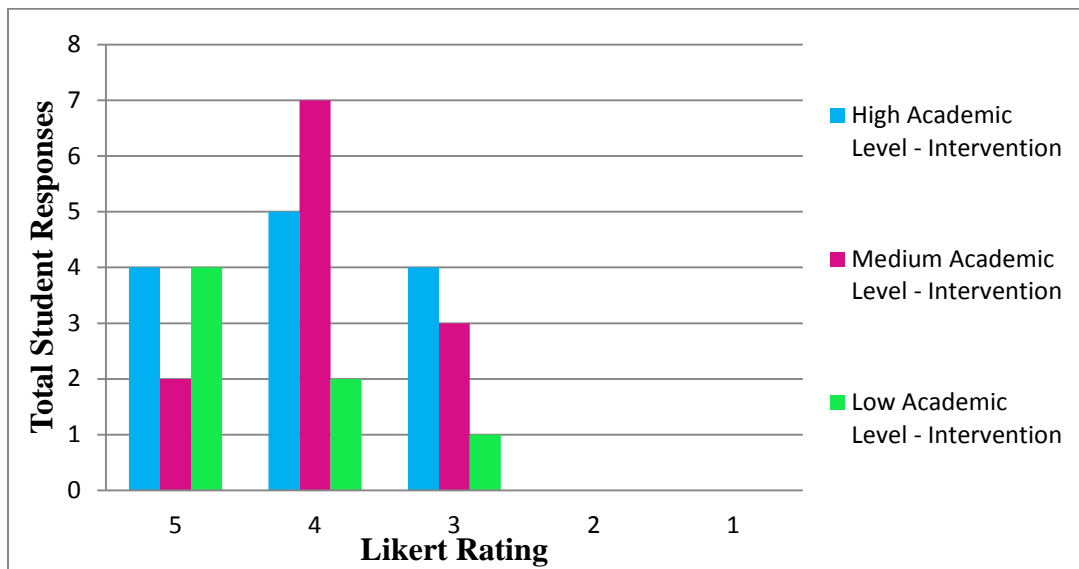


Figure 5: Distribution of student responses pertaining to interest by academic level for the intervention unit as measured according to surveys, (N=32). Note. Likert scale 5 = Strongly Agree, 4 = Agree, 3 = No Opinion, 2 = Disagree, 1 = Strongly Disagree.

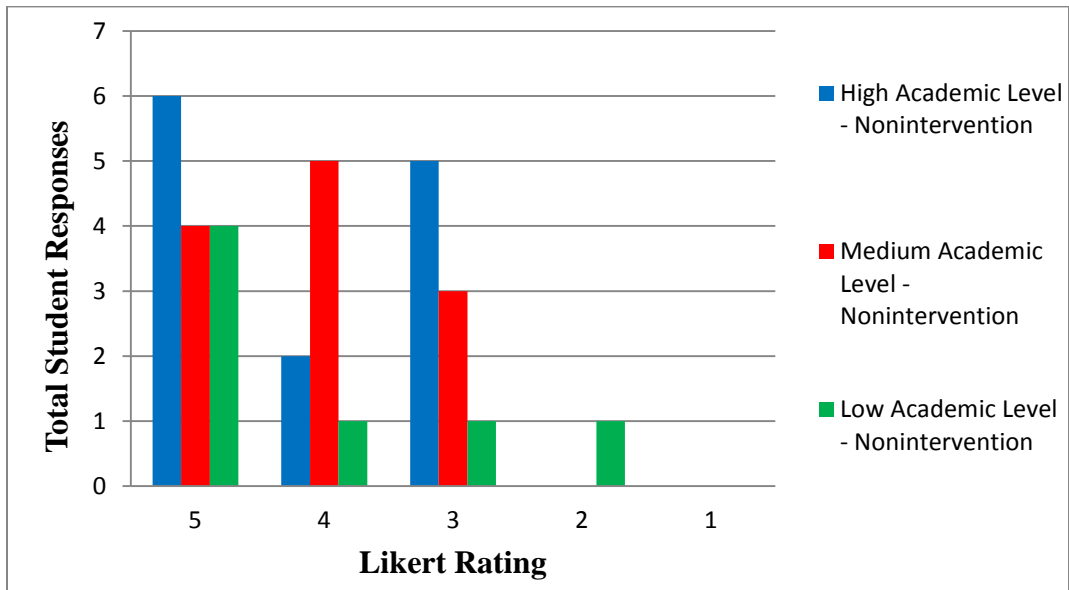


Figure 6: Distribution of student responses pertaining to enjoyment by academic level for the nonintervention unit as measured according to surveys, ($N=32$). Note. Likert scale 5 = Strongly Agree, 4 = Agree, 3 = No Opinion, 2 = Disagree, 1 = Strongly Disagree.

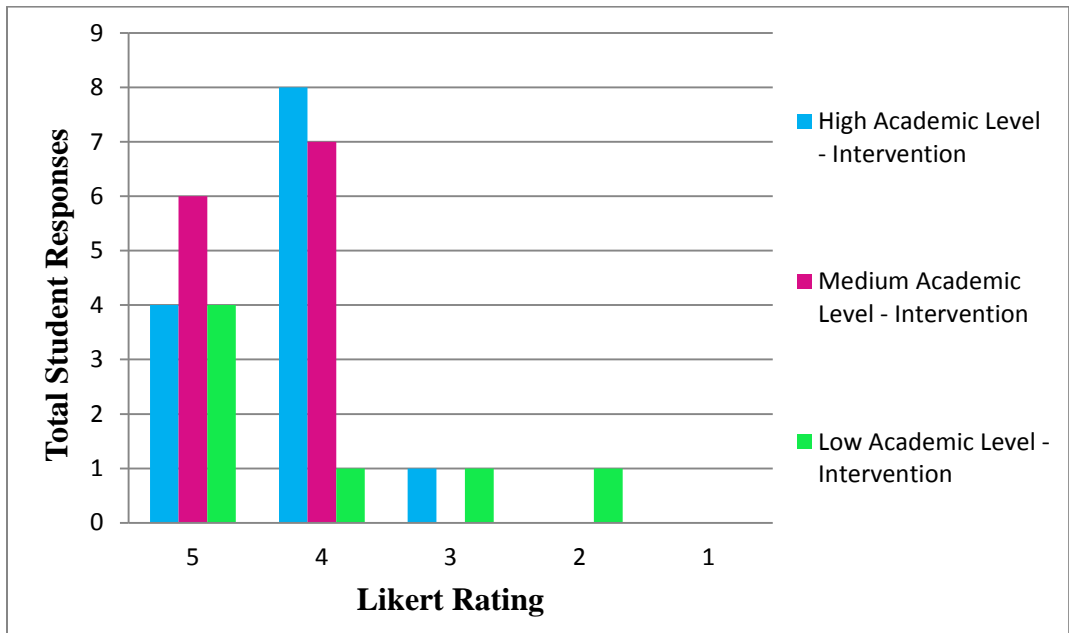


Figure 7: Distribution of student responses pertaining to enjoyment by academic level for the intervention unit as measured according to surveys, ($N=32$). Note. Likert scale 5 = Strongly Agree, 4 = Agree, 3 = No Opinion, 2 = Disagree, 1 = Strongly Disagree.

