ACCEPTANCE

This dissertation, TRANSFORMING A TRADITIONAL SCIENCE CLASSROOM WITH TECHNOLOGY-INTEGRATED PROJECT-BASED LEARNING TO MEET THE NEEDS OF 21^{ST} CENTURY LEARNERS, was prepared under the direction of the candidate's Dissertation Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree of Doctor of Education in the School of Education, Concordia University Irvine.

Belinda Dunnick Karge, PhD
Committee Chair

Michael Schulteis, ScEdD

Committee Member

John Randall, EdD
Committee Member

The Dissertation Committee, the Dean, and Executive Director of the Doctor of Education Program of the School of Education, as representatives of the faculty, certify that this dissertation has met all standards of excellence and scholarship as determined by the faculty.

Kent Schlichtemeier, PhD
Dean

Dwight Doering, PhD
Executive Director of the Doctor of Education Program

COPYRIGHT PERMISSION AGREEMENT
Concordia University Library
1530 Concordia West
Irvine, CA 92612
www.cui.edu/library

I, Afsaneh Miller, warrant that I have the authority to act on any copyright-related matters for the work, TRANSFORMING A TRADITIONAL SCIENCE CLASSROOM WITH TECHNOLOGY-INTEGRATED PROJECT-BASED LEARNING TO MEET THE NEEDS OF 21ST CENTURY LEARNERS, dated December, 14, 2019 to be included in the Concordia University Library repository, and as such have the right to grant permission to digitize, republish and use the said work in all media now known or hereafter devised.

I grant to the Concordia University Library the non-exclusive, worldwide rights to digitize, publish, exhibit, preserve, and use the work in any way that furthers the educational, research, and public service purposes of the Concordia University.

This Agreement shall be governed by and interpreted in accordance with the laws of the State of California. This Agreement expresses the complete understanding of the parties with respect to the subject matter and supersedes all prior representations and understandings.

ACCESS RESTRICTIONS

My electronic thesis or dissertation can be made accessible via the Concordia University Library repository with the following status (select one):

X Option 1: Provide open access to my electronic thesis or dissertation on the internet

□ **Option 2:** Place an embargo on access to my electronic thesis or dissertation for a given period from date of submission (select one):

□ 6 months □ 1 year □ 3 years

Permission Granted By:

Afsaneh Miller	Afsaneh Miller
Candidate's Name	Signature of Candidate
[redacted]	9/5/2019
Address	Date
[redacted]	[redacted]
Phone Number or E-mail Address	City/State/Zip

VITA
Afsaneh Miller

ADDRESS 1530 Concordia West
Irvine, CA 92612
[redacted]

EDUCATION

Ed.D.	2019	Concordia University Irvine Educational Leadership
Cred	2003	California State University at Fullerton, Single Subject (Biology) Secondary Credential (Expires 8/1/2022)
Cred	2014	California State University at Fullerton, Multiple Subject K-8 (CLAD) Credential (Expires 8/1/2018)
MA	1988	CSU Dominguez Hills, Carson Biology
BA	1985	CSU Dominguez Hills, Carson Biology

PROFESSIONAL LICENSES:

California, Clinical Laboratory Scientist, Microbiologist Specialist
California, Public Health Microbiology

PROFESSIONAL EXPERIENCE

2016-2018	Middle School Science Teacher XXX Private Schools-XXX
2014-2016	Middle School Science Teacher Le Port Montessori School Fountain Valley, Ca
2004-2016	Science Instructor Saint Francis of Assisi Catholic School Yorba Linda, Ca

TRANSFORMING A TRADITIONAL SCIENCE CLASSROOM WITH TECHNOLOGY-INTEGRATED PROJECT-BASED LEARNING TO MEET THE NEEDS OF 21ST CENTURY LEARNERS

by

AFSANEH MILLER

A Dissertation

Presented in Partial Fulfillment of Requirements
for the Degree of
Doctor of Education
in
Educational Leadership
December 14, 2019

ABSTRACT

This study examined the relationship between administrative support for teacher-led educational innovation in a private school and students' achievement scores on standardized achievement tests in an interrelated planning process to determine the feasibility of the successful use of technology-integrated PBL in science while attempting to mitigate all the challenges involved in the implementation of technology-integrated PBL. Additionally, the researcher looked at the effect of teacher's attitude and administrative support for the use of technology-integrated PBL in middle school science classrooms on the students' attitude and aptitude, and their levels of academic achievement on the standardized science test (CTP4).

The qualitative portion of this study was conducted using an ethnographic methodology to explore how the implementation of technology-integrated project-based learning could impact a middle school science classroom culture with the assumption that multiple educational theories such as constructivism, situated learning, the theory of change and the theory of learning and awareness impact of the implementation of technology-integrated project-based learning (PBL) in a middle school science classroom.

In developing each unit of study, the researcher considered students' prior knowledge and curriculum standards before selecting the topic of study that served to organize and drive classroom activities. Students worked collaboratively on cross-curricular academic tasks in small groups, producing an artifact as evidence of learning in a designated amount of time (Cheng, Lam, & Chan, 2008). The students then reviewed and evaluated their final product with help from the teacher before presenting their projects to their community of learners. The primary sources of data (Figure 3) collected included classroom researcher observations, structured student and staff surveys, classroom, and standardized science testing assessments

(CTP4), classroom artifacts, extensive note-taking, and developed written forms for recording the information gathered (Creswell, 2013).

The results of this research support the findings of Falik, Eylon, and Rosenfeld (2008) that showed despite the high positive impact technology-integrated PBL implementation could have for students, teachers require training and support to overcome their misconceptions and reluctance for implementing technology-integrated PBL in their classroom successfully. This study also confirmed that the students participating in PBL treatments showed significant increases in their Science Standardized Testing Scores on CTP4 during the testing cycle following the implementation of the technology-integrated PBL (2018-2019) as compared to the previous two testing cycles (2016-2017 and 2017-2018).

The researcher utilized triangulation and member checks to analyze and confirm the results of the study based on the data collected. The non-random convenience sampling from a single for-profit school may have generalized form this study population to other populations more difficult. Many variables outside of the researcher's control such as small class sizes, the level of the technological expertise of the individual teachers and students, the degree of scientific knowledge and ability, availability of technical infrastructure, student aptitude and attitude toward science and school and students' level of English language proficiency could have changed the outcome of the study. Analysis of the study data supported the study's hypotheses.

Due to the small sample size, the data collected were analyzed using a non-parametric inferential statistical test, including Spearman's Rank Correlation (Spearman Rho), Wilcoxon Signed Rank test. Despite the study's limitations, the overall findings support the use of PBL in science instruction since students in PBL treatment groups experienced significantly more

growth in Science Standardized Testing Scores (CTP4) and process skills. Moreover, a significant increase for these students suggested that sustained implementation is desirable. PBL is an effective instructional method in science process skills for this population. The study conclusions provided valuable contributions to the understanding of how the culture in a middle school science classroom culture affected the learning of science. This study's unconventional approach to collecting educational research data helped to inform efforts for effective means of monitoring the progress of science education.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Acknowledgments

In all your ways acknowledge Him,
And He shall direct your paths.

Proverbs 3:6 New King James Version (NKJV)

I praise God, who gave me the ability and the opportunity to realize a lifelong dream.

I thank my committee chair, Dr. Belinda Dunnick Karge, for her continuous support of my doctoral study and research for her patience, enthusiasm, and immense knowledge. I thank members of my committee: Dr. Michael Schulteis, and Dr. John Randall, for their encouragement, insightful comments, and hard questions.

I thank my beloved husband, Mr. Daniel Miller, for his unwavering support and encouragement throughout this journey. I thank my parents, Mr. Mohammad Reza Matin and Mrs. Mahin Matin, for their constant love and support along my life's journey. My parents instilled in me the importance of family, the value of hard work, and a passion for learning and education. Words cannot express how deeply I appreciate and love them.

CHAPTER 1: INTRODUCTION

Parents, educators, scientists, and government officials have been concerned about students' ability to deal with the changes brought on by the innovations in science and technology (Michaels, Shouse, & Schweingruber, 2008). Science affects students' lives. Understanding essential scientific skills such as critical thinking and problem-solving would enable students to improve the quality of their lives, pursue scientific careers or become scientifically literate citizens in a global society (Krajcik, Czerniak, & Berger, 1999).

Scientific learning takes place when students use their knowledge and skills to explore and construct solutions to complex, authentic questions and carefully designed products and tasks (Moursund, 2003). The use of project-based learning (PBL) in science could help young learners to ask questions, hypothesize, design experiments, gather and analyze data, produce artifacts, and communicate ideas through a process of investigation and collaboration. As students learn fundamental science concepts and principles, they become better prepared to deal with the scientific, technological, and social issues that face them in the future (Krajcik et al., 1999).

PBL has its roots in an instructional strategy that originated from John Dewey (1938). Dewey believed that it was essential to provide students with hands-on experience as part of learning. As opposed to traditional classroom projects, by simulating real problems and problem-solving PBL would allow students to explore questions based on their interests and needs in a student-centered process. Students could solve real-world problems using critical thinking, creativity, and research skills, while teachers carefully select educational standards that support the use of project-based learning (NYC Department of Education, 2009).

Chard and Katz (2000) described project-based instruction as a flexible framework, which began with the selection of a topic of study for the project that took into consideration students' prior knowledge and curriculum standards. The text selected by the teacher served to organize and drive classroom activities resulting in a series of artifacts or products, which culminated in a final product that addressed the driving question. In the last phase, the teacher's role was to help students review and evaluate their final product before the concluding event, where students share their results with their community (Curtis, 2002).

PBL promotes student learning by helping students to construct knowledge through a variety of learning experiences (Donnelly & Fitzmaurice, 2005). Students working collaboratively on cross-curricular academic tasks in small groups produce artifacts as evidence of learning in a designated amount of time (Cheng, Lam, & Chan, 2008). PBL allows students to share ideas, voice opinions, and discuss solutions, thus increasing students' level of class participation. Students show improved levels of cognitive development when fully engaged with an exciting project that enhances the quality of learning and teaching (Taylor & Parsons, 2011).

Reform efforts in science education place emphasis on the importance of rigor in science curriculum standards and the use of innovative pedagogical approaches such as PBL that make science more meaningful and support learners in authentic scientific practices (Krajcik, Mcneill, & Reiser, 2007; Kwek, 2011). As students investigate problems, they develop an understanding of fundamental scientific principles and concepts in a realistic environment that connects the classroom and real-life experiences. Understanding how scientists build, evaluate, and apply scientific knowledge could be a core part of connecting scientific knowledge to learners' experiences in the everyday world (Krajcik, Mcneill, & Reiser, 2007).

The use of PBL in science as a teaching approach has helped in the development of learning environments that reflect the nature of science (Krajcik et al., 1999). Research has suggested that innovation in curriculum and instructional practice requires that considerable attention be given to curricular content, classroom and curricular organization, individual and developmental differences in the use of knowledge (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2004). Furthermore, attention must be given to motivational orientation, cognitive and metacognitive strategies, teacher efficacy, opportunities for professional development, organizational time, and support for teacher reflection. For project-based instruction to be successful, projects must be designed in a manner that helps sustain student attitude, aptitude, and thoughtfulness. Teaching in this way requires close attention to project design and strategies that could lead to the successful implementation of PBL by instructors (Blumenfeld et al., 1991).

Statement of the Problem

Using technology-integrated PBL, teachers could introduce higher level, cognitively complex assignments, which in turn provide students with opportunities for problem-solving (Curtis, 2002). Through technology-integrated PBL, students could construct knowledge by solving complex problems using multiple sources of information and resources. Most importantly, students find projects, fun, motivating, and challenging because they play an active role in choosing and planning processes (Katz, 1994).

Despite the apparent benefits of PBL, its implementation has not been without challenges. Teachers who wish to implement PBL in the classroom have found it difficult to allow students to choose a topic of study that interests them within the confines of the prescribed curriculum (Andrews, 2014). Teachers have also found it harder to follow lesson-pacing guidelines because the in-depth investigations required often take longer than expected (Stepanek, 1999). Another issue faced by teachers has been the designing of assessments that accurately reflect evidence of student understanding of content constructed through PBL rather than delivered through the traditional single test given at the culmination of a unit of study (Curtis, 2002)

Critics of PBL have cited students' lack of prior experience as the reason for students not knowing what might be essential to learn. Additionally, critics of PBL believe that teachers' may not be able to cover the amount of material covered in a traditional classroom due to the level of work and planning involved for the teachers (Boud, D. & Feletti, 1997).

Beyond issues of lesson planning and assessment, often, the most prominent obstacles cited to the implementation of PBL by teachers have been the lack of time and resources. Teachers require the support of the administrators to mitigate issues of time and resources as part of the successful implementation of technology-integrated PBL in the classroom (Harrigan, 2014, Laboy-Rush, 2009; Thomas, 2000). Administrators' level of interest and level of knowledge about best instructional practices could lead to either encouragement or discouragement for teachers who desired to implement instructional methods such as PBL in their classrooms (Harrigan, 2014).

Purpose of the Study

The purpose of implementing technology-integrated PBL in a middle school science classroom was to learn if the use of this method of teaching would enhance the existing science curriculum while adhering to the curriculum standards and lesson pacing guidelines. Furthermore, the purpose of this realist ethnographic study was to see if the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom could lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science. An additional purpose of this study was to learn if access to an easy to use, lesson-planning platform, along with administrative support, could serve to change the attitude of teachers with basic knowledge of technology toward implementation of technology-integrated PBL in their classrooms to improve students' levels of academic achievement.

Research Questions

1. How could technology-integrated PBL be implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines?
2. How could the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science?
3. What would be the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement?

Hypothesis

H_1: The data collected would demonstrate how technology-integrated PBL could be implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines.

H_2: The data collected would demonstrate how the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom could lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science.

H_3: The data collected would demonstrate the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement.

Theoretical Framework

The current emphasis placed on student outcomes in education challenges teachers to develop and implement effective and efficient strategies such as PBL that translate into student engagement and learning (Leithwood, Seashore Louis, Anderson, & Wahlstrom, 2004; UNESCO, 2004). Multiple theories such as constructivism, situated learning, the theory of change and the theory of learning and awareness by Marton and Booth ("What is theory of change," n.d.; Krajcik et al., 1999; Marton & Booth, 1997; Moursund, 2003) support the use of PBL in the classroom.

The Constructivist Theory

The constructivist theory (Jean Piaget) stated that students create their knowledge in the context of their own experiences. When students actively engage with an authentic phenomenon requiring them to use and apply knowledge with multiple representations, they develop an understanding as they seek answers to questions about the natural world. In a constructivist classroom, students interpret received information considering pre-existing knowledge and experiences (Krajcik et al., 1999; Moursund, 2003). The teacher may make decisions and base actions on beliefs that are consistent with constructivism. However, constructivism does not suggest how an individual should learn but offers an account of how learners construct knowledge using the common elements of constructivist pedagogy, such as being student-centered, using different modes of instruction, and creating opportunities for understanding through purposeful group dialogue (Kemp, 2014).

Situated Learning Theory

A critical aspect of learning activity is the context and culture in which learning occurs. Like PBL, in a situated learning theory classroom, learners become involved in a community of practice in which both students and the teachers become actively engaged in carrying out a project in a supportive learning environment designed to facilitate learning that transfers to real-world settings (Korthagen, 2009, Moursund, 2003).

Cognitively engaged and motivated students tend to learn more and remember materials learned better than students who receive only didactic instruction (Johnson & Hayes, 2016). PBL problems need to be relevant to help students be intrinsically motivated (Moursund, 2003). Inquiry-based teaching methods often used by PBL teachers, focus on teaching students how to ask questions, observe, and interpret data, solve problems, conduct investigations, and develop an understanding of the scientific concepts (Goldstein & Bevins, 2016). PBL lessons could provide the needed environment in which students learn to work cooperatively with their peers as they explore and learn curriculum topics and social skills (Moursund, 2003).

The Theory of Learning and Awareness

The theory of learning and awareness developed by Marton and Booth (1997) investigated why some teaching methods were more effective than other strategies for producing meaningful learning outcomes. This theory emerged as an approach to studying learning outcomes from the viewpoint of different students' experiences to help them become aware that they can achieve a better quality of education if they could observe various facets of experience simultaneously so that the part-whole relationship becomes apparent. By applying this approach, teachers create a learning space where students can learn by using a variety of experiences (Marton & Booth, 1997).

The Theory of Change

The significant level of attention placed on curricular reform has only recently expanded to include the study of teacher training and development within the school setting (Peng et al., 2014). Using the theory of change (Carol Weiss) as a process to promote change and define goals and desired outcomes, organizations can study the relationship between all steps of teacher training and development by mapping pathways backward in chronological order ("What is theory of change," n.d.) By breaking down long-term goals and objectives into several shorter-term and observable outcomes, educational leaders can make informed decisions about strategies for change and reflectively evaluate the organization's plan for teacher training and development (Fullan, 2006).

Closing the student learning gap requires access to resources and a leadership committed to capacity building that focuses on accountability ("Effective Practices in Closing Achievement Gaps," 2019). Promoting capacity building and motivating the people would allow for the flow of ideas among all levels of an organization that, in turn, could track outcomes at each step to ensure their actions lead to the expected results (Fullan, 2006). Policies put in place by the leadership must allow for and support innovation by creating an atmosphere of encouragement with pathways that can realistically achieve measurable data generated along the way that can then be used to measure the success or the failure of the change pathways ("What is theory of change," n.d.)

Significance of the Study

This study was designed to contribute valuable insight and theory to the successful use of technology-integrated PBL in science, considering the level of importance placed on student enthusiasm for learning at the middle school level. Falik, Eylon, and Rosenfeld (2008) showed that although PBL implementation could have a significant educational potential for students, teachers required training and support to implement PBL in their classroom successfully. The outcome of this study may be useful for the development of improved training models, environments, and implementation strategies that promote the efficient use of technology-integrated PBL in middle school science classrooms.

As part of the study, the researcher sought to examine the relationship between broad sets of variables. The variables analyzed included the impact of the addition of technology-integrated PBL to the existing science curriculum and instruction; the impact of teachers' attitude toward the implementation of technology-integrated PBL in the classroom; the impact of the level of administrative support for the implementation of technology-integrated PBL in the classroom and the theoretical foundations of PBL. By identifying variables, a conceptual starting point was established for the successful implementation of PBL in the classroom. Providing the proper contextual environment could enhance the use of PBL to support of students' attitude and aptitude while helping teachers to deal with issues such as classroom management and assessment (Fallik et al., 2008). No other study has shown a direct tie-in between strategic planning and administrative support for teachers to implement technology-integrated PBL in their classrooms in a private school and students' achievement scores on standardized achievement tests in what might be an interrelated planning process.