Some students became more engaged in the learning process when peers helped them learn. One of the components of the PBL method of instruction is groupings. The

distribution of responses from the third survey question, “working with peers on projects motivates me to learn more about science,” in Figure 8 and Figure 9, suggests the groupings within the PBL model used in the intervention units may have aided in motivating the students to learn.

The median response for the low-achieving students was “Strongly Agree” on both the nonintervention and intervention surveys. The median response for high-achieving students dropped from “Strongly Agree” for the nonintervention unit to “Agree” for the intervention unit. Four high-achieving students moved from the “No Opinion” rating for the nonintervention unit to a rating of “Agree” for the intervention unit. The student that selected “Disagree” was a low-achieving student that stated, “I prefer to work alone as I learn more that way.”

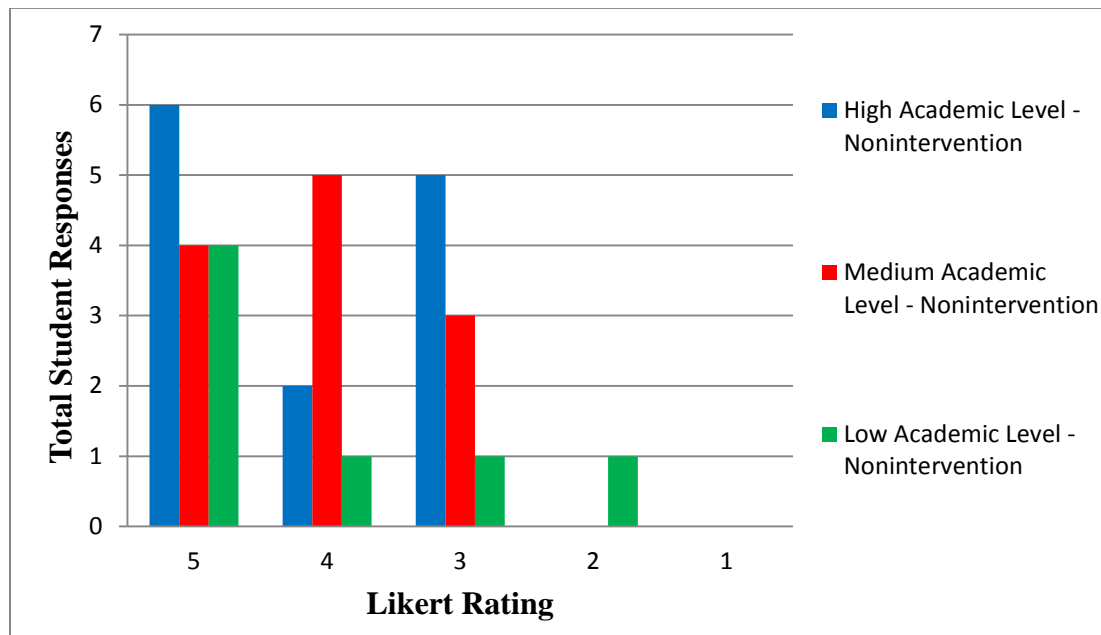


Figure 8: Distribution of student responses of peer motivation by academic level for the nonintervention unit as measured according to surveys, ($N=32$). *Note.* Likert scale 5 = Strongly Agree, 4 = Agree, 3 = No Opinion, 2 = Disagree, 1 = Strongly Disagree.

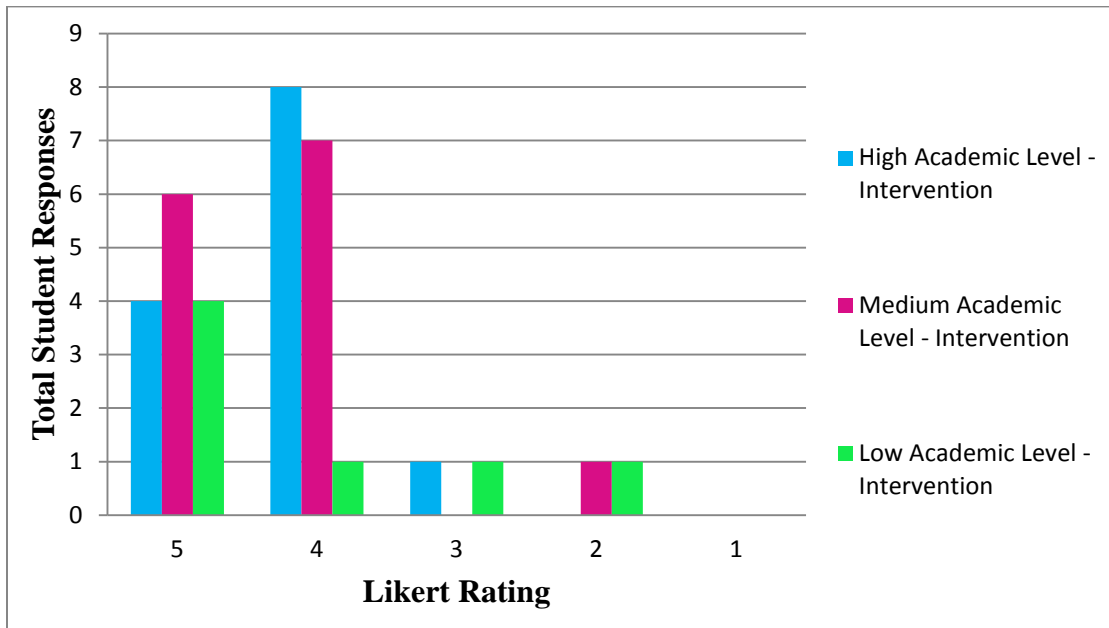


Figure 9: Distribution of student responses of peer motivation by academic level for the intervention unit as measured according to surveys, ($N=32$). *Note.* Likert scale 5 = Strongly Agree, 4 = Agree, 3 = No Opinion, 2 = Disagree, 1 = Strongly Disagree.

The final question from the survey addressed engagement in the phase of PBL known as problem-solving. The responses for, “I like to learn how to problem solve,” in Figure 10 and Figure 11 show a median response of “Agree.”

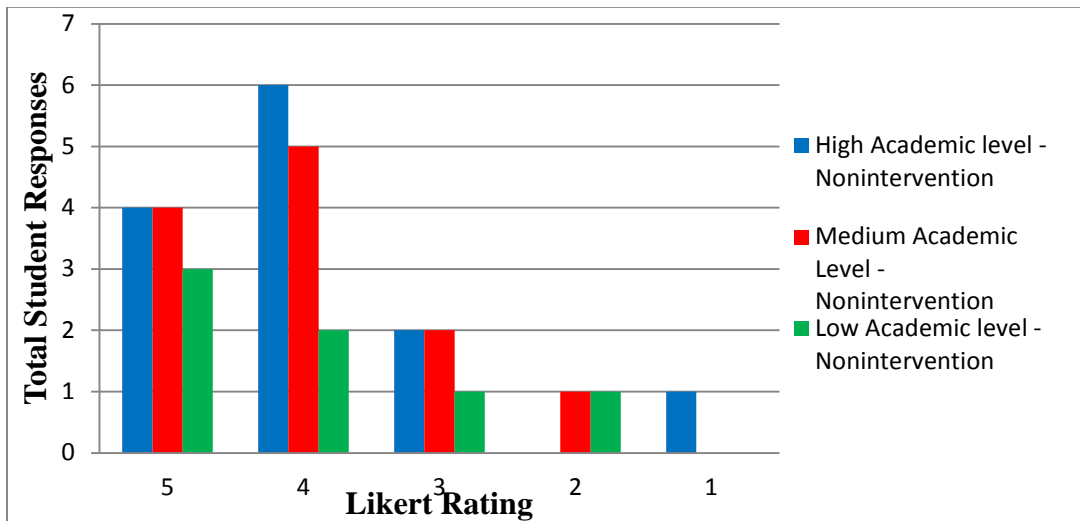


Figure 10: Distribution of student rating of engagement with problem solving by academic level for the nonintervention unit as measured according to surveys, ($N=32$). *Note.* Likert scale 5 = Strongly Agree, 4 = Agree, 3 = No Opinion, 2 = Disagree, 1 = Strongly Disagree.

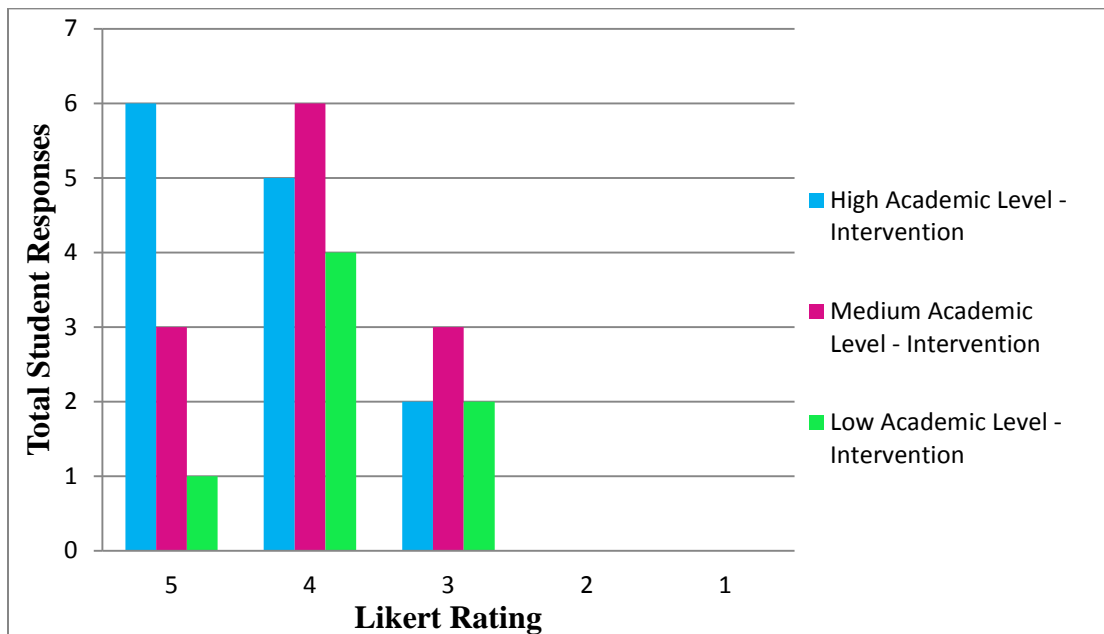


Figure 11: Distribution of student rating of engagement with problem solving by academic level for the intervention unit as measured according to surveys, ($N=32$). *Note.* Likert scale 5 = Strongly Agree, 4 = Agree, 3 = No Opinion, 2 = Disagree, 1 = Strongly Disagree.

Lower-achieving students selected “Agree” on average while the high and middle-achieving students were split between “Strongly Agree” and “Agree” responses. For the nonintervention unit, one high and one low-achieving student selected responses of “Disagree,” while one other high-achieving student selected “Strongly Disagree.” Upon review of the rating explanation the student with the response of “Strongly Disagree” stated, “I am uncomfortable when I do not know the answer.” Upon contacting the parent of this child, I was made aware of severe anxiety issues and a “resistance by the child to conform to anything other than teacher lectures with given formulas and straightforward answers.” In contrast, responses by other students included, “I enjoy problem solving because I get excited when I find the correct answer,” and “I like to problem solve because it gives me more experience with more problems that could occur every day,” and “problem-solving helps your brain and is fun.”

To conclude the assessment of student motivation and engagement, a colleague observed one class period during both nonintervention and intervention units of study. She focused her student observations on the academic levels within the class for elements of engagement, attitude, and motivation. In addition to whole class, one student from each academic level was observed and rated. Her Likert rating of “Agree” for low and middle-achieving students during the nonintervention unit changed to “Strongly Agree” for the intervention unit. She noted “Strongly Agree” for high-achieving students for both observations. The first observation included a teacher-led demonstration with a student volunteer followed by a discussion of motion. She noted that the class seemed “eager” but “ALL tuned in” when the student volunteer came up to the front of the class.

For the second observation, students began the class with Newton’s Laws and the idea of inertia, seatbelts, and vehicle crashes. Small group discussions around the importance of seatbelts led the class in the presentation on cars from different eras. The students had collaborated within a group setting, selected an era to research and then created an advertisement to sell their car to the class. Observations of individual students by Ms. Kurylo showed a definite increase in the level of engagement by the low-achieving students. Her comment, “interesting, two low-achieving students exceeded and did an outstanding job on presenting information,” provided evidence the students were engaged in the activities. Overall, her comments indicated that the students, “were enthusiastic,” and “excited” to present their information. Her only suggestion for improvement of student engagement was, “while audience is viewing the lesson require, students to take notes and comment on specific car data.”

When comparing my journal entries on student interest and motivation with the observations made by my colleague, we both noted a definite increase in the level of engagement during the last intervention unit. In addition, all the data sources suggest the PBL model of engaging the students into a topic, creating questions for research and discussion within peers, seemed to provoke most students to work together in order to complete the physics tasks they were given. That interaction may have been the catalyst to a higher level of engagement and perhaps increased motivation for the students.

The second subquestion for this project was to assess the effect of blended technology-based PBL lessons on students' long-term memory. Students were given an assessment similar to the post assessment approximately 14 days later. Three middle-achieving students completed the delayed assessment 28 days later due to spring break. Table 4 summarizes the average post and delayed unit assessment scores with percent change calculated. Although there is an expectation that scores will decrease on delayed assessments only the second intervention unit shows a drop in scores. The increase in scores from post to the delayed for the nonintervention and the first intervention unit was greatest among the lower-achieving students, although all academic levels increased. The high-achieving students scored higher overall on all assessments making the percentage of change less due to the higher scores on the post assessment. Middle-achieving students scored slightly higher on the postassessments than low-achieving students with the low-achieving students scoring as high or higher on the delayed assessment for the nonintervention and first intervention unit.