Researcher Background

As a scientist, the researcher brought her love and knowledge of scientific principles to the classroom. As a science teacher, the researcher had successfully used PBL as well as the principles of Science, Technology, Engineering, Arts, and Mathematics (STEAM) in her classroom with measurable impact on students' commitment to learning. Year after year, the researcher saw an average of 50% of her students enroll in high school honors science classes upon graduation from eighth grade. Based on self-reporting done by former students, many chose a career path involving the study of science upon graduation from high school. The researcher believed that her personal and professional background gave her the knowledge and experience needed to research this topic.

Definition of the Terms

The study provided explanations for terms that many people tend to confuse and mix in their studies; therefore, it was necessary to separate them and show them as individual words.

Benchmark lessons are teacher-directed lessons or classroom activities used to teach needed skills or concepts that help students develop understanding essential to project work (Krajcik et al., 1999).

Concept Map is a visual learning tool with associated spatial features that include concept hierarchy and relationships. A concept map is also a constructivist-based tool, facilitating active knowledge construction by the individual as opposed to the passive transfer of knowledge structures from an expert source to the individual (Rye, Landenberger, & Warner, 2013).

Cognitive strategies help learners to become academically successful. These include repetition, organizing a new language, summarizing meaning, guessing the meaning from context, using imagery for memorization (https://www.teachingenglish.org.uk/article/cognitive-strategies).

The Community of learners is composed of students, teachers, and members of society collaborating to investigate questions (Krajcik et al., 1999).

Cross-curricular teaching involves a conscious effort to utilize the knowledge and principles of more than one academic discipline simultaneously. The subjects may be related to a central theme, issue, problem, process, topic, or experience (https://www.collinsdictionary.com/dictionary/english/cross-curricular).

Culture-Sharing Group: A group of people that could be studied, described, and interpreted by ethnographic researchers with shared or learned cultural values, beliefs, and language developed because of interaction over time (Creswell, 2013).

Driving questions or problems organize and guide instructional tasks and activities (Krajcik et al., 1999)

Ethnographic Study refers to a method of study and observation of a culture-sharing group through immersing of the researcher in the day-to-day lives of participants (Creswell, 2013).

Fundamental scientific principles refer to extensively and reproducibly tested explanations for significant natural phenomena (http://evidence-based-science.blogspot.com/2008/02/what-is-scientific-law-theory.html).

Hands-on experience refers to the knowledge and skills gained from doing something rather than just reading about it or seeing it. (https://dictionary.cambridge.org/us/dictionary/english/).

Inert knowledge refers to knowledge stored in the memory that cannot be recalled and used in an appropriate situation (Moursund, 2003).

Integrated learning happens when previously learned knowledge is used to solve a problem (Moursund, 2003).

Interactive Science Folders (Journals) are tools used to promote student learning, enhance communication skills used to assess students' academic growth (Full Option Science System [FOSS], 2018).

Metacognitive strategies are methods used to help students understand how they learn (http://inclusiveschools.org/metacognitive-strategies/).

Motivational orientation relates to innate desires (e.g., interest) or external compensation (e.g., money) sources of motivation for a person to act (Ryan & Deci, 2000).

Portfolio assessment is the systematic, longitudinal collection of student work created in response to specific, known instructional objectives and evaluated by the same criteria (Barnhardt, Kevorkian, & Delett, 1998).

PBL is a teaching strategy where students develop knowledge and skills over time through investigation of an authentic, engaging, and complicated question, problem, or challenge (https://www.bie.org/object/document/pbl_essential_elements_checklist).

Receptional approaches to teaching are those in which teachers transmit information, and students receive the data (Moursund, 2003).

Suburban norms are the average of the scores from the most recent three years of testing by select suburban public-school Comprehensive Testing Program (CTP) users throughout the United States (Educational Records Bureau. (2019). Retrieved from https://www.erblearn.org/)

Teacher efficacy refers to teachers' beliefs in their abilities to organize and embark upon courses of action necessary to bring about desired results (Tschanmen-Moran, Woolfolk Hoy, & Hoy, 1998).

Technology comes from "two Greek words, transliterated techne, and logos. *Techne* means art, skill, craft, or the way, manner, or means by which a thing could be gained. *Logos* means word, the utterance by which inward thought is expressed, a saying, or an expression." ("Dictionary.com," 2018).

Technology-integrated PBL describes PBL infused with technological tools, databases, and online applications to facilitate learning (Kirkwood & Price, 2014).

Traditional Science classrooms could be defined as teacher-centered delivery of instruction to classes of students who are the receivers of information (Krajcik & Czerniak, 2014).

Transformational approaches to teaching and learning help students to make sense of the materials themselves rather than receive information to memorize (Moursund, 2003).

Limitations

The study population came from a single for-profit private school organization with three schools; therefore, it may not be possible to replicate the results of this study in all school populations. Although the student body was derived from a diversified population, the school employed a selective screening process for all incoming students that include an academic assessment as well as financial commitment from the parents. Eligible families could receive partial tuition assistance upon acceptance. Many variables that could impact the outcome of the student achievement in science such as small class sizes, the level of technological expertise of the individual teachers and students, the degree of scientific knowledge and ability, availability of technical infrastructure, student aptitude and attitude toward science and school and students' level of English language proficiency were outside of the control of the researcher. The researcher believed, based upon the work of Falik, Eylon, and Rosenfeld (2008), that to be successful, implementation of technology-integrated PBL in a middle school science classroom required a willingness by the teachers and support from the administration.

Delimitations

The desire to gain an understanding of the relationship between administrative support on teacher's attitudes toward the use of technology-integrated PBL in the classroom and level of students' learning determined the delimitations utilized by the researcher in this study. Additional considerations were given to the time required to complete the study, distance from other schools within the organization, space needed to do the study as well as other teachers' availability to participate by the researcher to determine the delimitations for this study.

The middle school level has a one-to-one iPad requirement. The elementary classrooms have access to iPad carts. All classrooms have Wi-Fi access and an Apple TV. Most classes have document cameras. The schools' computer lab could be utilized to provide students with weekly technology instruction. The school administration and faculty must seek a minimum of 20 hours of professional development annually. The school offers partial tuition reimbursement for staff members who wish to continue their formal education. All school administrators hold teaching as well as administrative credentials that enable them to understand and provide support for best practices in curriculum and instruction. Parents in the school work collaboratively with teachers and administration through the school's parent-teacher association to make changes and offer support.

Assumptions

This study included the following assumptions: (a) the researcher understood the concepts associated with the implementation of technology-integrated PBL in the classroom; (b) not all teachers would be receptive to integrating technology and project-based learning; (c) the data collected measured the knowledge, skills, and perception of the researcher involved in implementing technology-integrated PBL in the classroom to support student learning; (d) the interpretation of the data accurately reflected the impact of administrative support for implementing technology-integrated PBL in the classroom.

Organization of the Study

This research study has been presented in five chapters. Chapter one included the background of the study, statement of the problem, the purpose of the study, the significance of the study, the definition of the terms, theoretical framework, research questions, limitations, delimitations, and assumptions of the study.

Chapter two presented a review of the literature, including the impact of addition of technology-integrated PBL to the existing science curriculum and instruction, the impact of teacher attitude on the implementation of technology-integrated PBL in the classroom, impact of the level of administrative support on the implementation of technology-integrated PBL in the class and theoretical foundation of PBL. Chapter three described the methodology utilized for this research study. It included the selection of participants, instrumentation, data collection, and data analysis procedure.

Chapter four presented the study's findings, including demographic information, testing the research questions, and the results of data analyses for the research questions. Chapter five provided a summary of the entire study, discussion of the findings, implications of the findings for theory and practice, recommendations for future research, and conclusions.

Summary

Understanding essential scientific skills such as critical thinking and problem-solving would enable students to improve the quality of their lives and become better prepared to deal with the scientific, technological, and social issues that face them in the future (Krajcik et al., 1999). As opposed to traditional classroom projects, by simulating real problems and problem-solving PBL would allow students to explore questions based on their interests and needs in a student-centered process. PBL could promote student learning by helping students to construct knowledge through the building, evaluating, and applying scientific expertise as a core part of connecting scientific knowledge to learners' experiences in the everyday world (Krajcik, Mcneill, & Reiser, 2007).

Despite the apparent benefits of PBL, teachers who wish to implement PBL in the classroom have found it difficult to allow students to choose a topic of study that interests them within the confines of the prescribed curriculum due to students' lack of prior experience (Andrews, 2014). Teachers have also found it harder to follow lesson-pacing guidelines because the in-depth investigations required often take longer than expected due to the level of work and planning involved (Stepanek, 1999). Another issue faced by teachers has been the designing of assessments that accurately reflect evidence of student understanding of content constructed through PBL rather than delivered through the traditional single test given at the culmination of a unit of study (Curtis, 2002)

Beyond issues of lesson planning and assessment, often, the most prominent obstacles cited to the implementation of PBL by teachers have been the lack of time and resources.

Administrators' level of interest and level of knowledge about best instructional practices could lead to either encouragement or discouragement for teachers who desired to implement instructional methods such as PBL in their classrooms (Harrigan, 2014).

The purpose of implementing technology-integrated PBL in a middle school science classroom was to learn if the use of this method of teaching would enhance the existing science curriculum while adhering to the curriculum standards and lesson pacing guidelines. Furthermore, the purpose of this realist ethnographic study was to see if the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom could lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science. An additional purpose of this study was to learn if access to an easy to use, lesson-planning platform, along with administrative support, could serve to change the attitude of teachers with basic knowledge of technology toward implementation of technology-integrated PBL in their classrooms to improve students' levels of academic achievement.

Multiple theories such as constructivism, situated learning, the theory of change and the theory of learning and awareness by Marton and Booth ("What is theory of change," n.d.; Krajcik et al., 1999; Marton & Booth, 1997; Moursund, 2003) support the use of PBL in the classroom. The constructivist theory (Jean Piaget) stated that students create their knowledge in the context of their own experiences. When students actively engage with an authentic phenomenon requiring them to use and apply knowledge with multiple representations, they develop an understanding as they seek answers to questions about the natural world. In a constructivist classroom, students interpret received information considering pre-existing knowledge and experiences (Krajcik et al., 1999; Moursund, 2003).

A critical aspect of learning activity is the context and culture in which learning occurs. Like PBL, in a situated learning theory classroom, learners become involved in a community of practice in which both students and the teachers become actively engaged in carrying out a project in a supportive learning environment designed to facilitate learning that transfers to real-world settings (Korthagen, 2009; Moursund, 2003). The theory of learning and awareness developed by Marton and Booth (1997) investigated why some teaching methods were more effective than other strategies for producing meaningful learning outcomes. This theory emerged as an approach to studying learning outcomes from the viewpoint of different students' experiences to help them become aware that they can achieve a better quality of education if they could observe various facets of experience simultaneously so that the part-whole relationship becomes apparent. Using the theory of change (Carol Weiss) as a process to promote change and define goals and desired outcomes, organizations can study the relationship between all steps of teacher training and development by mapping pathways backward in chronological order ("What is theory of change," n.d.). By breaking down long-term goals and objectives into several shorter-term and observable outcomes, educational leaders can make informed decisions about strategies for change and reflectively evaluate the organization's plan for teacher training and development (Fullan, 2006).

Falik, Eylon, and Rosenfeld (2008) showed that although PBL implementation could have a significant educational potential for students, teachers required training and support to implement PBL in their classroom successfully. The outcome of this study may be useful for the development of improved training models, environments, and implementation strategies that promote the efficient use of technology-integrated PBL in middle school science classrooms.

The study population came from a single for-profit private school organization with three schools; therefore, it may not be possible to replicate the results of this study in all school populations. Many variables could have impacted the outcome of the student achievement in science such as small class sizes, the level of technical expertise of the individual teachers and students, the degree of scientific knowledge and ability, availability of technical infrastructure, student aptitude and attitude toward science and school and students' level of English language proficiency were outside of the control of the researcher. The researcher believed, based upon the work of Falik, Eylon, and Rosenfeld (2008), that to be successful, implementation of technology-integrated PBL in a middle school science classroom required a willingness by the teachers and support from the administration. The desire to gain an understanding of the relationship between administrative support on teachers' attitudes toward the use of technology-integrated PBL in the classroom and level of students' learning determined the delimitations utilized by the researcher in this study.

CHAPTER 2: REVIEW OF LITERATURE

Introduction

This chapter explains the impact of the addition of technology-integrated PBL to the existing science curriculum and instruction, teacher attitude toward implementation of technology-integrated PBL and the importance of researching the relationship between administrative support for the implementation of technology-integrated PBL and teachers' attitude towards enacting technology-integrated PBL in the middle school science classrooms. Teacher attitude and aptitude has recently become a subject of interest in educational research involving PBL (Blumenfeld et al., 1991; Grant & Branch, 2005). Therefore, this study attempted to build upon currently available research through looking at the correlation between the levels of administrative support on teachers' attitude towards implementing technology-integrated PBL in a middle school science classroom, the students' attitude and aptitude, and their levels of academic achievement on the standardized science test (CTP4).

Key Themes

Key themes for this literature review were: (a) the impact of the addition of technology-integrated PBL to the existing science curriculum and instruction; (b) the impact of teachers' attitude on the implementation of technology-integrated PBL in the classroom; (c) the impact of the level of administrative support on the implementation of technology-integrated PBL in the classroom and (d) the theoretical foundations of PBL.

Impact of Addition of Technology-integrated PBL to the Existing Science Curriculum and Instruction

Technological and scientific advances have made it necessary for every citizen to become scientifically literate to comprehend their world and make informed decisions (Hazen, 2002; McNamee, 2014). Technology has changed the way people learn and work. Employers seek to hire employees who not only have scientific or technical expertise but could also work collaboratively, think creatively, solve problems, as well as collect and analyze data (Rainie & Anderson, 2017).

The world students' face has become increasingly technological. Learners need to be able to present information in multiple formats such as text, graphics, and animation while retaining information and developing a deeper understanding of concepts (Seo, Templeton, & Pellegrino, 2008). The expansion of technology has led to a surge in the level of available knowledge. Educational institutions can no longer present their students with all the information needed to become successful for the rest of their lives (UNESCO, 2004; Scott, 2015). With access to technology from a very young age, many students may know more about technology than their teachers. Technology has made information so accessible that students could quickly locate information about fundamental concepts and subject matter topics as they explore solutions to questions (Eady & Lockyer, 2013; Gollub, Bertenthal, Labov, & Curtis, 2002; Groff, 2013). By being able to use and access technology, students could research issues that help them understand the topic studied (Boss & Krauss, 2007). The integration of technology has transformed the classroom and changed the teacher's role from the expert to the facilitator (Goos, Galbraith, Renshaw, & Geiger, 2000).

Because of the exponential growth in the amount of available information, and access to digital resources that enable them to communicate with others instantly, teens have become significantly different from previous generations (Krajcik & Czerniak, 2014). In direct contradiction to traditional classroom structures, technology-savvy adolescents often multitask, communicate, and collaborate with others in various ways using their digital devices (Weigel, Straughn, Gardner, & James, 2009). The infusion of digital tools and resources into the twenty-first-century classroom has led to shifting of roles for both teachers and students (Blair, 2012).

Students may not want to learn in an environment where they required to learn things they do not see as worth learning, regardless of adult expectations (Dweck, Walton, & Cohen, 2014; Toshalis & Nakkula, 2012). The International Society for Technology in Education (ISTE) 's National Educational Technology Standards (2007) has stated that the sixth through eighth-grade students need to be able to "Design, develop, publish, and present products (e.g., Web pages, videotapes). Using technology resources that demonstrate and communicate curriculum concepts to audiences inside and outside the classroom."

The institutional structure provided by PBL could meet the Next Generation of Science Standards (NGSS) three-dimensional structure by focusing on concepts that require students to cut across several academic disciplines while investigating highly complex problems. By infusing teaching practices with twenty-first-century skills that respond to the complex learning needs of middle school students, middle school educators would be able to provide students with the opportunity to practice under real-life situations similar to ones they would encounter in college and beyond (Discovery Education, 2017; "Families and Youth," 2019). For example, technological tools can help students to conduct experiments, collect data, and communicate with other scientists in real-time (Krajcik & Czerniak, 2014).

Curriculum, Instruction, and the Adolescent Mind

During adolescence, young brains experience one of the most critical periods of physical changes since infancy. During the early teen years, students go through body changes triggered by hormonal shifts that can, in turn, bring out intense feelings. Emotionally tweens become more independent of their family units and more concerned about fitting in with their peer groups. Although they can exercise critical thinking skills, tweens are hindered by the fact that the portion of the brain responsible for thinking through possible consequences of their actions is still under construction. A significant part of the young brain's growth and development involves the building and strengthening of brain pathways and structures such as the brain stem, cerebellum, occipital lobe, parietal lobe, frontal lobe, and temporal lobe actively mature during adolescence (Arain et al., 2013). During the early years of life, the adolescent brain created new brain cells and connections between the brain cells that are subsequently pruned starting around the age of three and into the teen years, and possibly even early twenties (Blakemore, 2012).

The frontal cortices that control reasoning, decision-making, and executive brain functions continue to change and mature well into adulthood (Fuster, 2002). The significantly underdeveloped prefrontal lobe responsible for communications, overall decision, regulating emotions, working memory, and executive functioning can lead to behaviors that are irrational, illogical, and impulsive (Reyna & Farley, 2006).

The adolescent behavior could interfere with effective classroom management and the delivery of curriculum and instruction. Studies of male and female brains have shown that even though the female brain has higher proportions of gray matter than white matter, male brains use nearly seven times more gray matter for action while the female brains use almost ten times more white matter (Jantz, 2014; "Intelligence In Men And Women Is A Gray And White Matter," 2005). This fact may explain the presence of stronger processing, verbal, and multitasking skills among young girls, whereas the presence of additional white matter may explain why the male brain can think more spatially (Dumontheil, 2014). A bigger amygdala means that boys and young men need to move around while learning as compared to girls and young women, who can sit still and focus on one subject for extended periods (“Male and Female Brains Are Not the

Same," 2018). Higher blood flow to the female brain, especially to an area called the cingulate gyrus, means that girls will think more about emotional memories (Jantz, 2014). Middle school teachers need to have a thorough understanding of the brain physiology of both male and female students to deliver curriculum and instruction in an active learning environment.

Tweens have been exposed to technology all through their lives. They are both consumers and producers of digital media products. However, the developmental issues associated with tween years can lead to irresponsible use of technology. By using digital citizenship instruction, teachers can be instrumental in providing the students with the skills they need to thrive in an ever-increasing digital society (Katz & Chard, 2000). The steadily increasing understanding of the human brain, how it stores and retrieves information, learns, builds and extends previous knowledge, thinks and makes decisions has caused the teachers' role to be changed to more of a guide rather than a source of knowledge (Boss & Krauss, 2007). Through a better understanding of neurological, physical brain maturation, cognitive, and social-emotional adolescent development, teachers can become better able to guide middle school students (Arain et al., 2013; Casey, Jones, & Hare, 2008; Discovery Education, 2017; Jantz, 2014).