Table 4
Average Postunit and Delayed Unit Assessment Scores and Percent Change

Nonintervention Unit				
Assessment Scores	Student Achievement Level			
	All (N=33)	High (n=13)	Middle (n=13)	Low (n=7)
Post	6.2	6.7	6.3	5.3
Delay	8.8	8.7	8.9	8.7
% Change	41.1	30.	41.5	65
Intervention Unit 1				
Assessment Scores	Student Achievement Level			
	All (N=30)	High (n=12)	Middle (n=12)	Low (n=6)
Post	6.7	8.2	5.8	5.3
Delay	8.1	8.3	7.8	8.9
% Change	23	.50	36	67
Intervention Unit 2				
Assessment Scores	Student Achievement Level			
	All (N=29)	High (n=12)	Middle (n=11)	Low (n=6)
Post	8.2	8.9	8.1	6.8
Delay	7.6	8.3	7.5	6.5
% Change	-6.8	-7.5	-6.8	-4.9

Note. Maximum score out of 10. Post refers to postunit and delay refers to delayed unit.

Individual student interviews utilizing concept maps provided additional data for long-term understanding of physics concepts. Student memory was assessed with the average post and delayed unit concept map scores summarized in Table 5. Similar to the assessment scores, the delayed scores were higher than the postunit concept map scores suggesting that the conceptual long-term understanding has improved with time. The middle student in the first intervention unit is the exception and this student completed the delayed interview three weeks late. The low-achieving students had the greatest percentage of change for the nonintervention unit while the middle and high-achieving students' greatest change was in the second intervention unit.

Table 5
Average Postunit and Delayed unit Concept Map Scores and Percent Change

Student	Nonintervention Unit Scores			Intervention Unit 1 Scores			Intervention Unit 2 Scores		
	Post	Delay	% Change	Post	Delay	% Change	Post	Delay	% Change
High 1	36	39	8	46	55	20	48	62	29
High 2	69	75	9	83	101	22	78	97	24
Middle 1	35	57	63	NA	NA	NA	37	68	84
Middle 2	66	67	1.5	92	68	-25	68	75	10
Low 1	32	75	134	78	92	18	55	88	60
Low 2	40	60	50	NA	NA	NA	79	81	2.5
Average	46	62	23	75	79	5	61	79	35

Note. NA = student was not interviewed. Post refers to postunit and delay refers to delayed unit.

Using the Likert Scale, students were asked to rate their confidence in learning based on the activities conducted in the classroom. The survey was given early in the nonintervention unit and toward the middle of the second intervention unit. The distribution of responses is shown in Figure 8 below. The median response for the statement, “I feel like the projects and labs that are conducted in this class help me understand the science concepts,” was fairly evenly distributed between “Strongly Agree” and “Agree.” One of the low-achieving students selected “Disagree” for both surveys and the students that selected “No Opinion,” were at the high-achieving level.

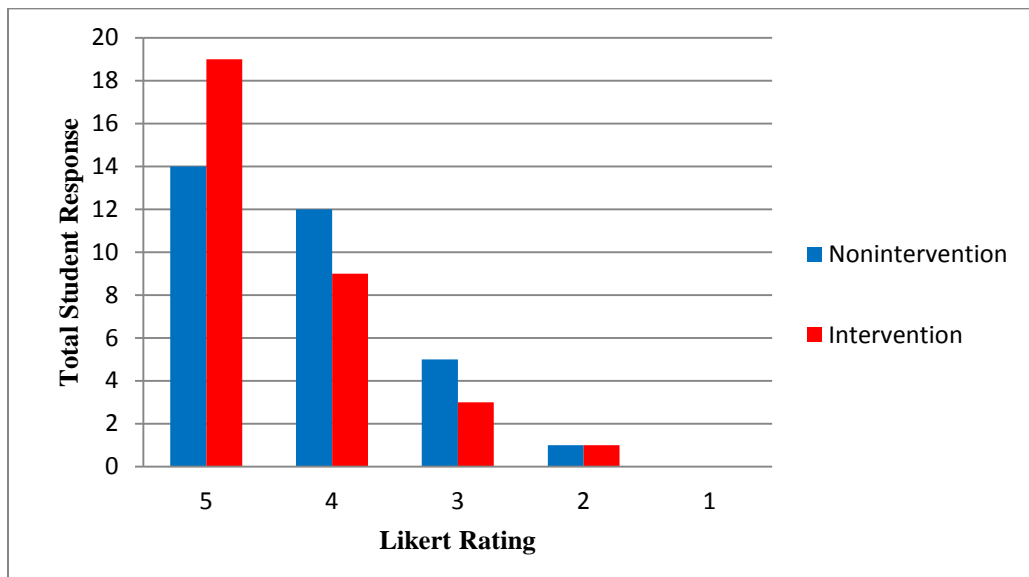


Figure 12: Distribution of student rating of long-term memory based on classroom activities as measured according to surveys, ($N= 32$). *Note.* Likert scale 5 = Strongly Agree, 4 = Agree, 3 = No Opinion, 2 = Disagree, 1 = Strongly Disagree.

These data sources suggest that the PBL model may have a positive impact on student long-term memory of physics concepts. Delayed assessments show an increase in scores for the first two units suggesting retention of the details increased. However, the final intervention unit contained material that was not reinforced after the unit completed and showed a slight drop in delayed scores for all academic levels. The delayed concept interviews showed students improved or maintained conceptual understanding of the material to all but one middle-achieving student. This student had been out ill and completed the delayed interview later than the other students. Results from the survey suggest confidence in learning increased when PBL interventions were put into place.

Lastly I looked at the effects of blended technology-based PBL lessons on my attitude and motivation. I reflected on the process in my weekly journal entries and surveys. My journal prompts included weekly responses to the statements, “I look forward to planning and implementing the day’s activities (traditional or PBL)” and

“students seem interested to use the technology to aid their learning.” My responses did not fluctuate much regarding planning of the intervention units, as I jotted down notes and ideas that I thought would interest the students. The PBL lessons were easy for me to prepare as my teaching style has been one of inquiry. Planning for the nonintervention lectures included writing down ideas that would often get crossed out due to lack of equipment or supplies. My weekly entries identified a little more personal frustration with finding the right content and delivery for lectures during the nonintervention unit.

As for student use of technology, my responses were neutral as some weeks the students seemed interested in using the computers and other weeks not so much. As the interventions were put into place the students were required to research and they divided the work within their groups. I noted that low-achieving students seemed to engage more and want to use the computers whereas high-achieving students did not seem to care one way or the other.

Beginning the engage phase of intervention was exciting as the students decided which way the lesson flowed. As they began to ask questions and formulate ideas it was easy to see the PBL process take shape. The nonintervention unit, although sufficient in helping students learn, makes the classroom environment more passive. I noted that the traditional classroom activities did not necessarily engage all learners; high-achievers led lab activities and low-achieving students followed along. As the teacher, there was more work to do to insure that the students understood the purpose of each lesson. In the PBL lesson model, as the student discussions and research phases took shape, there was more time for me to interact with each of the peer groups. Unfortunately, there was not much creation or reflection in the traditional classroom lessons that I created, making my

interaction mostly as a whole class. In the PBL lessons, the final phases of creating and reflecting brought out the student artists and politicians, as they drew sketches of animals and argued their point of view. On average, my survey responses to the statements, “I look forward to planning for class,” and “I am excited about the learning that is taking place in my classroom” were that I “Agree.” The PBL model appeared to be more efficient than the traditional model as a means to engage more of the students, create an environment of collaboration, and allow freedom for me to help individual students that needed some additional instruction.

Based on my reflections of the teaching process, the intervention units were the easiest to plan and teach even though they took more time. I enjoyed writing the lessons. By beginning the engagement phase of the intervention unit with a story that I could refer to, proved effective for reinforcing concepts. As the unit progressed, listening to the student discussions and reading the presentations for their fastest animal research reinforced my willingness to invest the time writing the PBL lessons. Seeing the students create catapults out of a shoebox, wooden sticks, tape, and rubber bands was exciting as they researched designs and made modifications in order to become more accurate.

On the other hand, the teacher-led environment of the nonintervention unit created the most challenges as generating lectures and lab activities that would invoke curiosity within my students was at times perplexing. The students went through the motions but engagement was nothing noteworthy. I have taught this content for a number of years and the traditional lecture model is fairly static with very little student interaction. In contrast, I noted that the PBL process is one that mutates as the students become engaged in the topic so the teacher portion of the lessons must remain flexible.

To my observer, my attitude did not change between nonintervention and intervention units. Ms. Kurylo stated, “you always appear enthusiastic and in touch with students as well as knowledgeable about the topic.” Although I did not feel as if my attitude changed from week to week, I did get the opportunity to know my students better through the assessments, interviews, surveys and explanations. As the units progressed my motivation did increase as I wanted every student to engage in the process and I desperately wanted to know why, if or when, they did not engage. Despite some frustrations and challenges implementing technology use into both the traditional and the PBL model of instruction is a plan I intend to work toward in future lessons.

INTERPRETATION AND CONCLUSION

This action research project was designed to identify what effects a curriculum based on PBL lessons that incorporated technology would have on student understanding, engagement and long-term memory within an eighth-grade science course. As I analyzed my data, I realized this was the first opportunity for these students to work within an inquiry environment. Applying problem-solving skills is still something innovative to my students and working with collaborative groups came with unique problems, more so for my high-achieving than my low-achieving students. These tribulations must be overcome for the students and the teacher to be effective within a PBL environment.

All students embraced the PBL model and the use of technology became a norm during the intervention units. One or two students made known the preference to go back to lecture-based teacher centered structure, nevertheless still actively participated in the process. The concept map interviews as well as the pre, post and delayed unit assessments exhibited student awareness of the ability of PBL as an effective model for

understanding and encouraging long-term recall of challenging science concepts. Based on the data collected, the PBL model of learning created an environment of collaboration, competition, and curiosity that perhaps made the learning more memorable allowing for easier recall of the concepts. The data suggests that the technology increased student motivation but modifications and more data should be gathered to ascertain to what degree the technology actually aided in student understanding.

My students came in with little to no experience in the PBL model of learning. The survey data suggests students were not opposed to the idea of collaborative groups for inquiry projects. Responses to an informal survey regarding which method of learning was best for their understanding, lecture or inquiry, resulted in 66% responded “lectures.” Their response for which method of learning was best for them when it came to motivation was the exact opposite; 66% responded “PBL/inquiry.” Low-achieving students made the most gains throughout the units and were the most engaged when it came to creating and demonstrating specific portions of labs and activities especially when technology was allowed. The PBL environment created opportunities for students to experience real-world applications enabling them to achieve a stronger understanding of the concepts for both traditional and nontraditional assessments.

VALUE

Through this assignment I was able to see the students embrace the idea of using the technology to research a project. My normal teaching style incorporates inquiry and I knew my challenges would be more in the portion of this project that was teacher-centered. This project enabled me to examine not only how I teach but how the students engage with the style of learning that is offered within my classroom.

One eye-opening experience came from my lowest group of students. As I evaluated the various assessments and scored the concept interviews for the low-achievers, I realized they really weren't that low. In some cases their scores were much higher than my middle-achievers. The connections, cross-links, and examples they created when making their maps made me realize they were probably low due to lack of engagement with the content. If I wanted to reach all of my students then I undeniably need to provide opportunities for all students to become involved in their learning.

Another implication of the project was that I became aware not everyone wants an inquiry environment. With activities that replace the traditional lecture, I was hopeful that student interest and understanding would increase, which it did to a degree. I firmly believe students need opportunities to be engaged and blending technology use with the PBL method provides one possible avenue to analyze, reason, and think at a higher level. Inquiry is not the complete answer though it is merely one of many effective strategies.

This project and the information identified were meaningful to me as I was compelled to re-evaluate myself as an educator. This project became self-directed professional development that challenged me and the students out of our comfort zones and caused us to embrace something new. My lofty ideas of making sure every student is allowed to learn in an inquiry environment did not take into account that not all students want that option and their feelings should not be ignored. I feel fortunate that the MSSE program not only pushed me to try a new approach to instruction, but also insured that my students had a voice in the learning via the surveys, interviews, and open prompts. I look forward to utilizing action research as a professional development tool in my future.

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APPENDICES

APPENDIX A

NONINTERVENTION MOVING BODIES LAB

Moving Bodies

Problem: How does the amount of mass of a body in motion affect its tendency to remain in motion? Using meter sticks, rubber bands, marbles, wooden block, string, and a paper cup students create a ramp with guardrails and roll marbles down the ramps to observe the motion. Students will make a bar graph comparing the distance the cup moved as a comparison of the number of marbles and the mass of those marbles.

There are many Physics labs available through web searches. The lab adapted from Poarch, briefly described above uses specific materials that allow students to monitor the motion of marbles and then graph the results (Poarch, 2003) retrieved from: http://science-class.net/archive/science-class/Lessons/Physics/Force_Motion/Moving_bodies.pdf,2003.

APPENDIX B
INTERVENTION UNIT 1
PBL-SPEED

PBL Speed Lab

Brief description of the inquiry lesson: Introduction to Physics: *What do the words speed and fast mean to you?*

Students will research the topic of speed and conduct calculations then using a web tool to perform the simple lab activity- This lesson reviews the basic "idea" we all have for what speed is and introduces the means for calculation and composition of various average speeds. Students calculate average speed of various snowmobiles and predict the outcome of a race.