Adolescence and motivation. Adolescence is the age where young people further develop their social and emotional competence. At this stage of their lives, young people become better able to understand and manage life tasks such as self-awareness, impulse control, learning, forming relationships, solving everyday problems, and adapting to the complex demands of growth and development. Adolescent students have also begun developing their abilities to think abstractly about various ideas as they strive toward understanding themselves relative to the world around them ("Developing Adolescents: A Reference for Professionals," 2002; Collins, 1984).

During adolescence, young people develop a need and commitment toward their peer group (Blakemore, Choudhury, & Charman, 2007). Students in middle school have started to develop the ability to distinguish right from wrong, show empathy toward others, and the need to be liked by their peers (American Psychological Association, 2002; Cole, 2008). During this period of their lives, young students experience self-esteem issues that could affect their personal and academic identities due to the conflict between their decisions and maturity level (Arain et al., 2013; Discovery Education, 2017). Adolescents could have different views about their ability to succeed academically. Some may believe that they have no choice over their academic skills, whereas others may feel that academic strength could improve over time (Cole, 2008; Dweck et al., 2014). When given the opportunity as part of the collaborative learning, young students who do not believe that they can succeed academically may choose lower-level tasks to demonstrate learning outcomes (Cole, 2008; Willis, 2007).

Middle school students may have different goals in mind about their academic careers. Whereas, proficiency versus ability motivate some students, learning and not performance may drive others. Tasks versus ego involvement may inspire some students. Students may also differ in how they perceive and value education (Toshalis & Nakkula, 2012; Wigfield & Cambria, 2010). Some students value learning, whereas others see education as a means earning grades, teacher, and parental approval, and avoiding consequences (Blumenfeld et al., 1991; Fallik, Eylon, & Rosenfeld, 2008; Pepper Rollins, 2017).

Extrinsic motivational methods such as rewards and punishment control student behavior and enhance classroom management without any positive impact on student learning and academic achievement ("Motivating Students," 2019). While external rewards might control immediate student behaviors, the behavior change may not continue to the next task (US Office of Special Education Program, 2015). Intrinsically motivated students are far more interested and excited about their academic performance. Inherently motivated students benefit from assignments, become more engaged in their work, self-regulate, and use higher-level learning strategies (Cheng, Lam, & Chan, 2008; Curtis, 2002). Learning choices in the classroom and meaningful feedback are essential to developing students' attitude and aptitude (Fallik, Eylon, & Rosenfeld, 2008; Pepper Rollins, 2017). Intrinsically motivated students could build their confidence when allowed to make choices and take ownership of the learning process (Pepper Rollins, 2017). Activities that challenge inherently motivated students help to build persistence, creativity, and self-esteem (Cole, 2008; Irvin, Meltzer, & Dukes, 2007). Projects that challenge students help them to develop critical thinking skills needed for the successful assessment of the quality of their work and provision of feedback for their peers (Scott, 2015). Challenging projects could teach students to work with limited resources such as time and money, develop personal responsibility for completing the project on time and, build skills for future careers (Cheng, Lam, & Chan, 2008; Curtis, 2002; Moursund, 2003).

Research has shown that as students move to middle school, they lose interest in science and develop negative attitudes toward learning science because classroom instruction moves away from engaging in the process of learning science to focusing on students memorizing facts and formulas (Kamara, 2015; Osborne, 2003; Prince, 2004). Through creation of learning opportunities that appeal to the young students' intellectual, social-emotional, physical, and moral developmental needs, teachers not only challenge their students to develop and apply twenty-first-century skills in their everyday lives but also respond to their desire for connection, affiliation, and self-assurance (Weigel, Davis, James, & Gardner, 2009).

Along with the social and emotional changes, tweens often experience physical changes that could affect the psychological and social aspects of their development (American Psychological Association, 2002). According to Maslow's hierarchy of needs, the need for survival motivates human behavior (McLeod, 2018). Young students who are not able to fulfill their physical requirements would not be able to achieve their full potential. Meeting the physical needs of adolescents requires access to sports and other physical activities, adequate nutrition, and rest in a safe and supportive learning environment (Discovery Education, 2017; "Male and Female Brains Are Not the Same," 2018). Educators need to become aware of the ongoing developmental changes inherent in adolescent brain composition, to bridge the gap between students' cognitive capacity and its impact on teaching and learning(Cole, 2008; Discovery Education, 2017; Eliot, 2009; "Families and Youth," 2019).

Educators should strive to provide safe, active learning environments where students could take risks, participate in an academic discussion with their peers, and build supportive relationships with both students and adults as to help strengthen students' social and emotional competence (Cole, 2008; Willis, 2007; Yoder, 2014). Teachers must be aware of how their students learn and value the students' knowledge acquired outside of the classroom. Teachers should involve students in instruction design and decision-making (Discovery Education, 2017; "Male and Female Brains Are Not the Same," 2018). Teachers could be instrumental in helping their students to integrate learning by seeing mistakes as learning opportunities. Teachers could encourage a positive attitude toward academic challenges in the young mind by focusing on the learner's effort and progress. By concentrating on abilities in a variety of different situations and contexts, teachers could enable students to use what they know (Dweck, Walton, & Cohen, 2014; Dweck, 2016; Discovery Education, 2017; Spinks, 2002).

Effective instructional strategies, such as PBL, could inspire bored students and raise their level of understanding and achievement (Usher & Kober, 2012). Student-centered approaches like PBL allow students to learn core information and develop knowledge through the active use of experience (Delisle, 1997; Krajcik et al., 1999). PBL has demonstrated a positive impact on student attitude and aptitude (Doppelt, 2009; Saleh, Cox, Fowler, & Duncan-Shemwell, 2010). Projects could stimulate students and increase student interest by involving students in solving authentic problems while working with others ("Motivating Students," 2019). Unfortunately, low-level tasks (use of worksheets) that are more prevalent in schools cause students to develop a lack of real understanding of the content and a poor attitude toward learning and schooling (Oberg, 2010).

PBL and differentiated instruction. The currently existing traditional system of education is highly compartmentalized and does not allow students to transfer knowledge learned in one domain to another quickly (Scott, 2015). Real-world problem-solving requires students to use information from multiple areas ("21st Century Skills for Students and Teachers," 2010). However, schools often ask students to solve domain-specific problems that lack real-world connections (Thomas, 2000).

PBL's use of driving questions and active engagement as part of a benchmark lesson in the context of the real world could differentiate PBL from didactic instruction. Because of an emphasis on active involvement, PBL has the potential for meeting the different learning needs of diverse students by helping them to develop long-term learning skills (NYC Department of Education, 2009; Hmelo-Silver, 2004). Using PBL, science teachers could plan and design differentiated lessons and projects aligned with their students' abilities and interests (Seo, Templeton, & Pellegrino, 2008). By considering student abilities and interests, teachers could intentionally create a differentiated learning environment (Habok & Nagy, 2016; Subban, 2006).

Providing access to information does not guarantee that it will be useful to the teachers and the students. The design of subject-matter curriculum and project support materials must enhance the teachers' knowledge base and help them to adapt existing projects or generate new ones considering their teaching circumstances and students (Clayton-Pederson & O'Neal, 2018; Kwek, 2011). The design, organization, and structure of data must support students' cognitive competence and help them while they are working on authentic tasks (Apedoe, Ellefson, & Schunn, 2012).

Development of a curriculum that attends to critical relations between learning and thinking must include projects with focused and meaningful units of instruction that integrate educational objectives and priorities as well as concepts from other disciplines or field of studies (Apedoe et al., 2012; Krajcik et al., 1999). PBL projects allow students to become responsible for their learning process by engaging with authentic scientific experiences that allow for the collaborative discovery of solutions to a real-world problem using an interdisciplinary approach. In this way, students develop the skills needed to apply knowledge previously gained by actively planning, designing, organizing, and carrying out activities such as investigations, presentations, and interviews. Projects have the potential to enhance understanding because they allow students to acquire and apply information, formulate plans, track progress, and evaluate solutions (Curtis, 2002). Reflection and goal setting must be essential components of any project.

Teachers would need to ask students to reflect on their work and set goals for their progress. Teachers could further assist students by creating mini-lessons around specific student learning goals (Department of Education and Training Melbourne, 2017). To differentiate instruction and support their students learning needs, teachers could use mini-lessons and learning centers. Teachers could provide students with mini-lessons and resources at teaching stations, depending on the individual requirements of the students. Thoughtfully designed and implemented projects could be more effective than traditional instruction for teaching concepts and helping students to develop long-term retention and recall (Aloisi, Major, Coe, & Higgins, 2014). However, when the projects focus on what students could create or do at the end of a unit without the process of investigation and element of discovery, projects fail to engage students in authentic learning (Saleh et al., 2010).

Due to an emphasis on innovation and transfer of knowledge, PBL could engage and encourage students (Kanter, 2009). Research has shown that students would be more likely to participate in authentic problem-solving using scientific principles and processes such as the scientific method, engineering design principles, sampling methods, and measurement skills (American Chemical Society, 2012; California Department of Education, 2016; McCright, 2012; Singer, Nielsen, & Schweingruber, 2012). Students would be more encouraged to learn when provided with choices in how they are to complete the work. Tasks that are authentic and challenging connect new ideas to prior knowledge, generate artifacts as an effective method of knowledge construction and closure, enhance student interests (Blumenfeld et al., 1991; Tinzmann et al., 1990). By allowing students to connect new information with previously acquired knowledge and real-world problems, PBL could incentivize students to develop a broad, integrated understanding of content and process rather than memorization of random facts (Curtis, 2002; Remmen & Froyland, 2014).

Sustained inquiry based on relevant and meaningful questions that meet the interests, abilities, and experiences of students has always been one of the hallmarks of science (Holbrook, 2009). In the absence of sustained inquiry, students memorize scientific information without understanding. Memorization could lead to gaining of inert scientific knowledge, but memorization could not explain the scientific phenomenon (Discovery Education, 2017; "Families and Youth," 2019; Jantz, 2014; Lenroot & Giedd, 2010; Lujan & DiCarlo, 2006). However, the use of significant issues or problems in science based on authentic experiences could reinforce conceptual understanding in a PBL classroom.

By enticing students with higher-order thinking tasks that allow the internalization of knowledge and comprehension, PBL could be used to improve students' scientific experience (American Chemical Society, 2012; Apedoe, Ellefson, & Schunn, 2012; Delisle, 1997; Discovery Education, 2017; "Families and Youth," 2019; Krajcik et al., 1999; Krajcik et al., 2007; Nextgenscience.org, 2013). Multidisciplinary science instruction could encourage the investigation of problems relevant to the context of real-life, thus drive students to understand subject matter content (California Department of Education, 2016).

Research has shown that learners construct knowledge by solving complex problems involving the use of multiple sources of information as well as other individuals as resources (Apedoe et al., 2012; Michaels et al., 2008). By working with various ideas students would be able to find information, plan, and design, build apparatus, collect data, analyze data, draw conclusions, and communicate findings through the creation of a concept map and generation of artifacts (Blumenfeld et al., 1991; Grant & Branch, 2005; Krajcik et al., 1999; Krajcik et al., 2007; Krajcik & Czerniak, 2014; Thomas, 2000; Tseng, Chang, Lou, & Chen, 2013).

A significant part of the ability to think like a scientist is the capacity to picture oneself as a scientist. By using PBL, students who work with scientists in the field and contribute to real-world research could see themselves as partner experts and take pride in their work and use of professional language and tools (Cole, 2008, National Education Association, 2012). Students could have a chance to deal with different challenges and solve problems in their learning process like adults in professional practice (Larmer, Mergendoller, & Boss, 2015). Their skills in scientific inquiry, use of instruments, observations, hypotheses, and data analysis skills improve as they gain experience (Boss & Krauss, 2007; Moursund, 2003; US Department of Education, 2017).

PBL and technology. The technology could help transform the science classroom into an environment in which learners actively construct knowledge (Groff, 2013; Guzey & Roehrig, 2016; McKnight et al., 2015). In PBL, teachers design the plans to support the teaching of required concepts. Still, the use of technology would help them to overcome the boundaries of the classroom to develop a more productive classroom environment (Blumenfeld, Krajcik, Marx & Soloway, 1994; Boss, 2015). The use of technology would make it possible for projects to become more than an event at the end of a unit of instruction. Engaging in real-world projects could change students' perspectives on learning (Klopfer, Osterweil, Groff, & Haas, 2009).

Although the use of technology may lead to improved understanding of scientific concepts, it should not be a replacement for students conducting an experiment or observing phenomena (*Science Teaching Reconsidered: A Handbook,* 1997). Students develop scientific beliefs as they do tests and make observations. However, the use of technology in PBL could assist teachers and students in carrying out investigations and develop products when the concept under investigation could not be studied within the confines of classroom space (Chanlin, 2008;

Finn & Ravitch, 1995). Technology integrated as a tool could help learners and teachers to gain access to information that may not otherwise be accessible as they work that toward achieving their learning goals (Boss & Krauss, 2007).

The implantation of technology in a collaborative environment alongside concept and skill learning processes using digital resources as part of PBL lesson plans has the potential to bring about the best learning outcomes for students during the critical middle school years (Apedoe, Ellefson, & Schunn, 2012; Krajcik et al., 1999; Seo et al., 2008). Although some awareness of the use of technology may be helpful before integrating PBL into any classroom, students and teachers do not need to have lots of expertise to use technology as part of the PBL lesson (http://www.battelleforkids.org/networks/p21). Students, as well as educators, could learn how to use various forms of technology during the process of integration (Moursund, 2003). A combination of PBL and technology could provide students with an opportunity to transfer knowledge learned from one area to another in a collaborative learning environment by focusing on solving a problem or accomplishing a task (Hmelo-Silver, 2004; Laboy-Rush, 2009). By creating their digital projects, students not only enhance their understanding of new materials but also connect concepts learned with authentic real-life examples (Groff, 2013; Kwek, 2011; Klopfer et al., 2009; U.S. Department of Education, 2017).

Through the routine use of technology to carry out the work in collaborative projects, pupils could learn from one another, build upon existing knowledge, and ultimately become independent, life-long learners (Dooly & Sadler, 2016). Using digital devices, students could learn to collect information from multiple sources and share information with others while developing content area expertise (Moursund, 2003). Access to a broader community of knowledgeable individuals and resources and ideas that others have to offer in different parts of the world could enable students to learn and share thoughts and ideas with other student scientists and professional researchers (U.S. Department of Education, 2017). Access to technology along with ability to collaborate and share in real-time with others, as well as ability to use tools for collection and analysis of data and production of artifacts, could lead to a more authentic classroom atmosphere (Cole, 2008; Krajcik, Czerniak, & Berger, 1999; Lipponen et al., 2003; National Education Association, 2012).

Collaborative Learning Environment

The educators must concern themselves with authentic questions that set the stage for classroom activities if they would like to develop students' minds by engaging them in a thorough understanding of curricular content (Kanter, 2009). Using collaborative learning strategies such as PBL, teachers, and curriculum designers could integrate knowledge gained from studying students' hobbies with the academic subject matter to generate an educationally rich environment (Kanter, 2009). More challenging and enjoyable ways to learn, such as collaborative learning, could promote a more engaging and meaningful learning experience for students (Fernandes, Mesquita, Flores, & Lima, 2014).

According to Krajcik, Czerniak, and Berger (1999), traditional learning environments could not measure students' ability to work as a team, show how students could apply their knowledge and skills to everyday life, nor would they prove that students could design and plan investigations. However, teachers could foster students' collaborative skills, help, and hold students accountable for their learning through the creation of a collaborative environment like PBL in the classroom ("Implementing Group Work in the Classroom," 2018; Tinzmann et al., 1990). Collaborative environments could allow the students to investigate critical driving questions, learn science concepts, form conclusions, use technology, develop products or artifacts that address the problem, and present findings (Habok & Nagy, 2016; NYC Department of Education, 2009). By implementing PBL in a well-managed structured environment, teachers could create opportunities for learning by providing students with access to authentic research, guiding students to solve problems, and making tasks more manageable. Additionally, teachers could assess progress, diagnose issues, provide feedback, and evaluate overall results (Blumenfeld et al., 1991; McCright, 2012).

Years of research into collaborative work have shown that regardless of academic achievement level, students who work together show improvement in standardized test scores, study skills, and organizational skills (Bruffee, 1998; Kelly, 2002; Wenglinsky, 2001). Often students learn better from their peers because their peers could translate difficult vocabulary into a language understandable by students (Davis, 2012). When students work with others, they have an opportunity for discussion of ideas (Curtis, 2002). When students work together, not only could they imitate what others are doing but also discuss the task and make thinking visible (Brame & Biel, 2015). When students work collaboratively, they control their learning through their choices (Remmen & Froyland, 2014). Working in small groups, students could work on a different aspect of the problem with different ideas that could lead to a solution.

The use of PBL could encourage students to work collaboratively with others to solve problems, share ideas, promote responsibility, develop literacy and critical thinking skills (Blumenfeld et al., 1991; Brame & Biel, 2015; Curtis, 2002; Frank & Barzilai, 2004). However, because students may have gaps in their knowledge, which can interfere with their ability to work collaboratively toward completion of PBL activities, teachers would need to establish classroom environments where students would be expected to collaborate with others respectfully, exchange ideas and negotiate meaning (Apedoe et al., 2012). By using PBL, teachers could help students gain the level of knowledge, broad problem-solving, and communication skills needed to address real-world problems (US Department of Education, 2017; Moursund, 2003). Thinking about an authentic issue could help students to consider how to design, build, and assess their final products. Student presentation of final projects would help them to develop their communication and presentation skills. Products allow students to engage in authentic learning with real-world connections while working collaboratively to solve problems (Boss & Krauss, 2007). This method of education could enable students to build competencies by working on multifaceted projects (Doppelt, 2009).

Much of science learning is hands-on. Still, there are times when it may not be practical or possible for students to participate in specific science activities because of cost, time, safety, or accessibility issues. Research has indicated that students with learning, language, emotional and behavioral disabilities, and those with limited English proficiency, benefit from collaborative learning opportunities (Navarrete & Watson, 2013). Collaborative technology tools such as computer simulations could be a useful approach to and augment what is already happening in the classroom. Simulations and virtual labs could allow students to explore complex topics and tasks in the same ways that professional scientists do (Akpan, 2001; Boss & Krauss, 2007; Seo, Templeton, & Pellegrino, 2008). Simulations and virtual labs could be especially helpful for students with disabilities. Students with physical limitations may not be able to experiment because of their physical disabilities. However, they could complete a simulation that permits them to see and interact with a scientific model for first-hand observations (Hasselbring & Glaser, 2000). Scientists routinely use many technological instruments in their daily work.