Inquiry Process	Notes	Your plan
<p>Questioning:</p> <p>Define problem/question:</p> <p>Focus on Physical Science</p> <p>Motion</p> <p>1. The velocity of an object is the rate of change of its position. As a basis for understanding this concept:</p> <p>a. Students know position is defined in relation to some choice of a standard reference point and a set of reference directions.</p> <p>b. Students know that average speed is the total distance traveled divided by the total time elapsed and that the speed of an object along the path traveled can vary.</p> <p>c. Students know how to solve problems involving distance, time, and average speed.</p>	<p>Start with a standards-based, teacher guided exploration of a topic as a whole class.</p> <p>Activate prior knowledge: KWL, surveys, student conversation etc.</p> <p>To prepare students with enough information to generate questions, you may need to provide background information through articles, online museum exhibits, direct instruction, audio recordings, videos, books, web sites, photos, art, etc.</p> <p>Through whole group participation, generate student questions about the problem/situation/guiding question.</p> <p>Criteria for question selection:</p> <ul style="list-style-type: none"> ● Is it personally relevant and socially significant? ● Is the student truly interested in the question? ● Is it researchable? ● Is it big enough? small enough? <p>Predict, set goals, and define outcomes, set timelines and accountability. (This step gets the class on the same page with</p>	<p>Have students consider the words speed and fast.</p> <p>What is speed?</p> <p>Brainstorm ideas of what these words mean to different people- (Conduct intro activity-if needed-see teacher notes below)</p> <p>Compare and contrast the two words</p> <p>Speed lab</p> <p>Goals: Day 1-introduce topic-have students run the interactive lab-do calculations in their journals</p> <p>Day 2—finish analyze questions</p> <p>Then begin research on animals</p> <p>Focus: research and find the three fastest animals known to man--able to explain how fast they are--why you chose these three—defend your choices</p>

	<p>how/where they will be going. Finalize your class focus.)</p>	
<p>Researching: Find and gather data, analyze, compare, experiment</p>	<p>Find or create information and look for patterns</p> <p>Instruction serves as a guide to help students meet their goals.</p> <p>Critically evaluate resources used (bias, validity, etc.).</p> <p>When reading identify the main idea and authors' point of view, identify key concepts, increase understanding of vocabulary, extract meaning (infer).</p>	<p>Focus: research and find the two fastest animals known to man and the slowest--be able to explain how fast or slow they are--why you chose these three—defend your choices—make poster with your choices-drawings--include your websites-they must be reliable---need a minimum three websites s.</p>
<p>Discussing: Students process information</p>	<p>Have students discuss, question, explain research findings and defend positions in small groups.</p> <p>Working in groups helps provide a diversity of views.</p> <p>What is the student accountability piece?</p>	<p>Working in groups of 4 divide the work so that everyone has a role; review any bias within the data researched; defend the position that your animal selections are accurate.</p>

<p>Creating:</p> <p>Does not have to be technology-generated and can be used as an assessment piece</p>	<p>Create a tangible artifact that addresses the issue, answers questions, and makes learning visible and accountable</p> <ul style="list-style-type: none"> • Essay • Presentation • Poster <p>Inquiry presentation framework:</p> <ol style="list-style-type: none"> 1. State problem or question 2. Develop proposition that can be argued 3. Provide background information 4. Support proposition with facts, statistics, examples, expert authority, logic and reasoning 5. Propose solutions and action ideas <p>How will you assess/measure whether or not students have understanding?</p>	<p>make poster or presentation with your choices-drawings--include your websites-they must be reliable---need a minimum three websites-defend your choices when presenting</p> <p>Upon completion of lab</p> <p>Simple informal assessment: “Muddy Point-identify the muddiest point in your mind about motion-speed and fast.</p>
<p>Reflecting</p>	<p>Arrive at a conclusion, take a stand, take action.</p> <p>Document, justify, and share conclusions with a larger audience</p>	<p>Share out your information on the animal choices</p>

APPENDIX C

INTERVENTION UNIT 1 SPEED AND ACCELERATION
PBL-CATAPULT LAB

PBL-Catapult Lab

SUBJECT AREA: Physical Science
History (weapons of old)

RATIONALE: Students will begin a new unit on force and motion this week. To aid concept understanding this lesson is a preview of Physics topics as it pertains to motion and force with discussion questions of words familiar to students through daily life. The vocabulary words: rate, speed, acceleration, velocity, and slope will be reviewed and defined. A description of the upcoming lab will be provided at the end of the lecture with video clips to guide students. The labs that follow will allow hands-on activities to aid in interpretation of concepts.

Discussion questions:

Ask students to consider how objects move.

Define Physics as it pertains to daily life.

USING TECHNOLOGY: Students will be led through a series of discussion questions and activities using a PowerPoint lecture format followed by video clips of trebuchets as weapons of war.

DISCUSS: review the concept of Physics and then discuss the idea of motion and any preconceived ideas of the topic of motion.

Discussion questions included in lesson: How do objects move? Define the terms *speed* and *acceleration*. Explain how the two terms are related. Address idea that speed does not necessarily mean movement is fast. Include how graphs are useful for understanding motion of objects and the forces that act upon objects. Teacher should have a solid understanding of graphing physics concepts.

Students will then research and create their own models of catapults to help students make their own connections to the concepts. Working in groups students will build catapults out of everyday objects to demonstrate their understanding of motion and forces by using the catapult to launch objects.

MATERIALS:

Students will need to obtain 1 shoebox (per lab group)

Teacher will provide:

Rubber bands (4 per group) /Popsicle sticks (2 per group)/1 plastic spoon

Scissors, ruler, 6 inch piece of masking tape/2 marshmallows

Pictures of catapults and a Target

Each group can design the catapult any way they want, but only use the materials provided-nothing extra. Groups will have time to design and build the catapult in class and then there will be a launching competition for distance and accuracy

After building their catapults, students will compete to see whose catapult can fling a

marshmallow the farthest and whose catapult can fling an object closest to a target. Once students have completed their catapults, the launching competition will take place. Using masking tape, a starting line will be marked. The target object will be placed about 10 feet in front of the line. The student teams will place their catapults on the line, one at a time, and fling a marshmallow at the target—their goal is to hit the target. Where each team's marshmallow landed will be marked with a piece of masking tape, labeled with the team's name.

There are many Physics labs available through web searches. The ideas for this lab was adapted from Henderson (1989).

APPENDIX D

INTERVENTION UNIT 1 FORCE-MASS-ACCELERATION
ROLLERCOASTER DESIGN

Roller Coaster Design

Students use technology to initiate discussion questions regarding how forces affect their bodies during a roller coaster ride. The interactive website describes these forces and helps the students design a roller coaster.

Discussion questions included in lesson:

How does a roller coaster work and define the terms *force* and *acceleration*. What type of force does the rider feel when the roller coaster ride is beginning? Middle? Ending?

Teachers should have some understanding of how a roller coaster works in order to facilitate the design portion of the roller coaster and to help students that may encounter questions.

Roller coaster labs can be obtained from Internet searches and the ideas for this activity were generated from (Annenberg Learner, 2013).

APPENDIX E
INTERVENTION UNIT 1
PARACHUTE LAB

Parachute Lab

OBJECTIVES/PURPOSE:

Students will understand the following:

1. Gravity is the force of attraction that causes objects to fall toward the center of the earth.
2. Air resistance, or air friction, can slow down the acceleration of a falling object.
3. The area “fronting the wind” affects the amount of air resistance a falling object encounters.
4. Terminal speed is the speed at which the downward pull of gravity is balanced by the equal and upward opposing force of air resistance for a falling object.

MATERIALS:

Lightweight plastic kitchen garbage-can liners

Scissors

Ruler

8 20-inch lengths of light string

2 plastic sandwich bags

2 raw eggs

PROCEDURE:

1. Distribute materials to each group.
2. Use the following directions to build two “parachutes” for an ordinary chicken egg:
 - From a lightweight plastic kitchen garbage-can liner, cut out **two squares**. Make one square 10”x 10”, and a second square **either** 20” x 20” or 30” by 30”
 - Make a parachute out of each square by tying a piece of string to each corner of the square, then attaching the other ends of the strings to a plastic sandwich bag.
 - Place a raw egg in each of the sandwich bags.
3. As a group we will then drop each unfurled egg parachute from a height of ten feet, (or more) and then determine whether or not your group’s predictions were confirmed.