Although students may not have access to many of these tools in the classroom, they could use simulations and multimedia tools to work as scientists, collaborate with their peers, model scientific processes, conduct virtual experiments, and actively participate in research with scientists locally and around the world (Guzey & Roehrig, 2016). Students could learn to think like scientists, develop scientific language and engage in an authentic scientific discussion by making observations, forming hypotheses, debating each other's work and ideas, and providing feedback (UNESCO, 2010; NYC Department of Education, 2009). Using PBL could provide students with more knowledge, skills, and time than working alone (http://www.battelleforkids.org/networks/p21; Railsback, 2002). By working collaboratively to pursue solutions to driving problems, anchored in real-world situations, students develop a meaningful understanding of fundamental scientific concepts (Krajcik et al., 1999; Krajcik et al., 2007).

Collaborative learning tools could foster discussion, help students develop reasoning skills, confront scientific misconceptions, and refine theories. The device or software selected could allow students to manipulate an object or image and view a scientific concept in many ways (Hasselbring & Glaser, 2000). Being able to manage pictures and information could help students to retain concepts better. The use of digital documents could enable students to revisit their artifacts and develop their ideas further by using multiple digital resources in the same way that scientists in the field do (US Department of Education, 2017). A computer interfaced with electronic probes could detect temperature, voltage, light intensity, sound, distance, dissolved oxygen, or pH. The probes could digitally record and graph the data collected. The graphical data collected could allow students to see trends in their data and focus on the concepts they are exploring and ask new questions related to the experiment (Klopfer, Groff, Hass, & Osterweil, 2009; US Department of Education, 2017).

Assessment and PBL

To succeed in the world, young people not only need to develop critical thinking and problem-solving skills but also practical skills and knowledge required for college and career readiness ("21st Century Skills for Students and Teachers," 2010). The goal of education curricula should be to help students develop twenty-first-century skills rather than solely focusing on curricular learning outcomes. Teachers should engage in the ongoing evaluation of their teaching, to help themselves, parents, and the public as well as policymakers to improve instruction and focus on what society values most in education (Stanovich & Stanovich, 2003).

The elements of college and career readiness could be assessed and efficiently taught. However, most U.S. schools continue to measure students' progress by testing them only on a prescribed set of state and national standards ("Assess Teaching and Learning," 2016). Schools have continued to use standardized, multiple-choice tests despite the lack of provision of useful information about students' progress toward long-term goals (Organization for Economic Cooperation and Development, 2008). Standardized tests like the Partnership for Assessment of Readiness for College and Careers (PARCC) and Smarter Balanced Assessment Consortium (SBAC) assessments appear to offer some improvements over existing state tests by asking students to analyze complex texts and respond to challenging writing prompts. However, by focusing on language arts and math, they fail to offer any information about real readiness for college and careers (McGroarty & Robbins, 2012). By comparing students' curriculum-based performance and growth with similar groups of students enrolled in independent private schools, suburban public schools, and district norms, standardized tests such as CTP4 can provide detailed reporting using scaled scores, stanines, and percentiles to inform instruction and learning (Educational Records Bureau, 2017).

Teaching methods and assessment tasks should integrate and align with the educational standards to allow the students to participate in the process of discovery and learning through meaningful activities (Oberg, 2010; Remmen & Froyland, 2014). A significant understanding of standards-based curriculum and instruction not only meets the purpose of classroom accountability but also addresses the need to help individual students to use what they have learned to solve problems as evidence of active learning (Kanter, 2009).

Assessment should not be limited to traditional tests given for purposes of generating grades (Aviles & Grayson, 2017). Traditional paper and pencil tests could provide teachers with a limited amount of information about each student. Traditional tests only allow teachers to see the final answer given by a student, without letting the teacher know how the student arrived at that answer (Cole, 2008). Infusion of creative thinking into the design of authentic projects has the potential to help teachers change their teaching methods and adopt alternative assessment methods that consider pupils' different learning styles and informs their teaching (Curtis, 2002; Guskey, 2003; Oberg, 2010). By using alternative assessments with clear expectations, teachers could create appropriate, motivating, and differentiated classroom instruction that could help all students succeed (Oberg, 2010).

A major criticism of current science education has been the level of emphasis placed on solving well-defined, closed issues (UNESCO, 2010). Alternative assessments that measure critical thinking skills such as performance assessments, persuasive essays, projects, and student portfolios provide opportunities for students to demonstrate that they grasp the overall significance of what they have learned. The use of alternative assessments could allow students to display their knowledge and skill levels while providing teachers with the needed opportunity to get to know their students (Educational Testing Service, 2003). Because different learners would respond to different assessment methods differently, a variety of assessment techniques could ensure appropriate assessment of all students. By using a variety of forms of evaluations, teachers could let students express understanding in ways consistent with their strengths (Educational Testing Service, 2003, Thomas, Allman, & Beech, 2004). Resources such as graphic organizers could allow teachers to do a formative evaluation of ongoing learning while a finished product could enable teachers to do summative assessments (Krajcik et al., 1999). Continuous and purposeful formative and summative assessments that provide teachers with a comprehensive understanding of the students' knowledge and skill levels can ensure academic progress for all students while preventing loss of instructional time (Oberg, 2010; Krajcik et al., 1999).

The use of a range of evaluation practices within their curriculum could help teachers with the creation of engaging lesson plans that meet instructional needs of the student, according to their abilities and skill levels based on the assessment data (Guskey, 2003; Department of Education and Training Melbourne, 2017). The evaluation process would also need to include student interpretations of their learning using self-evaluation techniques such as journal reflections (Oberg, 2010; Krajcik et al., 1999).

Student projects created using digital media that show their learning could provide opportunities for teachers to do authentic assessments and develop differentiated instruction based on students' knowledge levels and learning goals (NYC Department of Education, 2009). By embedding evaluation consistent with the process of inquiry and investigation into the curriculum, instructors would be able to measure what the students have learned based on the lessons taught (Ruiz-Primo & Furtak, 2006). Alternative assessments that show what students have learned, such as performance tasks, student contribution to classroom discussions, ability to solve problems and the teacher's observations within the classroom setting could provide teachers with critical information needed to create a curriculum aligned to the students' skills and interests. As concrete and explicit tools for learning, artifacts, or student-generated classroom objects could allow students to build an understanding of the concepts studied. Members of the community of learners could critique artifacts, thus providing students with opportunities to revise their objects as they further their knowledge (Krajcik et al., 1999; Krajcik, Mcneill, & Reiser, 2007).

In a learner-centered classroom, teachers provide the students with the learning objectives, resources, assessment tools as guides for student learning ("Learner-Centered Assessment," 2018). The hands-on experience with scientific content using PBL could create a learning environment that allows students to work collaboratively with others and participate in the assessment process (Kwek, 2011; Thomas, 2000). Students' ability to make choices in their learning process could provide them with the opportunity to work cooperatively and independently while providing teachers with the prospects for authentic assessment (Davis, 2012). Authentic and relevant evaluations could motivate students to become active participants in their learning by allowing them to demonstrate their abilities and knowledge as they progress toward college and career readiness (Oberg, 2010; Krajcik et al., 1999).

Impact of Teacher Attitude on the Implementation of Technology-integrated PBL

Implementation of PBL in the classroom involves several challenges. PBL implementation would require the classroom teacher to know problem-solving strategies needed and possesses a complete comprehension of the subject matter required to engage and challenge the students as they carry out the project. The knowledge and the ability level of the teacher tend to be the most powerful predictor of student success (Blumenfeld et al., 1991; Frank & Barzilai, 2004). Many teachers have difficulty-implementing PBL because of their beliefs about learning and teaching (Park & Ertmer, 2007; Thomas, 2000). The underlying principals involved in project-based instruction could frequently be in direct opposition to teachers' views regarding their role, the goals of education, and how students learn (Anderman, Sinatra, & Gray, 2012; Habok & Nagy, 2016). Novice teachers leave preparation programs armed with classroom management routines, whole-class activities, and assessment and accountability practices that focus on fact retention (National Foundation for the Improvement of Education, 1999; Menzes & Maier, 2014). Some teachers may view learning as a process of obtaining information and motivation as a problem of developing favorable attitudes rather than active engagement (Blumenfeld et al., 1991; Frank & Barzilai, 2004). Teachers may not want to enact PBL in the classroom because of the belief that projects could prevent the teaching of content due to students' interest in their projects (Fernandes, Mesquita, Flores, & Lima, 2014). PBL represents a fundamental shift from how the teachers learned science. Therefore, teachers find the implementation of PBL challenging (Blumenfeld et al., 1991; Kanter, 2009; Jenkins, Williams, Moyer, George, & Foster, 2016).

Teachers who implement PBL must not only understand scientific content but also teach science as a process. PBL teachers could demonstrate skills such as observing, predicting, graphing, investigating, and answering questions while connecting the lesson with essential concepts to help students understand why they are doing the activity (Apedoe et al., 2012; Krajcik et al., 1999). Additionally, teachers need to have the ability to create student-centered lesson plans that teach thinking and problem-solving strategies essential in helping students who may feel frustrated in a non-traditional learning environment that requires more effort on their part.

PBL teachers could teach not only academic subject areas but also skills such as collaboration, communication, and problem-solving to equip students for success in the twenty-first century using a student-centered approach (Cheng et al., 2008). PBL teachers support students' application of knowledge using several strategies. Because children come to school with prior understandings of their world, PBL teachers could create learning environments that encourage the students to revise and expand their viewpoint to integrate new ideas into their knowledge of scientific concepts. By allowing students to ask questions, dialogue with a community of learners, and make predictions, teachers could help students to gain confidence in their abilities. Teachers could help their students to make connections, develop an in-depth understanding, and construct knowledge by interacting with others (Frank & Barzilai, 2004; Krajcik et al., 1999). By implementing PBL in the classroom, teachers could help students to develop an integrated understanding by providing students with opportunities to use and apply their knowledge, thus retaining more of the information learned in the classroom (Thomas, 2000).

PBL classroom activities often involve students in planning and carrying on investigations. PBL activities could provide students with opportunities to develop a robust, integrated understanding of learned concepts and application of skills to new situations while answering the driving question (NYC Department of Education, 2009). Application of learned concepts and skills to new circumstances could help students to build connections between the new ideas and old ideas (*How People Learn Brain, Mind, Experience, and School*, 2000). Additionally, by providing multiple resources such as books, journals, science equipment, supplies, and computers, PBL teachers could help the students to develop further understanding by seeing different presentations of the same information (Glowa & Goodell, 2016; National Education Association, 2012).

PBL teachers provide students with time for reflection on how they used material learned in the classroom to improve their world (Guzey & Roehrig, 2016). In science, reflection requires students to think about alternative questions, consider new possible hypotheses, and view different answers based on the conclusions found (Delisle, 1997; Krajcik et al., 1999). The cycle of asking and refining questions, brainstorming ideas, making predictions, designing experiments, gathering information, collecting, and analyzing data, drawing conclusions, and communicating ideas with others could help students to construct a solid integrated understanding of the topic and related concepts (NYC Department of Education, 2009).

PBL has changed the way teachers provide classroom instruction from a reception approach to a transformational approach. The use of technology means that teachers are no longer the only source of information in the classroom. In a PBL classroom teacher serves as a guide in the classroom, encouraging student exploration, and learning, not as a presenter of knowledge (Groff, 2013). Teachers' role has changed from a lecturer to more of a consultant or an advisor (Frank & Barzilai, 2004). As teachers use PBL, they also develop their understanding of teaching and learning to become a guide for students through the process of learning. PBL teachers enable students to interact more with each other more than with the teacher (Delisle, 1997). Teachers who embrace the role reversal could become more motivated as teachers and lifelong learners (Goos et al., 2000).

Managing elementary and middle grades classrooms could be challenging tasks whenever teachers try new ideas (Beaty-O'Ferrall, Green, & Hanna, 2010). Teacher's style of classroom management and the importance they place on performance could create classroom conditions that affect whether students would choose to pursue learning or performance goals while working on projects (Hannah, 2013). Although the implementation of PBL could present teachers with classroom management challenges, teachers who implement PBL report fewer disciplinary problems due to the high levels of student engagement (Krajcik, Mcneill, & Reiser, 2007).

Regardless of the teacher's style, classroom projects could create ambiguity for students about evaluation and what counts as an acceptable artifact (Blumenfeld et al., 1991; Krajcik et al., 1999). By implementing PBL in the classroom, teachers must balance students' need for a choice with their own need to have students learn content defined by state curricular mandates and selection of student artifacts that demonstrate subject matter understanding. By emphasizing learning over grades, PBL teachers encourage risk-taking. By focusing on proficiency rather than performance, PBL teachers change the learning environment by using an evaluation criterion that looks at proficiency rather than performance (Brookhart, 2008).

Although there could be a connection between the desire to learn and instruction, creating a desire to learn does not necessarily translate into a higher student cognitive involvement. Research has shown that teachers could influence students using instructional practices that encourage active learning on the part of students and hold students accountable for understanding (Blumenfeld et al., 1991). However, it is no less important to examine how teachers can be encouraged to create and implement active learning strategies such as PBL in the confines of their classrooms ("Center on Education Policy," 2019; Gbollie & Keamu, 2017; Hightower et al., 2011; Schaps, 1992).

Impact of the Level of Administrative Support for the Implementation of Technology-integrated PBL

PBL leaders must have a significant understanding of the content and understand the project design process. Leaders must also be familiar with project assessments and be able to promote twenty-first-century skills (Larmer et al., 2015). Leaders must be comfortable in shared leadership models and be able to develop a culture of inquiry, teacher collaboration, student-centered classrooms, and rigorous learning environment. Shared leadership opportunities could help the leaders to pinpoint, use, and rely upon the expertise of the school community to define direction and vision (Leithwood et al., 2004). System change could be much easier to accomplish when teachers initiate changes in the learning process (Boyd-Dimock & McGree, 1995).

Through the revision of and reflection upon the school mission, leaders could form cohesive and coherent progress (Knapp, Copland, & Talbert, 2003). Leaders could help their staff manage the change by continually communicating expectations and creating structures that support staff growth and progress in a culture of professionalism, transparency, respect, trust, common purpose, and a shared vision ("National Association of Elementary School Principles," 2013). To create the kind of environment necessary for student-centered approaches, administrators must make a difference with the people directly involved with them (Mulford, 2003). Leaders could help support the PBL process by creating a school structure conducive to the implementation of PBL. By creating a positive atmosphere, leaders could be instrumental in constructing circumstances that support their staff through challenges (Chen, 2011). The support administrators provide teachers could be critical in creating an environment conducive to new approaches and innovative techniques. Through administrative support, teachers feel the confidence to try and the courage to proceed ("National Association of Elementary School Principles," 2013).

Administrators could support the implementation of technology-integrated PBL by creating an environment where the teachers feel empowered to try new and creative teaching strategies that directly influence the success of the students (U.S. Department of Education, 2017; Sheninger & Murray, 2017). Administrators could help their faculty to see how the new and innovative ideas fit in with the mission of the school and improved student performance on high stakes testing. Administrators could increase teacher empowerment and teacher morale by allowing teachers to decide what and how to teach ("Building a School Culture that Supports Teacher Leadership," 2015). By empowering teachers, administrators could encourage teachers to accept leadership roles, share their knowledge and skills with the others on staff and learn new skills that lead to an increase in student learning (Moran, 2015). Empowered teachers have a stake in the school's success (Gardner-Webb University, 2018). Therefore, empowered teachers could be more interested in collaboration with their colleagues and the improvement of the school's performance through participation in data-driven decision-making. The data could develop the basis for a shared vision (Leithwood et al., 2004).

Teacher collaboration must begin with a driving question that could help add purpose and focus on the mission of the school. Leaders could help engage the students and staff by giving them voice and choice, as well as shared leadership opportunities (Burgess& Bates, 2009). A collaborative culture could have a substantial impact on the school community by creating more effective teaching and attitudes toward innovative teaching strategies (*Organization for Economic Cooperation and Development*, 2009). Administrators could set up a culture where sharing ideas and creating projects together is an expected and inherent part of the curricular process (Fisher, Frey, & Pumpian, 2012). By establishing goals for collaboration, administrators could help facilitate the exchange and transfer of knowledge from one participant to another. Establishment of structured planning time with a clear set of expectations and outcomes by the administrators could serve to provide teachers with needed instructional support and articulation across departments (Sheninger & Murray, 2017). Additional benefits of administrative support include access to resources, minimization of potential schedule conflicts and class interruptions, and the creation of a sense of team spirit (Moran, 2015). Leaders could help with the development of physical classroom structures, the creation of block periods, time for teacher collaboration, ensuring that PBL meets the standards and alignment with other school initiatives (Wolfe, 2012).

For PBL to succeed, administrators must support the staff by providing access to professional development opportunities (P.D.). Effective P.D. should be long-term and focus on the in-depth engagement of teachers rather than merely cover some materials and expect teachers to absorb it (Gulamhussein, 2013; McConnell, Parker & Eberhardt, 2013). Effective P.D. requires active learning. Teachers who participate in active learning would be more likely to bring PBL into their classrooms. Through effective use of P.D., administrators could help to set up a culture that invites participation and establishes a sense of ownership throughout the PBL implementation process ("21st Century Skills for Students and Teachers," 2010; Habegger, 2008; Red Clay Consolidated School District, 2011).

A culture built over time could help shape the way the faculty, student, and parents interact. Leaders must understand the school's culture to ensure the success of any innovation efforts. Administrators could help integrate PBL into the school structure and culture by implementing school-wide projects, consistent assessments, collaborative project opportunities, and securing access to technology hardware and software. The integration of technology could create a path for the inclusion of content combined with the ability to research, find, and present information (Clayton-Pederson & O'Neal, 2018; U.S. Department of Education, 2017). The integration of technology should not be a replacement for books, articles, maps, encyclopedias, or other paper materials. Educational technology was designed to be one more resource in the classroom for use by children as they learn (Blair, 2012). Use of digital and electronic resources such as internet research, blogs, forums, electronic communications, and software along with PBL to present final products could motivate students and encourage them to take responsibility for their learning. The learner's progress when using educational technology could be self-determined by the rate at which the pupil wishes to move forward. Technology integration may change the classroom structure to a less controlled environment because not all learning would be sequential, and not all knowledge would be dependent on instruction ("Centers for Implementing Technology in Education," 2016). Therefore, teachers would need administrative support to create environments that enable students to explore using computers throughout the day and make choices in their learning (Moeller & Reitzes, 2011).

Administrators could facilitate bringing the real world into the school by helping students gain access to internships and shadowing experiences, setting up interviews, and inviting guest speakers (Fullan, 2002). Giving students opportunities and choices enables them to construct their knowledge and take a leadership role in their education (Groff, 2013; Leithwood et al., 2004).

Theoretical Foundations of PBL

With the emphasis on student outcomes in education, teachers have become challenged to develop and implement effective and efficient strategies such as PBL that translate into student engagement and learning (Leithwood, Seashore Louis, Anderson, & Wahlstrom, 2004; UNESCO, 2004). Use of PBL in the classroom has been supported by multiple theories such as constructivism, situated learning, the theory of change and the theory of learning and awareness by Marton and Booth ("What is theory of change," n.d.; Krajcik et al., 1999, Marton & Booth, 1997; Moursund, 2003).

The Constructivist Theory

The constructivist theory (Jean Piaget) stated that students learn best when they could create their knowledge in the context of their own experiences while actively engaged with an authentic phenomenon, using, and applying knowledge, multiple representations, use of learning communities in the same way scientist develop their understanding as they seek to answer questions about the natural world. The constructivist theory stated that students build knowledge and understand experiences based on their current and previous knowledge (Bada & Olusegun, 2015). Cognitive constructivism focused on student autonomy, personal attitude and aptitude, and ownership of the learning process. Cognitive constructivist believed that prior knowledge could promote inquiry with open-ended questions (Bada & Olusegun, 2015). Social constructivism focused on real-world problems that are relevant and meaningful to the students within a learning group. Social constructivist used activities encouraged the student to justify their responses through discussion, questioning, and group presentations. The teacher's role was then to help when requested (Kim, 2001).

In a constructivist classroom, students would interpret received information considering pre-existing knowledge and experiences (Krajcik et al., 1999; Moursund, 2003). Although a teacher may make decisions based on beliefs consistent with constructivism, constructivism does not suggest how an individual should learn. Constructivism offers an account of how learners construct knowledge using the common elements of constructivist pedagogy such as being student-centered, using different modes of instruction, creating opportunities for understanding through purposeful group dialogue, exploring, scaffolding, interpreting, negotiating and creating learners interact with the environment (Bada & Olusegun, 2015; "Education Theory/Constructivism and Social Constructivism - UCD - CTAG," 2019; Kemp, 2014). When learners deal with a more complicated task, they experience cognitive demands. Teachers will need to consider the cognitive needs experienced by students and teach accordingly (Cole, 2008; "Learning Theories," 2007).

PBL principles could promote lifelong learning through the process of inquiry and constructivist learning. PBL encourages collaborative and self-directed learning. Using PBL principles, students could create meaning and build personal interpretations of the world (National Education Association, 2012). In PBL, learners could be given a problem and asked to develop possible solutions through research and discussion within their group (Thomas, 2000). The instructor would then guide rather than provide knowledge. From the social constructivist perspective, feedback, and reflection on the learning process and group interactions would be considered essential aspects of PBL (Brame & Biel, 2015).

The Situated Learning Theory

A critical aspect of learning activity could be the context and culture in which learning occurs. In a situated learning theory classroom, learners become involved in a community of practice in which both students and the teachers could be actively engaged in carrying out a project in a supportive learning environment designed to facilitate learning that transfers to real-world settings (Korthagen, 2009"; Moursund, 2003).

Cognitively engaged and motivated students tend to learn more and remember materials learned better than students who receive only didactic instruction (Johnson & Hayes, 2016). Problems need to be relevant to students to help students be intrinsically motivated (Moursund, 2003). Inquiry-based teaching methods often used by PBL teachers focus on teaching how to use science process skills such as observing and interpreting data (Friesen & Scott, 2013). PBL could help students learn about the scientific method, develop a higher-order understanding, tendency to ask questions, solve problems, and be willing to conduct investigations (Goldstein & Bevins, 2016). PBL lessons could provide the needed environment in which students could learn to work cooperatively with their peers as they explore and learn curriculum topics and social skills (Moursund, 2003).

The Theory of Change

The significant level of attention placed on curricular reform has only recently expanded to include the study of teacher development within the school setting (Peng et al., 2014). Using the theory of change (Carole Weiss) as a process to promote change by defining goals and desired outcomes and then mapping pathways backward in chronological order, organizations could study the relationship between all steps of teacher training and development ("What is theory of change," n.d.). By breaking down long-term goals and objectives into several shorter-term and observable outcomes, educational leaders could make informed decisions about strategies for change and reflectively evaluate the organization's plan for teacher training and development (Fullan, 2006).

Closing the student-learning gap requires access to resources and a leadership committed to capacity building that focuses on accountability (Michaels et al., 2008). Promoting capacity building and motivating the people would allow for the flow of ideas among all levels of an organization that, in turn, would track outcomes at each step to ensure their actions lead to the expected results (Fullan, 2006). Policies put in place by the leadership must allow for and support innovation by creating an atmosphere of encouragement with relevant pathways that could realistically achieve measurable data generated along the way. The data could then be used to measure the success or the failure of the change pathways ("What is theory of change," n.d.)

The Theory of Learning and Awareness

Marton and Booth (1997) developed the theory of learning and awareness to investigate why some teaching methods were more effective than other strategies for producing meaningful learning outcomes. This theory emerged as an approach to studying learning outcomes from the viewpoint of different students' experiences to help them become aware that they could achieve a better quality of education if they observed various facets of experience simultaneously so that the part-whole relationship becomes apparent. By applying this approach, teachers could create a learning space where students would learn by using a variety of experiences (Marton & Booth, 1997; Marton et al., 2004).

Students could see and learn through careful reflection and comparison with the teacher's ways of seeing or teaching the lessons' objective. As a result, the students could reach a deeper understanding of the object of learning. The effectiveness of a given teaching method or approach would depend on the ability of the process to allow the students to discern the critical features of the object of learning and come to a better understanding of what must be learned (Organization for Economic Cooperation and Development, 2009).

The theoretical concepts of discernment, simultaneity, and variation (Marton & Booth, 1997) could be used when analyzing learning as well as teaching. According to Marton and Booth (1997), defined patterns of variation characterize ways of experiencing a phenomenon.

Therefore, to experience an event in a certain way, one must experience every model of change. The object of study would thus be to explore the extent to which teachers contribute to the creation of a pattern of change in the classroom. Unless a change happens, students could not differentiate the learning of different content and would not be able to develop their awareness toward the specific content they might come across (Irvin et al., 2007). The change would be necessary for creating intellectual challenges among students by allowing them to see similarities and differences (Marton & Booth, 1997).

Quality learning involves a much higher level of cognitive construction of knowledge rather than a simple function of the individual characteristics of a learner, the quantity of subject expertise acquired by the students, and the pedagogies adopted by teachers (Department of Education and Training Melbourne, 2017). Variations of a learning object, organized in distinctive focal awareness concerning a particularly critical feature, allow students to see differences and similarities by helping them to develop discernment and knowledge (Marton et al., 2004). By doing so, students could make use of what they have learned to help with their future learning and investigation. The knowledge they construct involves a higher cognitive level because students need to organize, interpret, relate, and anticipate data they gather as procedural and contextual knowledge (Kwan & Chan, 2004).

The contrast between contextual and procedural knowledge has been part of the educational approaches to problem-solving as a basis for teaching science and technology without enough empirical research of what happens in classrooms (Krange & Ludvigsen, 2008). Procedural knowledge could be used in the performance of algorithms or procedures through automatic and unconscious steps (McCormick, 1997). In contrast, conceptual knowledge could not be gained by rote as part of a more substantial body of knowledge, interrelated concepts, rules, and even problems.

By implying that students must be able to build meaning for procedural knowledge before mastering it, many researchers and educators assume a connection between procedural knowledge and contextual knowledge (Joersz, 2017, Star & Stylianides, 2012, Schwartz, 2007). Understanding how to follow a procedure to obtain an answer to a problem quickly could be essential to studying science, but knowing how to follow procedures could not be considered the essence of learning science (Brame & Biel, 2015).

Summary

This chapter explains the impact of the addition of technology-integrated PBL to the existing science curriculum and instruction, teacher attitude toward implementation of technology-integrated PBL and the importance of researching the relationship between administrative support for the implementation of technology-integrated PBL and teachers' attitude towards enacting technology-integrated PBL in the middle school science classrooms. This study attempted to build upon currently available research through looking at the correlation between the levels of administrative support on teachers' attitude towards implementing technology-integrated PBL in a middle school science classroom, the students' attitude and aptitude, and their levels of academic achievement on the standardized science test (CTP4). Technology has enabled learners to locate and present information in multiple formats such as text, graphics, and animation while retaining information and developing a deeper understanding of concepts (Seo, Templeton, & Pellegrino, 2008). The integration of technology has transformed the classroom and changed the teacher's role from the expert to the facilitator (Goos, Galbraith, Renshaw, & Geiger, 2000). The implantation of technology in a collaborative environment alongside concept and skill learning processes using digital resources as part of PBL lesson plans has the potential to bring about the best learning outcomes for students during the critical middle school years (Apedoe, Ellefson, & Schunn, 2012). Along with access to technology, the ability to collaborate and share in real-time with others, as well as the useful tools for collection and analysis of data and production of artifacts, could lead to a more authentic classroom atmosphere (Cole, 2008).

During adolescence, young brains experience one of the most critical periods of physical changes since infancy. Middle school teachers need to have a thorough understanding of the brain physiology of students to deliver curriculum and instruction in an active learning environment (Boss & Krauss, 2007). Students in middle school have begun developing their abilities to think abstractly about various ideas as they strive toward understanding themselves relative to the world around them (American Psychological Association, 2002). Young students may be motivated for different reasons. Some value proficiency versus ability, whereas learning and not performance may drive others. Some students value learning, whereas others see education as a means of earning grades, teacher, and parental approval, and avoiding consequences (Blumenfeld et al., 1991; Pepper Rollins, 2017). Extrinsic motivational methods might control immediate student behaviors; the behavior change may not continue to the next task (US Office of Special Education Program, 2015). Intrinsically motivational methods help students to become more engaged, self-regulate and use higher-level learning strategies (Cheng, Lam, & Chan, 2008). Projects that challenge students help students to develop critical thinking skills, work with limited resources such as time and money, develop personal responsibility for completing the project on time and, build skills for future careers (Cheng, Lam, & Chan, 2008). Through creation of learning opportunities that appeal to the young students' intellectual, social-emotional, physical, and moral developmental needs, teachers not only challenge their students to develop and apply twenty-first-century skills in their everyday lives but also respond to their desire for connection, affiliation, and self-assurance (Weigel, Davis, James, & Gardner, 2009). Student-centered approaches like PBL allow students to learn core information and develop understanding through the active use of knowledge (Delisle, 1997). Projects could stimulate students and increase student interest by involving students in solving authentic problems while working with others ("Motivating Students," 2019). Real-world problem-solving requires students to use information from multiple areas ("21st Century Skills for Students and Teachers," 2010). Because of an emphasis on active involvement, PBL has the potential for meeting the different learning needs of diverse students by helping them to develop long-term learning skills (NYC Department of Education, 2009). By considering student abilities and interests, teachers could intentionally create a differentiated learning environment (Habok & Nagy, 2016). PBL projects allow students to become responsible for their learning process by engaging with authentic scientific experiences that allow for the collaborative discovery of solutions to a real-world problem using an interdisciplinary approach. Research has shown that students would be more likely to participate in authentic problem-solving using scientific principles and processes such as the scientific method, engineering design principles, sampling methods, and measurement skills (American Chemical Society, 2012). By allowing students to connect new information with previously acquired knowledge and real-world problems, PBL could incentivize students to develop a broad, integrated understanding of content and process rather than memorization of random facts (Curtis, 2002).

According to Krajcik, Czerniak, and Berger (1999), traditional learning environments could not measure students' ability to work as a team, show how students could apply their knowledge and skills to everyday life, nor would they prove that students could design and plan investigations. However, teachers could foster students' collaborative skills, help, and hold students accountable for their learning through the creation of a collaborative environment like PBL in the classroom ("Implementing Group Work in the Classroom," 2018). Teaching methods and assessment tasks that integrate and align with the educational standards to allow the students to participate in the process of discovery and learning through meaningful activities (Oberg, 2010) along with the use of alternative assessments could enable students to display their knowledge and skill levels while providing teachers with the needed opportunity to get to know their students (Educational Testing Service.Org [ETS], 2003). Because different learners would respond to different assessment methods differently, a variety of assessment techniques could ensure appropriate assessment of all students. Infusion of creative thinking into the design of authentic projects has the potential to help teachers change their teaching methods and adopt alternative assessment methods that consider pupils' different learning styles and informs their teaching (Curtis, 2002). Student projects created using digital media that show their learning could provide opportunities for teachers to do authentic assessments and develop differentiated instruction based on students' knowledge levels and learning goals (Galvan & Coronado 2014; NYC Department of Education, 2009). Continuous and purposeful formative and summative assessments that provide teachers with a comprehensive understanding of the students' knowledge and skill levels can ensure academic progress for all students while preventing loss of instructional time (Oberg, 2010)

PBL teachers should demonstrate skills such as observing, predicting, graphing, investigating, and answering questions while connecting the lesson with essential concepts to help students understand why they are doing the activity (Apedoe et al., 2012).

Additionally, teachers need to have the ability to create student-centered lesson plans that teach thinking and problem-solving strategies essential in helping students who may feel frustrated in a non-traditional learning environment that requires more effort on their part. PBL teachers should teach not only academic subject areas but also skills such as collaboration, communication, and problem-solving to equip students for success in the twenty-first century using a student-centered approach (Cheng et al., 2008). PBL teachers need to create learning environments that encourage the students to revise and expand their viewpoint to integrate new ideas into their understanding of scientific concepts. By implementing PBL in the classroom, teachers could help students to develop an integrated knowledge by providing students with opportunities to use and apply their knowledge, thus retaining more of the information learned in the classroom (Thomas, 2000). PBL activities could provide students with opportunities to develop a robust, integrated understanding of learned concepts and application of skills to new situations while answering the driving question (NYC Department of Education, 2009). PBL teachers could help the students to develop further understanding by seeing different presentations of the same information (Glowa & Goodell, 2016). PBL teachers provide students with time for reflection on how they used material learned in the classroom to improve their world (Guzey & Roehrig, 2016). PBL teachers enable students to interact more with each other more than with the teacher (Delisle, 1997). Teachers who embrace the role reversal could become more motivated as teachers and lifelong learners (Goos et al., 2000). By implementing PBL in the classroom, teachers must balance students' need for a choice with their need to have students learn content defined by state curricular mandates and selection of student artifacts that demonstrate subject matter understanding.

The support administrators provide teachers could be critical in creating an environment conducive to new approaches and innovative techniques. Administrators could support the implementation of technology-integrated PBL by creating a situation where the teachers feel empowered to try new and creative teaching strategies that directly influence the success of the students (US Department of Education, 2017). Administrators could help their faculty to see how the new and innovative ideas fit in with the mission of the school and improved student performance on high stakes testing. By empowering teachers, administrators could encourage teachers to accept leadership roles, share their knowledge and skills with the others on staff and learn new skills that lead to an increase in student learning (Moran, 2015). Empowered teachers could be more interested in collaboration with their colleagues and the improvement of the school's performance through participation in data-driven decision-making.

Use of PBL in the classroom has been supported by multiple theories such as constructivism, situated learning, the theory of change and the theory of learning and awareness by Marton and Booth ("What is theory of change," n.d.; Krajcik et al., 1999, Marton & Booth, 1997; Moursund, 2003). The constructivist theory (Jean Piaget) stated that students learn best when they could create their knowledge in the context of their own experiences while actively engaged with an authentic phenomenon, using, and applying knowledge, multiple representations, use of learning communities in the same way scientist develop their understanding as they seek to answer questions about the natural world. In a situated learning theory classroom, learners become involved in a community of practice in which both students and the teachers could be actively engaged in carrying out a project in a supportive learning environment designed to facilitate learning that transfers to real-world settings (Korthagen, 2009".; Moursund, 2003). Using the theory of change (Carole Weiss) as a process to promote change by defining goals and desired outcomes and then mapping pathways backward in chronological order, organizations could study the relationship between all steps of teacher training and development (“What is theory of change,” n.d.). By breaking down long-term goals and objectives into several shorter-term and observable outcomes, educational leaders could make informed decisions about strategies for change and reflectively evaluate the organization's plan for teacher training and development (Fullan, 2006). Marton and Booth (1997) developed the theory of learning and awareness to investigate why some teaching methods were more effective than other strategies for producing meaningful learning outcomes. This theory emerged as an approach to studying learning outcomes from the viewpoint of different students' experiences to help them become aware that they could achieve a better quality of education if they observed various facets of experience simultaneously so that the part-whole relationship becomes apparent. By applying this approach, teachers could create a learning space where students would learn by using a variety of experiences (Marton & Booth, 1997; Marton et al., 2004).

CHAPTER 3: METHODOLOGY

Introduction

The purpose of implementing technology-integrated PBL in a middle school science classroom was to learn if the use of this method of teaching would enhance the existing science curriculum while adhering to the curriculum standards and lesson pacing guidelines. Furthermore, the purpose of this realist ethnography study was to see if the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom would lead to changes in students' attitudes and aptitude, resulting in an improved overall academic achievement for science. An additional purpose of this study was to learn if access to an easy to use, lesson-planning platform, along with administrative support, could serve to change the attitude of teachers with basic knowledge of technology toward implementation of technology-integrated PBL in their classrooms to improve students' levels of academic achievement.

Ethnography, as the philosophical study of culture-sharing groups, involved the use of key informants, observations, and open-ended interviews. As an observer, the ethnographer recorded the behavior of the culture-sharing group using field notes. Field notes included notes, photographs, video recording, as well as other artifacts that helped the ethnographer learn about the culture-sharing group. The unique ethnographic methodologies and processes influenced this mixed-method study by allowing the researcher to use firsthand knowledge gained through long-term presence to paint a vivid picture of a culture-sharing group in a science classroom (Creswell, 2013).

To gain an accurate description of the culture-sharing group, the researcher (realist ethnographer) became involved in the daily routines of the participants under study. By combining the qualitative ethnographic methods with Quasi-experimental nested design, the researcher attempted to ensure production of useful data that address the study's guiding questions and add to the existing body of knowledge about transformation of science education in the twenty-first century (Sangasubana, 2011)

The methodology used in this study has been presented in this chapter. The chapter has been organized into six sections: (a) setting and participants, (b) sampling procedure, (c) instrumentation and measures, (d) plan for data collection, (e) plan for data analysis, and (f) plan to address ethical issues.

Research Questions

1. How could technology-integrated PBL be implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines?
2. How could the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science?
3. What would be the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement?

Setting and Participants

The goal of this ethnographic study was to develop an understanding of a culture-sharing group (Creswell, 2013). The researcher, as a participant-observer, interacted with the student participants daily within the context of the school and classroom environment to collect the data needed for an understanding of the culture sharing group.

The researcher purposefully selected the middle school studied from a private school organization located in Orange County, Southern California. The organization comprised of four schools including three elementary schools (Pre-Kindergarten to eight-grade) and one high school in urban settings. Each elementary school had one Director and one Assistant Director. The high school had one Headmaster and one Assistant Headmaster and three Student Deans. The number of teachers and non-academic staff varied at each campus, depending on the number of students and programs at each location.