CONCLUSIONS: After your group has performed its experiment, prepare to discuss and describe the changing forces that acted on the parachutes as they fell and the resulting changes in the parachutes' motion. How did the falls of the larger parachutes differ from the falls of the smaller ones?

Understanding Motion & Force

1. Define the terms *speed* and *acceleration*. Explain how the two terms are related.
2. How can creating and analyzing graphs be useful for understanding forces and motion in objects?
3. Construct a position-versus-time graph for the following set of data: ($D1=0$ m, $T1=0$ sec), ($D2=7$ m, $T2=3$ sec), ($D3=14$ m, $T3=6$ sec), ($D4=21$ m, $T4=9$ sec), and ($D5=28$ m, $T5=12$ sec). Discuss how you would use this graph to determine the speed of the object being represented.

Review questions:

4. Identify if the object in question 3 is moving with constant speed or constant acceleration? Explain how you arrived at your conclusion.
5. If the object in question 3 continued to move, explain how you might use the data plotted on its x- and y-axes to determine how far the object would travel in 19.5 additional seconds.
6. From the graph constructed in question 3, calculate the object's speed at three-second intervals, and then use this new information to construct a speed-versus-time graph for the object.

Lesson created by M. Bernard and A. Cole-SEMS teachers.

APPENDIX F

INTERVENTION UNIT 2
INTRODUCTION TO INERTIA

Introduction to Inertia

Moving Marbles with Momentum

Supplies: Two rulers, Tape, Six large marbles

This experiment introduces 3 concepts about inertia (the tendency of a body to remain at rest or to stay in motion unless acted upon by an external force - in other words, the resistance to motion or change) and momentum (the speed or force of motion or in more technical terms - the product of a body's mass and linear velocity) :

Procedure: Tape the yardsticks parallel about 1/2 inch apart; place marbles in the middle slightly apart and then flick one marble-write observations and explain what happens to the momentum of marbles. Repeat procedure using two marbles that are touching with a third marble placed away, flick the single marble, observe and explain what happens to each marble. Continue making changes to the positions of the marbles using other combinations. Make observations and explain the idea of inertia in your explanation.

Free Fall

Supplies: Partner, Chair, Newspaper, 2 marbles or pieces of fruit approximately the same size.

Purpose: Illustrate and demonstrate the force called gravity (the attractive central gravitational force exerted by a celestial body such as the earth) that pulls everything on Earth downward. Discuss whether or not this force pulls heavy objects faster than a light object?

Procedure: Place newspapers on the floor around the lab station. Stand by the lab station while your partner lies on the floor peering at the newspaper.

Hold the 2 marbles in each hand. Extend your arms straight out away from your body (and over the newspapers) so that each marble is the same height from the floor. Let go of both marbles at the same time. Predict what will happen. Observe: Did they hit the newspaper at roughly the same time?

Now stand in the same position but this time hold a marble in one hand and some other small object in the other hand. Predict what will happen: Let go of both of these objects at the same time. At what point did the marble and the grape hit the floor? Test with other objects available-repeat procedure.

Conclude and reflect.

APPENDIX G

INTERVENTION UNIT 2
PROJECT NEWTON'S SCOOTER

Newton Scooters

Skills Focus: Controlling variables, making models, predicting, communicating

Investigation Rules require that you build a vehicle that can demonstrate Newton's laws of physics. Your teacher must approve your design before building. Your vehicle must use Newton's third law of motion to move and must be made from scrap material-no store bought or original parts can be used. The path of the vehicle must be straight and the vehicle must move 1.5 meters in order to cross the finish line. Students must make a sketch of the model and explain all the forces acting upon the vehicle.

Newton Scooters is an inquiry lesson available through the extended curriculum contained with our textbook (Pearson, 2008).

APPENDIX H
STUDENT ASSESSMENT

Student Assessment

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

Nonintervention Unit (motion and energy)

- 1) Why do scientists need an accurate and consistent way to measure distance when they study motion of objects? Explain
- 2) An object moves 3 cm to the right, then 6 cm. to the left, then 8 cm to the right; what is the object's final displacement from its origin?
- 3) What are the differences in how balanced and unbalanced forces affect motion?
- 4) What is a reference point?
- 5) Describe the energy transformations that occur when you bounce a ball.

Intervention Unit 1 (speed and acceleration)

- 1) What two components does acceleration involve?
- 2) Define the term speed.
- 3) If you drive 250 miles in 6 hours and another 200 miles in 7 hours, what is your average speed? Show your work to explain your answer.
- 4) Describe two ways in which velocity can change.
- 5) Calculate the acceleration of an object with a final velocity of 16 meters/second and an initial velocity of 2 meters/second. Show your work to explain your answer.

Intervention Unit 2 (Forces-Newton's laws)

- 1) What is inertia and how is it involved in Newton's first law of motion?
- 2) State Newton's three laws in your own words.
- 3) What is meant by conservation of momentum?
- 4) What are the four types of friction and provide an example of each.
- 5) Describe how Newton's third law explains how a squid squirts through the water without using its fins or tentacles.

APPENDIX I
STUDENT SURVEY

Student Survey

This is a voluntary survey and will not affect your grade

1 = Strongly Disagree 2 = Disagree 3 = No opinion 4 = Agree 5 = Strongly Agree

- | | |
|---|-----------|
| 1. I enjoy going to science class | 1 2 3 4 5 |
| 2. I am interested in the science topics that I am learning this year | 1 2 3 4 5 |
| 3. Lab activities are the best way I learn. Explain. | 1 2 3 4 5 |
| 4. Lecture and note taking helps me learn the material the best. | 1 2 3 4 5 |
| 5. I have a good understanding of how the main objectives for this unit are important to the current unit that we are studying. | 1 2 3 4 5 |
| 6. Using technology in the classroom helps me remember the information. | 1 2 3 4 5 |
| 7. Working with peers on projects motivates me to learn more about science | 1 2 3 4 5 |
| 8. I feel like the projects and the labs that are conducted in this class help me understand the science concepts. | 1 2 3 4 5 |
| 9. I like to learn how to problem solve. Explain your rating. | 1 2 3 4 5 |
| 10. I feel confident that I can learn about motion, speed and force in this class | 1 2 3 4 5 |
| 11. Postintervention: What is the most important thing that you understand from this unit? Please use evidence or data from the unit to support your opinion. | |
| 12. Postintervention: How does the project based type of learning compare to the lecture-based learning for you? What helped you using problem-based learning, what did not? | |
| 13. Should technology be used in the classroom? Why or why not? How does technology help you learn? | |
| 14. What are the biggest challenges you have when performing a science lab activity? Explain. What changes can be made by you and or the teacher to help overcome these challenges? | |

APPENDIX J
STUDENT CONCEPT INTERVIEW

Student Concept Interview

Participation is voluntary; you may choose not to answer any question or skip questions and you may stop at any time. Your participation or no-participation will not affect your grade or class standing in any way.