The total population of the student body was 1853 in Pre-Kindergarten to twelfth grade, 161 teachers, and 12 administrators (retrieved from the school's website). The students in this study followed a schedule that consisted of nine periods, each approximately 42 minutes in length. More specifically, the students' schedules included five core academic classes and four to five encore (computer, arts/foreign language/physical education) classes with the remaining time devoted to lunch and an elective course (retrieved from the school's website). This study proceeded in the science class, one of the essential cores, yearlong academic courses. The school administration and the students' parents or guardians granted permission to implement the study.

The population for this study consisted of approximately 22 sixths, 27 sevenths and, 22 eighth grade students at the experimental site, about 40 eighth grade students at the control site, one science teacher as a participant-observer (realist ethnographer) at the experimental site, and one science teacher at the control site. Additionally, 12 teachers, three administrators participated in the study.

The students' ages ranged from 11 years old to 14 years old. All the students in the sample attend regular education classes. The students' demographics consisted of primarily Asian (54%); white (29%), Hispanic (7.9%) and African American (2%) and others (7%) come from middle to high socioeconomic backgrounds. Classes have a mixed distribution of boys and girls and educational skill levels (retrieved from the school's website). The participants in the study were a non-random convenience sample because they were students who attended the school as well as teachers and administrators employed by the organization who agreed to sign the consent forms (Creswell, 2013).

Students within the organization have been participating in standardized testing for mathematics, language arts, and science. The standardized testing outcomes show that the mean scores for sixth, seventh, and eighth-grade students in math and language arts are routinely higher than the mean scores of students in similar grade levels within surrounding school districts (K.D. Robinette, personal communication, July 19, 2017).

As a long-term teacher, the researcher had previously established a relationship with the student participants based on mutual trust and respect. The existing relationships provided the researcher (as an ethnographer) with the opportunity to examine how technology-integrated, PBL influenced the students' ability to interact with one another, discuss their choices, and create collaborative relationships within the culture-sharing group. Furthermore, the researcher was able to analyze the impact of technology-integrated PBL on the middle school students' science achievement scores, and academic engagement during the implementation of technology-integrated, PBL in the science classroom.

Sampling Procedures

As described in *Figure 1,* the mixed-method study using realist ethnography (qualitative) and quasi-experimental design (quantitative) was conducted using six, seven, and eighth-grade students enrolled at a private middle school as of August 2018. The non-random, convenience sample at the experimental site comprised 71 six, seven, and eighth-grade students (retrieved from the school's website), one science teacher who was also the researcher as a participant-observer (ethnographer) at one of the middle schools within the private school organization. The non-random, convenience sample at the control site included 40 eighth grade students and one science teacher. Additionally, the researcher sampled 12 teachers and three administrators within the private school organization (retrieved from the school's website).

In choosing the sample size of students and school staff, the researcher considered convenience and practicalities of cost and time and availability. Therefore, the study sampled 18 six grade students (82 percent of the sample size of 22 students), 18 seventh-grade students (67 percent of the sample size of 27 students), and 14 Eighth-grade students (63 percent of the sample size of 22 students). Additionally, the study sampled 12 teachers (7.45 % of the sample size of 161 teachers), and three administrators (25 % of the sample size of 12 administrators).

The Concordia University Institutional Review Board (Appendix A) gave prior approval for the data collection process involved in the research study to ensure compliance with the Standards for Ethical Conduct of Research. Furthermore, the school site administrators gave the researcher prior permission to research with little or no disruption to the activities at the school.

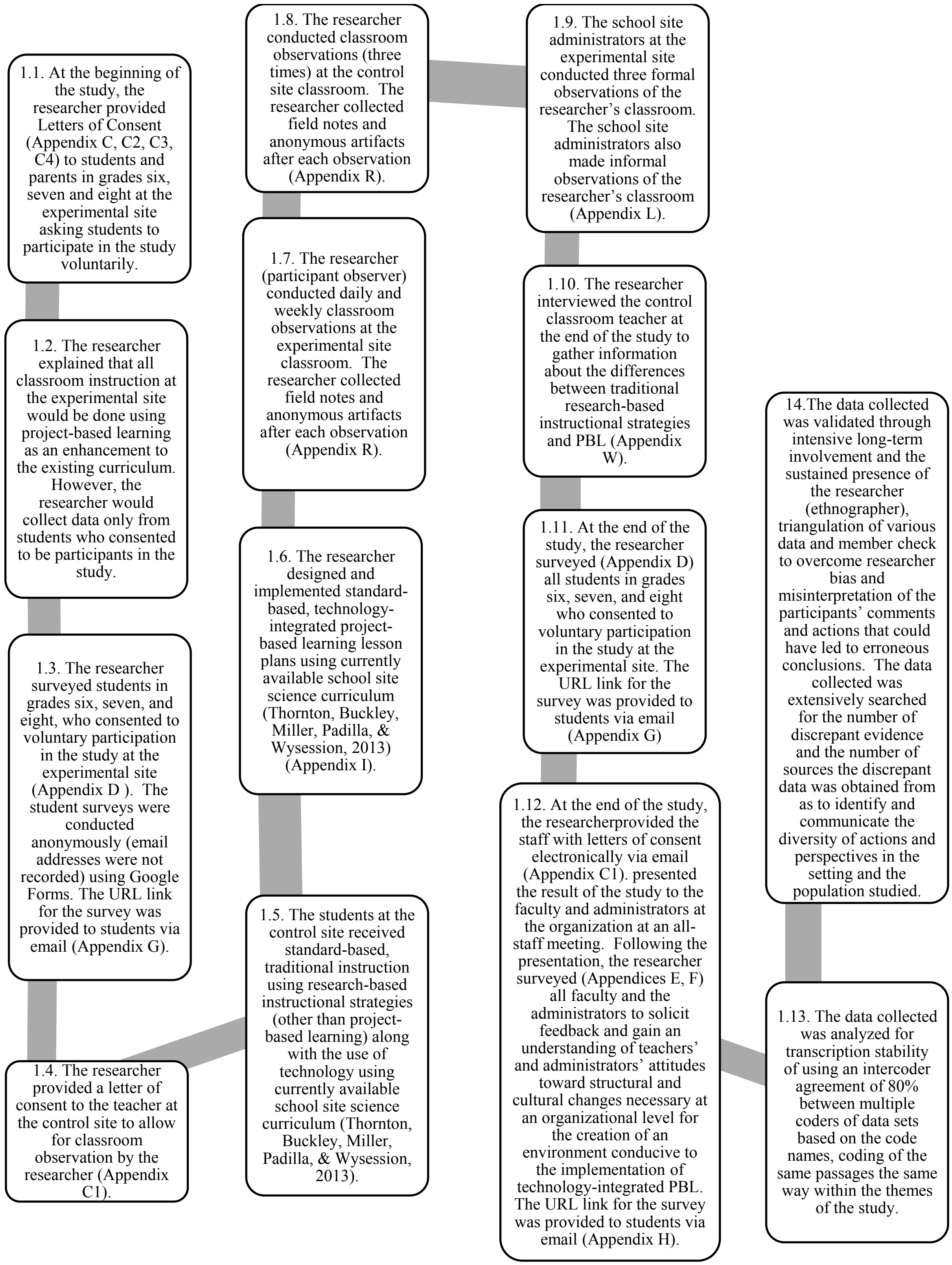


Figure 1. Sampling Procedure

Instrumentation and Measures

The instruments used as part of this study have been shown in *Figure 2.*

Survey & Observations	Lesson Plans	Rubrics	Interactive Science Folder (Journal)	Tests
• Student letter of consent (App C) • Student participant survey (App D) • Classroom observation protocol (App R) • Teachers and Adminstrators Survey (App E & F) • Teacher Interview (App W)	• PBL lesson plans (Appx I) • Essential elements checklist (App J) • Project Plan (App O) • Problem Development Checklist (App N) • Concept map (App M)	• Lesson plan evaluation rubric created by the investigator (App K) • Three informal and formal observations (App L) • Formative assessment (App S) • Summative Assessment (App T) • Interactive Science Folder (Journal) evaluation rubric (App U)	• Interactive Science Folders (Journals) (Full Option Science System (App V)	• Critterion-refferenced assessment (formative & summative) • Standardized Science Tests CTP4

Figure 2: Study Instruments

The sixth, seventh, and eighth-grade experimental science classrooms consisted of 71 students. The letters of consent that were provided for each pupil and their parents (Appendices C, C2, C3, C4) explained the purpose of the study, what the participants would do, how the data collected would be used and disclosed to obtain informed consent. The letter of consent indicated that although all students would receive regular science instruction, using technology-integrated PBL as an enhancement to the existing curriculum, the researcher would only collect and use data from students who voluntarily consented to be participants in the study (Maxwell, 2013).

Furthermore, the letter of consent indicated that participation in the study was voluntary and would not place the participants at undue risk. The researcher ensured the confidentiality of the participants by using anonymous surveys, pseudonyms, and group data reporting.

Furthermore, the destruction of the data collected at the end of the study meant that the data collected could not be linked to individual participants.

Students who agreed to be participants (experimental group) were asked to complete an online survey created using Google Forms (Appendix D) at the beginning and the end of the study. The URL link for the survey was provided to the students via email (Appendix G). Study participants were a convenience sample due to their enrollment in the school at the time of the study. The survey was peer-reviewed before use in the study to ensure validity and reliability. All surveys were designed using a Likert scale of measurement to be attractive, organized, and easy to complete (Jacques et al., 2016). All questions and pages were numbered. Instructions were designed with clarity and organization in mind. The researcher's name was included at the beginning, as well as at the end of the surveys. Questions were organized in a logical sequence beginning with non-threatening questions early on to ensure participation of all respondents.

Student participant survey was developed to collect data on student general background information, how students learn, attitude toward the use of technology in the classroom, attitude toward working in collaborative groups, attitude and aptitude toward science education and students' understanding of PBL (Frank & Barzilai, 2004, Blair, Czaja, & Blair, Harrigan, 2014; McCright, 2012). The questions on the survey were intentionally phrased using the first-person singular to obtain information from each student (Frank & Barzilai, 2004; Blair, Czaja, & Blair, 2014). The student participant survey (Appendix D) was examined for clarity of questions and appropriateness of the content. The wording of student surveys considered the age and comprehension level of the participants who were answering the questions. The survey included questions concerning PBL, designed to check for accuracy of student responses, and draw out complete explanations. The survey questions included Likert scale questions, closed-ended, dichotomous questions, as well as multiple coded, scaled, and open-ended questions designed to get the students to provide additional information (Maxwell, 2013).

Upon completion of the study, the teachers, and administrators from all school sites within the organization were invited to participate in online surveys created using Google Forms (Appendices E & F) following a presentation by the researcher at a regularly scheduled in-service meeting. A letter of consent that was provided for each staff member via email (Appendix C1) explained the purpose of the study, what the participants would do, how the data collected would be used, and disclosed to obtain informed consent from the staff participants. The URL link for the survey was provided to the staff via email (Appendix H).

Staff members who agreed to participate in the survey were a convenience sample due to employment with the organization during the study. The survey was peer-reviewed to ensure validity and reliability. The staff surveys (Appendices E & F) were examined for the organization, clarity of the instructions and questions as well as the appropriateness of the content. The survey questions included Likert scale questions, closed-ended, dichotomous questions as well as multiple coded, scaled, and open-ended questions designed to check for accuracy of responses, and draw out complete explanations (Maxwell, 2013; Jacques et al., 2016). All questions and pages were numbered. The researcher's name was included at the beginning, as well as at the end of the questionnaires and surveys. Questions were organized in a logical sequence beginning with engaging and non-threatening items early on to ensure the participation of all respondents. The questions on the survey were intentionally phrased using the first-person singular to obtain each participating staff member's general background information, perceptions and attitudes toward collaborative work, understanding of students' learning styles, use of technology in the classroom, use of PBL in the classroom and role of administrative support for teachers (Frank & Barzilai, 2004, Blair, Czaja, & Blair, 2014). Staff survey also contained open-ended questions about the role of administrative support on teacher attitude to implement technology in the classroom and the benefits and challenges involved in the implementation of technology-integrated PBL (McCright, 2012).

PBL lesson plans (Appendix I) were developed based on the essential elements' checklist (Appendix J) required for a PBL Lesson plan. The essential elements checklist was developed by the researcher using Buck institute guidelines for PBL lesson plan design and development (https://www.bie.org/object/document/pbl_essential_elements_checklist). Problems were designed by students using the problem development checklist (Appendix N) created by the researcher. Using the problem development checklist (Appendix N), students were asked to develop problems (questions) that were developmentally appropriate, utilize student personal knowledge and experiences, consider student skills and resources and support classroom curriculum goals (Bluemenfeld, Fishman, Krajcik, et al., 1999, Krajcik, Marx, & Solloway, 2000; Moursund, 2003).

The lesson plan evaluation rubric, created by the investigator (Appendix K), ensured that the lesson plan contained literature-based criteria for PBL based on the principals of PBL. The lesson plan was evaluated using a Likert scale that reflected if the lesson plan included a goal of the project (lesson), the essential question, the relationship of the project with the real-life, precise definition of the students' and teacher's role, the application of the acquired knowledge, the interdisciplinary aspects of the project, the final product of the project, collaborative group work, student conducted research, and the students' areas of interest. The teacher's role in the lesson plan was defined as one who facilitates exploration, development, and communication of ideas and concepts. The lesson plan also addressed student skills (perform, draw, research, measure, compare, find, decide, discuss, criticize, imagine) required for successful completion of a project. The evaluation rubric was used by the administration during three informal and formal observations (Appendix L) to determine if PBL was conducted efficiently in the classroom. The administrator evaluators observed and examined the physical setting of the experimental classroom, the participants' activities and interactions, conversations, attitudes, and demeanors and even the researcher's behavior using the Classroom observation protocol (Appendix R).

In developing rubrics for the assessments (Appendices S & T), the researcher considered classroom climate, students' background knowledge, engagement with the problem, participation and collaboration, creativity, technology skills, ability to work collaboratively, determination of mastery, assessment of mastery, ability to provide constructive feedback, student involvement in the assessment process as well as how assessment data could be used to improve classroom teaching (Oberg, 2010).

The researcher used the classroom observation protocol (Appendix R) during each of the three informal observations conducted at the control site. The observations were done in the eighth-grade classroom. The control classroom teacher used research-based instructional strategies other than PBL. The researcher interviewed (Appendix W) the control classroom teacher at the end of the study to gather information about the differences between traditional research-based instructional strategies and PBL.

CTP4 standardized science test scores from 2016-2017, 2017-2018, and 2018-2019 academic years were collected for experimental study participants. Additionally, CTP4 results for the same testing cycles were obtained for the control site classroom. The CTP4 standardized science achievement test is a rigorous assessment for high achieving students that "helps to compare content specific, curriculum-based performance to the more conceptual knowledge base found in reasoning tests" (Educational Records Bureau, 2017). The CTP4 science scores reflected content proficiency (percentage correct) only. Although the Educational Records Bureau (ERB) did not provide national norms, they did offer suburban norms for the content proficiency scores. Science scores were considered statistically significant if they fall ten percent above or below the suburban norm. Scores above ten percent of the suburban norm are advanced, scores that fall within ten percent of the suburban norm (above or below) are proficient, and scores that fall ten percent below the proficient range are basic. Scores below basic were considered minimal (K. Robinette, personal communication, July 19, 2017).

Reliability

The reliability of experimental data speaks to the consistency and stability of data collected. Criterion-referenced tests provided by the publisher of the curriculum used in the researcher's school were used as part of this study. Each test was available as a version A or a version B test that measured the same concepts at the same level of difficulty, thus ensuring the internal consistency reliability of an exam. Internal consistency reliability ensured that the test was reliable even if participants read the items on a test differently based on their experiences and backgrounds. Split half reliability was used to calculate internal consistency based on the concept of dividing a test into two halves to find the correlation between the two halves to establish validity and reliability of the whole test as well as each half-evaluated (Sprinthall, 2012). Scorer/rater reliability was conducted to ensure consistent and equitable scoring of tests considering scorer fatigue, external influences on scorers that may cause differences in scoring.

Each test was copied before being graded. Each test was graded once, and then re-graded on a different day using a fresh copy of the same test. The scores were then compared to establish scorer/rater reliability (Sprinthall, 2012).

The researcher obtained detailed field notes of classroom activities. The stability of data collected was analyzed using an intercoder agreement of 80% between multiple coders of data sets based on the code names, coding of the same passages the same way, and the agreement on the themes of the study (Creswell, 2013). To ensure the reliability of the standardized science assessment and the testing procedure, testing coordinators at each campus within the researcher's educational organization were responsible for making sure that testing conditions for CTP4 met the standard classroom testing procedures. Each coordinator received a testing schedule and timeline, testing materials list, and directions for administration of the test. A parallel form of reliability was achieved through a comparative analysis of CTP4 science standardized tests administered in 2016-2017, 2017-2018, and 2018-2019 academic years containing items that assessed the same skill and knowledge base of the same group of students. The scores were then correlated to evaluate the consistency of the results across alternate versions. New students admitted during the 2018-2019 academic year were excluded from parallel reliability analysis due to a lack of available CTP4 testing scores from the 2016-2017 and 2017-2018 academic years.

Validity

Validity referred to the ability of a method to measure what the researcher believed it should be measuring. Assessing the validity expressed a judgment about the extent to which relevant evidence supported the research claims (Maxwell, 2013). To establish internal validity researcher addressed how well the research instruments measured what they were expected to measure through evaluation of formative and summative criterion-referenced tests used for this study to make sure all the relevant areas of the topic studied were represented in the tests. A comparison was made between materials taught and what was tested. The similarity between these areas indicated very high content validity. Item validity of each assessment verified whether all the elements of each test were on the topics studied in the classroom. Sampling validity was used to ensure that the items on a test represented the full breadth of the content tested.

Internal validity allowed the researcher to say with a degree of certainty that no other variables other than the independent variables were responsible for the change in the dependent variables. Threats to internal validity are alternative explanations of the results that are not related to the treatment (Maxwell, 2013). Threats to internal validity included test directions not being understood by the participants that could cause their answers to vary because of different interpretations. Additionally, confusing, and ambiguous test terms, as well as vocabulary and acronyms that were too difficult for test-takers to understand, could have made it difficult for the test takers to answers the questions on the test. Untaught items included in the achievement tests and failure on the part of the students or proctors to follow standardized test administration procedures might have influenced the test results.

To control the threats to internal validity, the researcher used multiple validation strategies. Intensive long-term involvement (ethnography) led to repeated observations. The continued presence of the researcher as a participant-observer (ethnographer) helped rule out distortions and premature conclusions. Triangulation of detailed and varied data such as meticulous note-taking as well as an accurate transcription of specific events was used to help the researcher develop a complete account of the events studied. A member check was employed to overcome researcher bias and misinterpretation of the participants' comments and actions. To further overcome researcher bias, the data was collected but not examined or analyzed until after the study data collection phase had been completed. The data collected was extensively searched for discrepant evidence and the sources of the discrepant data to identify and communicate the diversity of activities and perspectives in the setting, and the population studied (Maxwell, 2013; Oliver-Hoyo & Allen, 2006). Additionally, the tests were administered to the groups of students at each grade level who attended science class at the same time each day throughout the life of the study (Maxwell, 2013).