Please think out loud as you create a concept map using the following terms. You may add additional terms, or linking phrases as you work.

Nonintervention Unit (motion)

Motion, reference point, distance, displacement, vector, relative motion, meter, energy

Intervention Unit 1 (speed and acceleration)

Speed, average speed, acceleration, velocity, slope, instantaneous speed, kilometer, initial velocity, final velocity, speed formula, distance, Law of Conservation of Energy

Intervention Unit 2 (force and Newton's Laws)

Force, newton, net force, friction, gravity, inertia, projectile, momentum, balanced forces, unbalanced forces, air resistance, acceleration, mass, free fall, velocity, Newton

APPENDIX K
WEEKLY TEACHER JOURNAL PROMPTS

Teacher Journal Prompts

1. Students were on task and seemed curious today.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
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Explain:

2. Students seem interested to use the technology to aid their learning.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
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Explain:

3. I looked forward to planning and implementing the day's activities (traditional or PBL).

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
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Explain:

4. What were some comments made by the students that provided evidence of their learning with this intervention?
5. What are the two best things that happened in class today? Why were they the best?
6. What if anything created frustration in class today? How did you respond?
7. How did the students react to the changes in teaching style? Explain.
8. Other comments.

APPENDIX L
OBSERVER FEEDBACK FORM

Observer Feedback Form

Date: _____ Time: _____

Portion of class observed: Beg Middle End

Prompts for when a colleague observes the students/teacher during intervention and nonintervention units. Each prompt solicits an explanation but is not always necessary.

1 = Strongly Disagree 2 = Disagree 3 = Not Sure 4 = Agree 5 = Strongly Agree

1. Students appeared engaged in the lesson. Explain. 1 2 3 4 5
2. Students had a positive attitude regarding the class activities Explain. 1 2 3 4 5
3. Students were showing motivation to solve problems. Explain 1 2 3 4 5
4. What seems to motivate the students and what does not? Explain.
5. Teacher seemed enthusiastic about teaching the content Explain. 1 2 3 4 5
6. High achieving students were motivated and engaged in the activities. 1 2 3 4 5
7. Middle achieving students were motivated and engaged in the activities. 1 2 3 4 5
8. Low achieving students were motivated and engaged in the activities. 1 2 3 4 5
9. Teacher was motivated and engaged in the lesson activities 1 2 3 4 5
10. What improvements would you suggest for this class? Explain.
11. Other comments.

APPENDIX M
TEACHER SURVEY

Teacher Survey

1 = Strongly Disagree 2 = Disagree 3 = Not Sure 4 = Agree 5 = Strongly Agree

1. Students appeared engaged in the lesson 1 2 3 4 5
Explain.

2. Students had a positive attitude regarding the class activities 1 2 3 4 5
Explain.

3. Students were showing motivation to solve problems 1 2 3 4 5
Explain.

4. Students asked questions that applied to the class topic. Explain. 1 2 3 4 5

5. I was enthusiastic about teaching the content. 1 2 3 4 5
Explain.

6. I looked forward to planning for the daily activities 1 2 3 4 5
Explain. (Include both PBL and traditional planning)

7. I am excited about the learning that is taking place 1 2 3 4 5
in my classroom. Explain.

APPENDIX N
SCORING RUBRIC FOR CONCEPT MAP

Scoring Rubric for Concept Map

Map Component	Possible points	Awarded points	Special things noticed about map
Proposition			
Clear and meaningful to the central topic	2 each		
Beyond given set of terms	3 each		
Not properly linked	1 each		
Vague	1 each		
Branch			
Top	1 each		
Successive branches	3 each		
Levels of hierarchy (general to specific)	5 each level		
Cross Links	10 each		
Examples	1 each		
Total			
Overall reaction to map and special things noticed.			

Adapted from Novak and Gowin (1984)

APPENDIX O
PROJECT TIMELINE

Project Timeline

Dates	Class Plan	Data Collection Instruments
Nonintervention Unit: Motion		
Mon January 13	Teacher Prep Day-no students	Nonintervention preunit assessment and preassessment
Tue January 14	Introduction of motion	student survey + student concept interviews
Wed January 15	Reference point, distance lecture, note taking	Teacher journaling
Thur January 16	Activity-distance and displacement	Nonintervention preassessment peer observation
Fri January 17 Mon January 20	Analysis of scientific method <i>Holiday-no school</i>	Teacher survey
Tue January 21 Wed January 22	Moving Marbles Lab Completion of lab	Teacher journaling
Thur January 23	Progress monitoring worksheets involving graphing the motion of an	
Fri January 24	Drawing diagrams	Teacher survey
Mon January 27 Tue January 28	Walkabout activity outside to measure distances and	Postunit intervention peer observation
Wed January 29	Conclude and review motion	Teacher journaling + Postunit Student concept interviews + postunit student survey (postunit)
Intervention Unit 1: Speed and Acceleration		
Thur January 30	<i>Introduction to Speed Tortoise and Hare analog</i>	Preintervention 1 assessment + postnonintervention assessment + preunit concept interviews
Fri January 31 Mon February 3	Introduce the PBL project: What is Speed-begin research	Teacher Survey + preintervention student survey + Intervention 1 peer observation
Tue February 4	Speed project research and presentation design	
Wed February 5	Speed Project presentations	Teacher journaling

Thur February 6	Speed project presentations completion; acceleration activity	
Fri February 7	Introduce Research and Design of Catapult; begin design and testing	Teacher survey
Mon February 10		
Tue February 11	Catapult Lab competition	Postintervention peer observation
Wed February 12	Roller Coaster activity	Teacher journaling + Delayed nonintervention unit concept interviews and assessment
Thur February 13	Parachute Lab performance assessment	Delayed nonintervention unit student survey + post intervention unit 1 student survey + Post nonintervention: Student concept interviews
Fri February 14	<i>School Holiday(s)</i>	Teacher survey
Mon February 17		

Intervention Unit 2: Force and Newton's Three Laws

Tues February 18	<i>Engage students gravity</i>	Preintervention 2 assessment + preintervention student survey + postintervention 1 assessment Preintervention 2 peer observation
Wed February 19		Teacher journaling
Thurs February 20	<i>Newton's First Law: Lab activities: Galileo's Free Fall; Moving Magical Marbles</i>	Pre Intervention 2 Student Concept Interviews
Fri February 21	<i>Chapter 9 quiz</i>	Teacher survey

Mon February 24	Newton's 1st Law	
Tue February 25	Introduce PBL project: Newton's Scooter	
Wed February 26	Newton's Scooter worksheets- practice problems with Force, Mass and Acceleration	Teacher journaling
Thur February 27	<i>Investigate/Research: Scooter</i>	
Fri February 28	<i>Design: Scooter</i>	Postintervention: Peer observation Teacher survey
Mon March 3 Tue March 4 Wed March 5	<i>Complete/Compete</i> Chapter 10 Test	Postintervention Concept Interview + student survey + assessment
Monday March 25		Delayed intervention 2 assessment and student survey delayed intervention 2 student concept interviews