To control bias, the researcher compared the data collected in the experimental classroom using PBL with the data collected in the control classroom using traditional research-based instructional strategies. To avoid bias in the data collected, the researcher used an intercoder agreement of 80% between multiple coders of data sets based on the code names, coding of the same passages the same way, and the agreement on the themes of the study. Additionally, the researcher triangulated control classroom data with other sources of data collected and checked for alternative explanations.

External validity addresses how well the findings from a research study could be applied to people in different settings, different ages, or from alternate lifestyles. Threats to external validity, such as funding or frequency of intervention, could indicate if the results of the study may be generalized across alternative situations such as those involving different age groups, socioeconomic groups, and people of diverse cultural backgrounds. Treatment variations created by external variables such as funding or frequency of intervention, outcomes of the study, and settings created by the availability of resources were among other threats to external validity. External validity could be established if the intervention could demonstrate a high account of power, thus indicating an increase in the ability of the intervention to influence other populations. External validity could be increased through participant sampling choice. A more significant sample size with multiple demographics and ethnicities, socioeconomic status, as well as international participants, could increase external validity.

CTP4 test used by the researcher's organization measured advanced skills in keeping with the advanced curriculum used by the organization. Because the study school selected has no features that make it different from other small private school organizations with a traditional science curriculum offered in grades six, seven, and eight, the researcher found no reason to study teachers in other private school settings. Students participated in surveys anonymously to ensure that students were responding honestly, thereby eliminating any power the researcher might have had over them as their science teacher. Data collector characteristics and data collector bias were controlled because the researcher was also the data collector. Educational Records Bureau (ERB) scored the Standardized Science Achievement tests, thus helping to eliminate validity issues caused by collector bias and teacher fatigue (Creswell, 2013).

Data Collection

The quantitative data for this study were collected using a Quasi-experimental method that utilized technology-integrated PBL and the available science curriculum at the researcher's organization (Thornton et al., 2013). The study was conducted during a structured, scheduled school day for one academic year (2018-2019). The study included one to two-week projects involving the participation of adults other than school site staff, with scientific expertise within the school community. The projects focused on the academic community, looking for the assets within the researcher's school community.

As a participant-observer (ethnographer), the researcher also employed qualitative ethnography methods of data collection to generate rich and detailed data. The primary sources of data (*Figure 3*) collected included classroom researcher observations, structured student and staff surveys, classroom and standardized testing assessments, classroom artifacts, extensive note-taking, and developed written forms for recording the information gathered (Creswell, 2013).

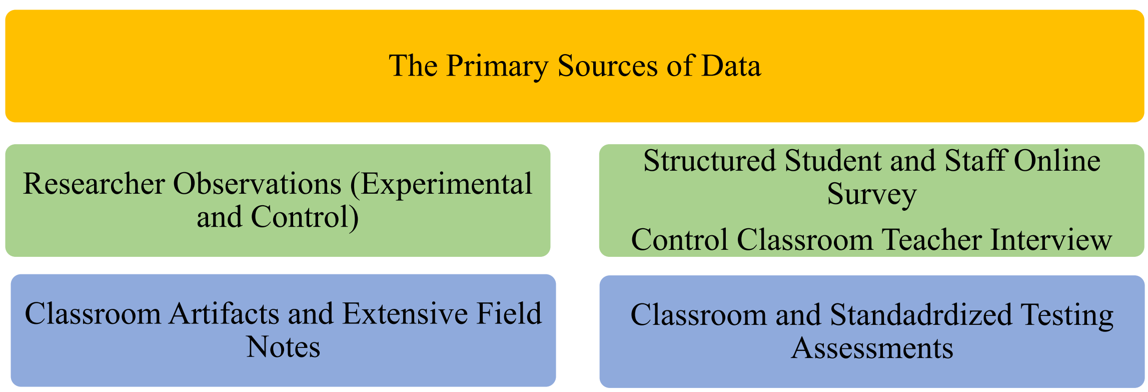


Figure 3. Primary Sources of Data Collected

Procedure

The researcher (ethnographer) developed an experimental study design using PBL (*Figure 4*) before the start of the study.

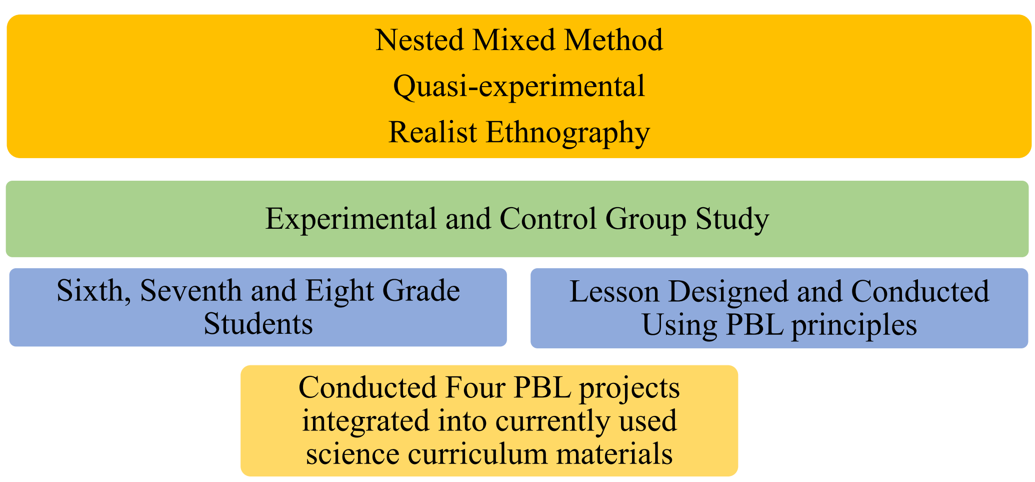


Figure 4. Study Design Process

Before the start of the study, the researcher designed a student-centered classroom environment conducive to collaborative learning. Student work areas were organized, and needed daily supplies were kept within easy reach. A variety of scientific experimental supplies was routinely available for student use and rotated based on the students' projects. With access to iPads (one-to-one), classroom resources, and school and nearby public libraries, students could acquire information from primary and secondary sources for their research (*Figure 5*).

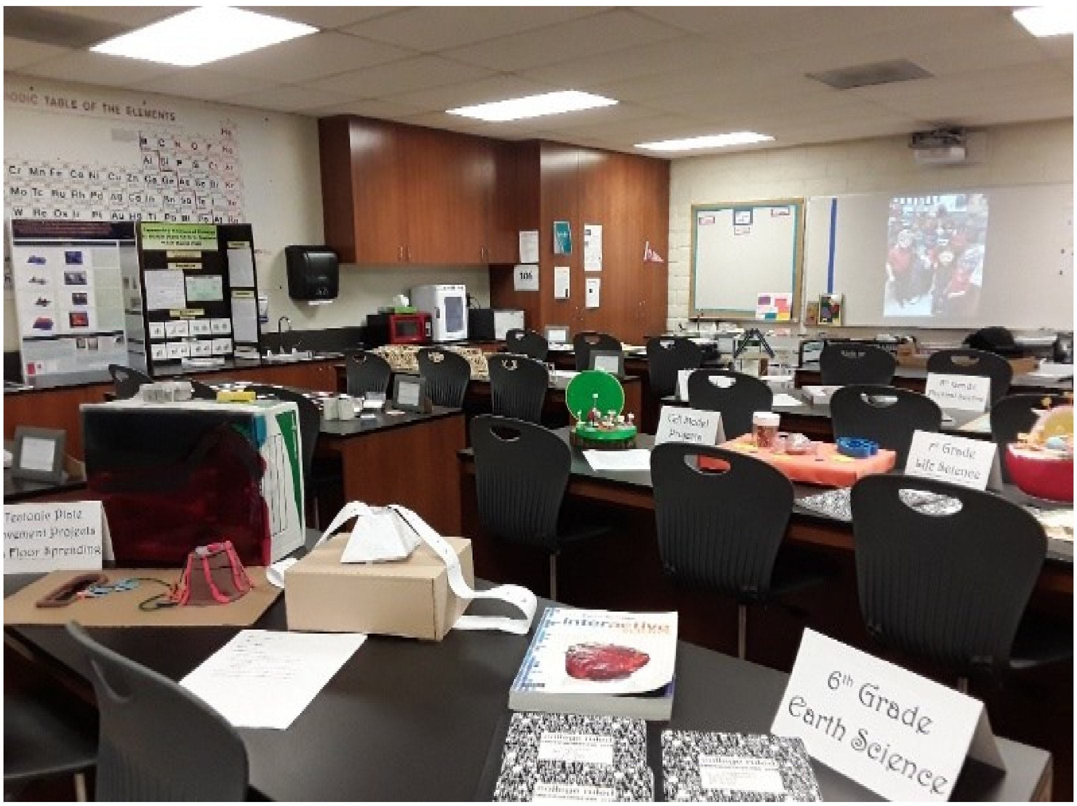


Figure 5. Science Classroom

The researcher placed students in small teams with the expectation that the teams would change at the end of each project or a unit allowing students to work with other classmates (Figure *6*).

Figure 6. Students Working in Groups

Classroom expectations were set and discussed (Appendix B) as soon as groups formed. The classroom expectations stated that all group members must participate, be considerate, and help others on the team and be respectful when there are disagreements. These expectations were revisited each time groups changed.

As could be seen in *Figure 7*, the researcher discussed and modeled what was meant by collaboration and working together as a team. The researcher monitored and joined group discussions to demonstrate further collaborative practices such as active listening. Researchers modeled how teams could work together to find an answer to the question that all team members could agree upon or demonstrate respectful disagreement when members of the group had differing opinions on the solution to the problem.

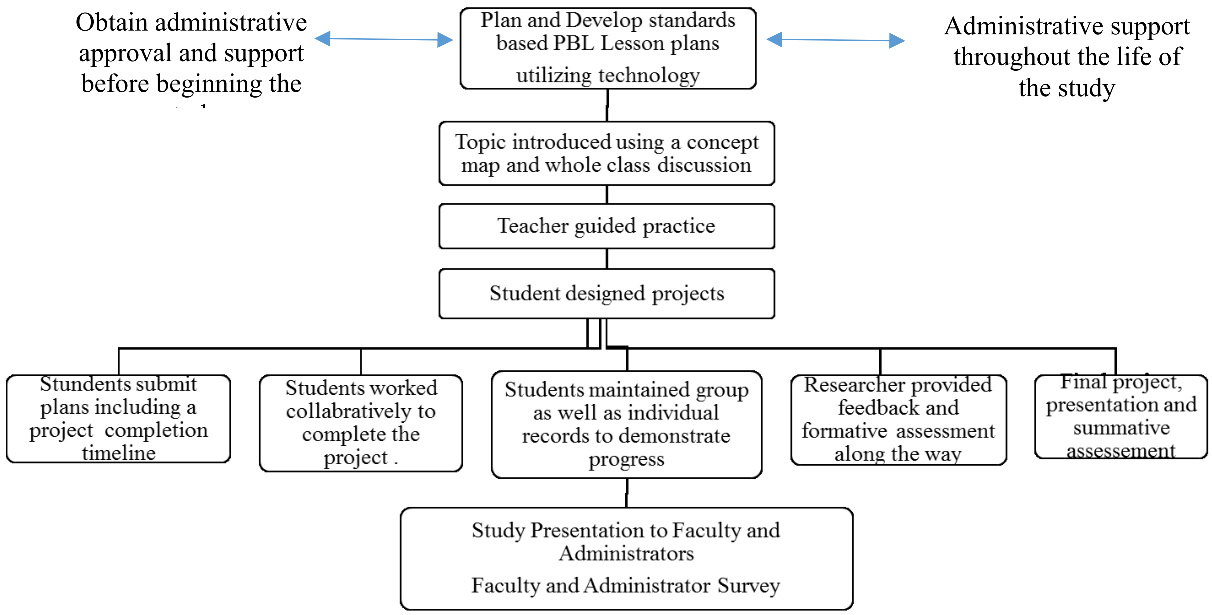


Figure 7. Plan for Data Collection

The students in sixth, seventh, and eighth-grade experimental science classrooms consisted of 71 students. Letters of consent (Appendices C, C2, C3, C4) for participation in the study and completion of an online survey created using Google Forms (Appendix D) were provided for each pupil (Maxwell, 2013). The researcher shared the digital link for the online survey (Google Forms) with all students via email (Appendix G), using the students' school email accounts. The students were encouraged to log in to the website hosting the online survey using the digital link provided by the researcher, at their convenience during the one week that the survey was made available before the start of the study. The online survey tool (Google Forms) allowed students to complete the survey without capturing their email address. Students were not required to put their names or any other identifying information on the survey (Oliver, 2010). Furthermore, the survey site did not maintain a record associating students' login credentials with the surveys completed by the students, thus allowing the participants to be assured of anonymity during the survey completion process (Baysura, Altun, & Yucel-Toy, 2016).

Question 1. How could technology-integrated PBL be implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines? The researcher planned and developed lesson plans that contained literature-based criteria for PBL (Appendix X). To ensure that the grade-level science standards, as well as school site curriculum goals, were met the researcher selected the topics of the study based on California middle school science standards (California Department of Education, 1998), New Generation of Science Standards (2013) and lesson pacing guidelines provided by the currently used science curriculum (Thornton, Buckley, Miller, Padilla, & Wysession, 2013).

The sixth-grade curriculum consisted of an introduction to Earth Science. The topics covered in the sixth-grade curriculum included the basic structure of the earth, plate tectonics, earthquakes, volcanoes, weathering, and erosion as well as the earth's resources. The seventh-grade curriculum consisted of an introduction to life Science. The topics covered in the seventh-grade curriculum included the essential characteristics of living things, the cell and its structures, genetics, and the science of heredity, DNA, microbial life, plants, animals, and an introduction to the human body. The eighth-grade curriculum consisted of an introduction to Physical Science. The topics covered in the eighth-grade curriculum included the basic structure of different Phases of Matter, atoms, molecules, and the Periodic Table of Elements, bonding and chemical reactions, acids and bases, forces, and motion (Thornton et al., 2013).

Because all students received the same instruction, using teacher-created literature-based PBL lesson plans, before the start of the study, the pupils were notified that scores received for their classroom activities, assignments, assessments, and projects would affect their course grade. Therefore, all students were encouraged to show diligence toward all their academic activities.

Before the introduction of a new unit of study, the researcher assessed students' prior knowledge by using diagnostic pretests (Appendix X1) (Thornton et al., 2013) provided by the currently used science curriculum. At the beginning of each chapter, students' prior knowledge was assessed using a criterion-referenced chapter pretest (Appendix X3). The topics were introduced to students using concept maps (Appendix M) (Rye, Landenberger, & Warner, 2013). The style and design of concept maps varied depending on the topic of discussion. Students were asked to document the concept map (Appendix M) that was created during the topic introduction in their science journals. As part of each class period, students updated their notes and concept map to show daily progress. The concept map was displayed through the end of the unit so students could add information to the concept map as a means of documenting whole class progress (Ozdemir, 2006; Rye et al., 2013). The concept maps were used for formative assessment of students' progress throughout the life of the unit or chapter (*Figure 8*).

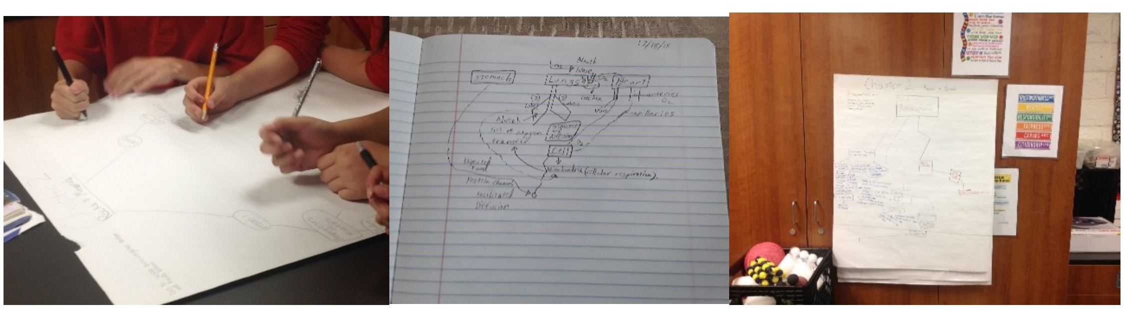


Figure 8. Concept Maps

Subsequently, students were given additional instruction through a benchmark lesson (Appendix X). These lessons helped students to acquire background knowledge before being presented with the project. For example, during the benchmark lesson on Introduction to Matter

(Appendix X, Lesson 3), the students received instructions on how to use laboratory tools such as a tri-beam balance to measure weight (mass) and laboratory glassware to measure volume (*Figure 9*).

Figure 9. Learning to Measure Volume

Students were provided with instructions on how to use the concepts of mass and volume in density calculations. Additionally, students received instruction on the Archimedes principle for calculating the density of non-geometric objects. Following the benchmark lesson, the students were placed in small groups of two to four students who worked together for two to three weeks during regular class time towards finding the answer for a common driving question in a project using the principles of PBL integrated with currently used science curriculum. In the measuring matter lesson (Appendix X, Lesson 3), the students were challenged to build a device that could accurately measure the masses of powdered solids and liquids. Students were also required to develop a method to measure volume without using standard laboratory equipment and collect data that could be used to calculate the density of items while following laboratory safety procedures. Students were provided with guidelines (Appendix Y) that clarified expectations and project deadlines (*Figure 10*).

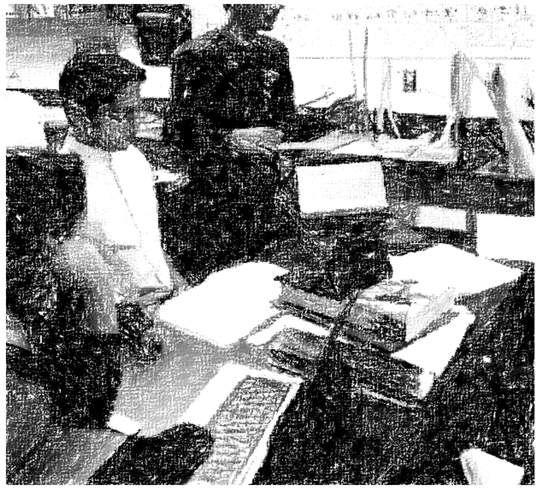


Figure 10. Collaborative Groups

Students could work and speak with others in the school community who were experts on the topic of study to help them with their investigations and project planning. Members of student groups were asked to be responsible for their learning while the teacher provided support and encouragement to facilitate learning (McCright, 2012). In the beginning, the researcher offered much guidance for all students. Once the students became more comfortable working in their groups and were able to take on more responsibility for the team's project, the researcher transitioned to providing advice and suggestions as a facilitator and guide, reminding students of upcoming deadlines and expectations while holding students accountable for their learning process (Gerlach, 2008; McCright, 2012). Students were expected to design and test their projects or prototypes and maintain detailed documentation (*Figure 11*) of their design process using their Interactive Science Folders and Journals (Appendix U) (Chesbro, 2006, Doppelt, 2009).

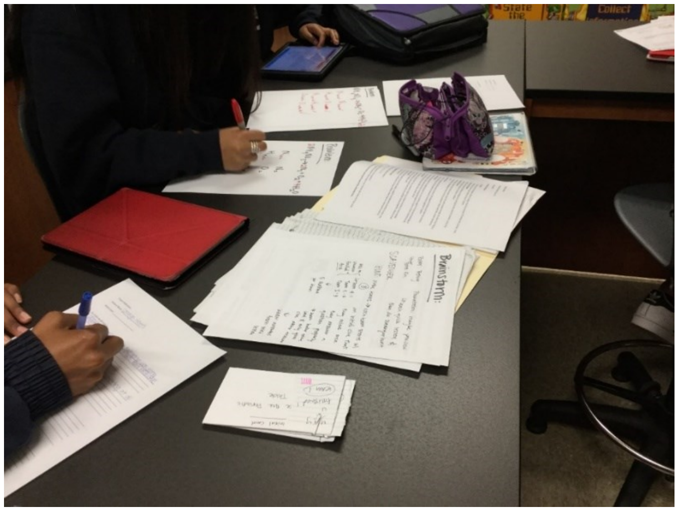


Figure 11. The Design Process

Students were asked to submit their plan (design) for the project (Appendix O) before the start of the project. As part of their plan, students were required to submit a timeline (*Figure 12*) for project completion, presentation of the final product, and individual student self-evaluation.

Task	Due Date
Research and gather information for your project.	October 25, 2018
Design and construct a balance	October 25, 2018
Create a scale drawing of the final product (must be color-coded and fully labeled).	October 29, 2018
Select containers and develop a method to measure the volume	October 29, 2018
Test Balance, redesign, and retest if necessary.	October 30, 2018
Make density measurements of objects.	October 30, 2018
Project presentation	November 1, 2018

Figure 12. Student-Created Project Timeline

The researcher provided students a checklist (*Figure 13*) to assist the students with the process of formulating a driving question (Appendix N) that their investigations would answer. Problems designed by students needed to be developmentally appropriate, utilize student personal knowledge and experiences, consider student skills and resources, and support classroom curriculum goals (Blumenfeld, Fishman, Krajcik, et al., 1999, Krajcik, Marx, & Solloway, 2000; Moursund, 2003).

In developing the problem, we considered the need for…	Yes	No
Appropriateness of the content when we developed our problem.	x	
The availability of skills and resources, either in or out of the classroom.	x	
Our experience and ability level in dealing with this type of problem.	x	
The current curriculum and learning goals of the class.	x	
Our curricular interests and learning styles.	x	
Creating a driving question.	x	
Developing individual and group evaluation strategies.	x	

Figure 13. Student-Created Problem Checklist

Throughout the investigational process, students were expected to be responsible for their learning while the teacher provided support and guidance to facilitate learning (McCright, 2012). Each student was expected to be involved in representing what was learned while working in their level of core competencies through the production of artifacts and products. Students were required to maintain their individual and collaborative group notes using their Interactive Science folder and Journals. Students were required to take detailed notes chronological order, either individually or collaboratively, for each project (investigation) to help them develop a better understanding of the concept studied and how scientists use it (*Figure 14*).

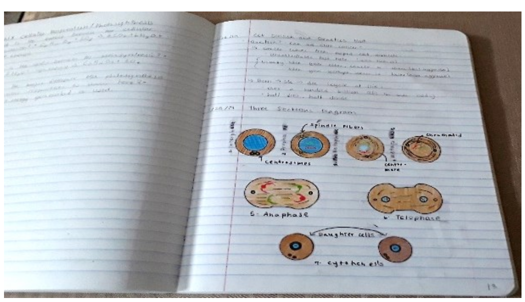


Figure 14. Student notes in the Interactive Science Journal

The student received both written and oral comments regarding their progress as well as the needed technology training throughout the life of the project (Jacques, Bissey, & Martin, 2016). Students' projects were assessed using a formative assessment rubric (Appendix S) and a summative assessment rubric (Appendix T). The formative assessment was designed to provide students with feedback while the project (investigation) was still in progress to allow students to make necessary changes and corrections as they moved toward completion of the projects or investigations and achievement of learning goals. The summative assessment was designed to evaluate students based on items such as meeting project milestones on time, quality of the final product, teacher observations of students' work in the classroom, team reports, individual reports.

Student Interactive Science Folders and Journals were also used for formative assessment throughout the life of the unit (chapter) and as well as a summative assessment at the end of the unit (chapter) (Rye et al., 2013). Student folders and journals were assessed using the Interactive Science Folder and Journal evaluation rubric (Appendix U). Students were evaluated on the quality and type of data recorded (Full Option Science System [FOSS], Grace, 2014) during the life of the project. Student awareness of the evaluation process and its focus on progress rather than a final product, helped students to become responsible for their learning and reduced students' level of stress and anxiety (Jacques, Bissey, & Martin, 2016).

In preparation for project presentations, the students worked collaboratively with the teacher to review and evaluate the whole project, select materials to share, find creative ways to share their knowledge and make a purposeful transition between the conclusion of the project and the topic of study in the current as well as the next project (Ozdemir, 2006). Each team was asked to complete the project and present a final collaborative project report (Hou, 2010) to other students and administrators (*Figure 15*). The finished products of the projects consisting of group and individual written reports, a poster, or a model presentation demonstrating a scientific principle were evaluated at a culminating event where students shared what they had learned with others.

Figure 15. Project Presentation Day

At the completion of chapter, criterion-referenced tests (chapter posttest and benchmark summative unit posttest) available as part of the teacher resources(Appendices X2 & X4) that accompany the existing curriculum (Thornton et al., 2013) were administered by the researcher as part of the classroom assessment practices to measure comprehension of materials and ensure content knowledge proficiency. The tests included multiple-choice, fill-in-blank, true, or false, short answer, essay questions. The researcher administered the tests as part of the classroom assessment practices. Before returning any formative or summative project assessment documents to the students, the researcher made electronic, scanned copies of paper documents submitted by students. The researcher also made electronic copies of digital documents submitted by students. The researcher removed all student identifying information before making any copies of student artifacts (Oliver, 2010). The researcher photographed project presentation artifacts such as prototype and posters before returning the artifact to the students.

At the end of the project, students reflected on their collaborative efforts (*Figure16)*. In their written reflections (Appendix Q), each student described the general process followed by the group to achieve their learning goals, stated their contributions to the team effort, and suggestions for future improvements. Student reflections provided the researcher with insight into how the groups were functioning and any necessary future changes that needed to be made (Frank & Barzilai, 2004).

> To complete this project, I had to build a scale that measured both mass and volume. I solved these two problems with a balance scale and a container. To measure mass, I used a balance scale because balance scales are an excellent way to find the mass of an object. Volume can be measured simply with a container that has markings that show the amount of liquid in the container. The suggestion was to make the scale bigger and capable of measuring more and larger objects. The containers I had only carried 20 mL, and a better idea would be to have larger container for a larger volume. For that, I would have also needed a bigger scale because the scale that I built for this project was very small. I also think that I learned a lot from this project. I learned how to build and use a balance scale. I also learned how to solve the problem of finding density, for which I needed a mass and a volume. I realized that a balance scale is one of the best methods for finding the mass of objects, and that to find the volume I simply need a measuring cup."

Figure 16. Student-Created Reflections Sample

The researcher collected data daily and weekly using the classroom observation protocol (Appendix R). Participant behavior and attitudes were observed and examined as part of the

study using classroom observations protocol (Appendix R) and online student surveys (Appendix D). Photographs of classroom activities were collected as part of classroom observation. These photographs were grouped and coded. The field notes, documented in the researcher diary, included the students' progress, problems, daily explanatory, and reflective notes on the physical setting of the classroom, the participants, activities and interactions, conversations, student attitude and demeanor, and even the researcher's behavior. All the notes and thoughts recorded during these observations were considered field notes (Creswell, 2013; Doppelt, 2009).
The researcher also collected artifacts demonstrating the implementation and use of PBL and technology integration into the currently used science curriculum (Baysura et al., 2016).

Instructional artifacts were collected based on their relevance to the learning activities, demonstrating student engagement in the classroom learning activities (Remmen & Froyland, 2014). Classroom artifacts gathered included items such as quizzes, examination results, and formal and informal student products such as Interactive Science folder and Journals, research papers, and project background reports. Other artifacts collected included class handouts, weekly lesson plans, and pictures of students engaged in PBL activities (Oliver-Hoyo & Allen, 2006).

The researcher (ethnographer) conducted observations of the control classroom using the Classroom Observation Protocol (Appendix R). The control teacher provided the researcher with anonymous student artifacts collected in the control classroom. The students at the control site did not experience any changes in their classroom instructional routine while using the currently available curriculum, research-based instructional strategies (i.e., inquiry-based science), as well as technology. The instruction in the classroom was conducted using research-based instructional strategies, as was expected by the school organization. The researcher did a follow-up interview with the control classroom teacher at the end of the study to examine the similarities and differences between the experimental and control groups. The interview focused on gaining insight into similarities and differences between project-based learning and other research-based instructional strategies.

Additionally, students were assessed using the CTP4 standardized science achievement test during the 2018-2019 academic year. The results were compared to students' 2016-2017 and 2017-2018 CTP4 standardized science achievement test scores in the same content area to determine if the implementation of PBL had led to an increase in the students' performance levels on the standardized tests. The CTP4 scores were analyzed by ERB, considering the level of the student's English proficiency, and learning challenges based on the information provided by the school site. Testing accommodations were made for students with testing anxiety. Student fatigue was mitigated by dividing the CTP4 test along curriculum topic areas to be administered over two weeks in three-hour blocks. Also, all students could become familiar with the testing format during a practice session before the start of the CTP testing.

Additional protocols were drawn up to deal with field issues that included incomplete data generated when student participants were absent or could not complete assigned work, lost or incomplete participant information (Appendix V). All research data was stored on the researcher's laptop that was password protected and backed up to a personal storage device kept in a locked cabinet at the researcher's office (Maxwell, 2013).

Question 2. How could the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science? Project-based learning lesson plans created by the researcher (Appendix I) were enhanced using technological tools and skills. The addition of digital technology to the curriculum potentially allowed students to personalize their learning. Allowing students to explore and apply their knowledge in the ways that worked best for them could have led to changes in students' attitude, aptitude, and improvement of overall academic achievement for science. By having access to digital workspaces in an active learning environment, students were able to participate in teamwork, communicate with others, create artifacts, personalize learning, and develop critical thinking in an authentic setting (*Figure 17*).

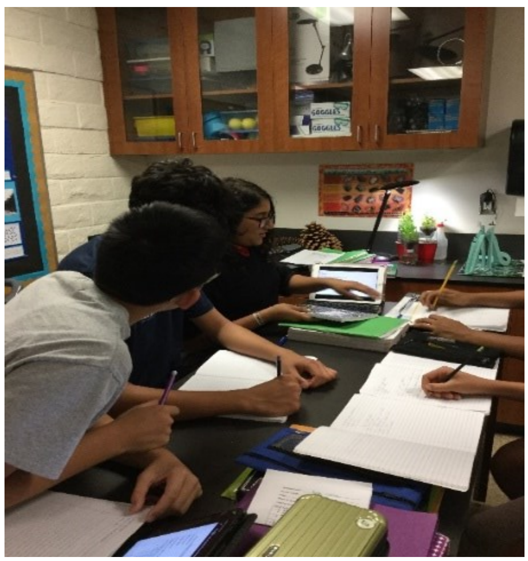


Figure 17. Data Sharing and Collaboration Meeting

Using web-based tools such as Google Docs, students collaborated in real-time using a shared digital workspace where they created documents, edited content, tracked progress while working on projects with each other, and the classroom teacher (researcher) as part of their learning process. By using personal iPads, students could access and use apps such as Keynote and Pages to create reports and presentations as part of their projects. Additionally, students chose to create an iMovie, take photographs on the iPad, create other types of documents such as books using a book creation app, create animation or Claymation, create a digital storyboard, and add music to their movie or create original songs using GarageBand to document their learning process (*Figure 18*).

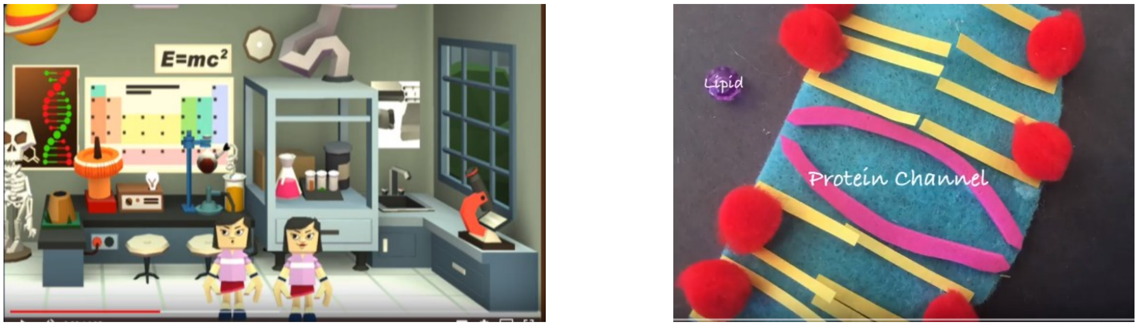


Figure 18. Examples of Student-Created Digital Projects

Using iPad features such as Airdrop and the classroom Apple TV, students created digital projects on their iPads with their peers and constructive feedback from a larger group. Additional iPad features such as Speak Screen and typing feedback embedded in apps such as Pages and touch screen helped students to interact with the learning materials and personalize learning. Using technology, students gather and analyze data both inside and outside of the classroom while sharing that data in real-time with their peers, members of the community using apps such as face time and video chat.

The slow-motion setting on the iPad camera allowed students to record experimental outcomes for further investigation and analysis of the data collected. Using the built-in gyroscope and accelerometer on the iPad, students recorded the speed of objects and measured angles as part of their physics experiments with force and motion. Using the camera function of the iPad, students photographed the microscopic features of a cell (*Figure 19*).

Figure 19. Onion Skin Picture was taken with Student iPad

Calculator apps were used to analyze data. Scientific simulation apps helped the students to learn about laws of physics, super volcanoes, study the Periodic Table, do chemistry experiments, participate in virtual dissections, and learn about Polymerase Chain Reaction (PCR). Interfaced electronic probes helped students to detect temperature, voltage, light intensity, sound, distance, dissolved oxygen, or pH. The data generated by the probes were digitally recorded and provided graphical data that could allow students to see trends in their data and focus on the concepts explored by asking new questions related to the experiment ("Centers for Implementing Technology in Education," 2016).

During the study, the researcher (ethnographer) conducted three informal observations of the control classroom using the Classroom Observation Protocol (Appendix R) and a follow-up interview (Appendix W) with the control classroom teacher at the end of the study to examine the similarities and differences between the experimental and control groups. Educational technology was integrated with the curriculum at both the experimental and control sites. Therefore, the interview focused on gaining insight into similarities and differences between how technology was used to enhance project-based learning as well as other research-based instructional strategies.

Question 3. What would be the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement? Administrative support was instrumental in the completion of this study. Before the beginning of the study, the researcher worked with the school site administrators to minimize potential schedule conflicts and class interruptions throughout the life of the study. Administrators continually supported the research by providing the researcher with adequate planning time, physical classroom resources, and time for teacher collaboration, classroom observations, and lesson plan evaluations to ensure that PBL lesson plans developed by the researcher met the standards and aligned with other school initiatives (Poulos, 2016). Throughout the life of the study, the researcher received additional support from the administrators to gain access to students' standardized testing data as well as technology support the help students with the use of their iPads and other technological tools (Moeller & Reitzes, 2011).

During the study, the administrators were asked to observe the researcher's classroom formally (3 times) using Classroom Formal Observation Rubric (Appendix L) to ensure that the compliance of the PBL lesson plans with state and school site teaching standards. Using the Lesson Plan Evaluation Rubric (Appendix K), the school site administrators evaluated the researcher's weekly lesson plans. Although the researcher had adequate physical access to the school site administrators, all lesson plans, rubrics, and evaluation forms were shared with the administrators electronically using a shared Google Doc folder. The use of Google Docs helped the researcher with the data collection process and created an open and continuous line of communication with the school site administrators.

Following the completion of the study, the administrators provided the researcher with an opportunity to present the content of the study, its application in the classroom environment, assessment methods, and the study results during an all-staff in-service meeting. To solicit feedback and gain an understanding of teachers' and administrators' attitudes toward structural and cultural changes necessary at an organizational level for creation of an environment conducive to the implementation of technology-integrated PBL, the researcher asked the teachers and administrators to participate in a voluntary and anonymous online survey using Google Forms (Appendix E & F). This survey was designed to help the researcher with collecting data about opinions on achievement, attitudes toward science, collaborative workgroups, learning styles, use of technology in the classroom and PBL in the class as a whole (Frank & Barzilai, 2004, Blair, Czaja, & Blair, Harrigan, 2014, 2014, McCright, 2012). The survey contained groups of items on general background information, attitude toward collaborative groups, views on benefits of working in groups, opinions on challenges of working in groups, knowledge of learning style, attitude toward the use of technology in the classroom, understanding of PBL, open-ended questions about teacher attitude towards implementation of technology in the classroom, and teachers' and administrators perceptions of benefits and challenges involved in implementation of technology-integrated PBL (McCright, 2012).

A letter of consent (Appendix C1) for participation in the study and completion of an online survey using Google Forms (Appendix E &F) was provided for each staff member (Maxwell, 2013). The researcher shared the digital link for the online survey (Google Forms) with the staff via email (Appendix H), using the member' school email accounts. Participation in the survey was voluntary. However, the staff was encouraged to log in to the website hosting the online survey using the digital link provided by the researcher, at their convenience during the one week that the survey was available. The online survey tool (Google Forms) allowed the staff to complete the survey without capturing their email address. The staff was not required to put their names or any other identifying information on the survey (Oliver, 2010). Furthermore, the survey site did not maintain a record associating staffs' login credentials with surveys completed by the staff, thus allowing the participants to be assured of anonymity during the survey completion process (Baysura, Altun, & Yucel-Toy, 2016). Data Analysis

The study variables have been shown in *Figure 20*. The detailed list of the study variables could be found in *Figure 21*.

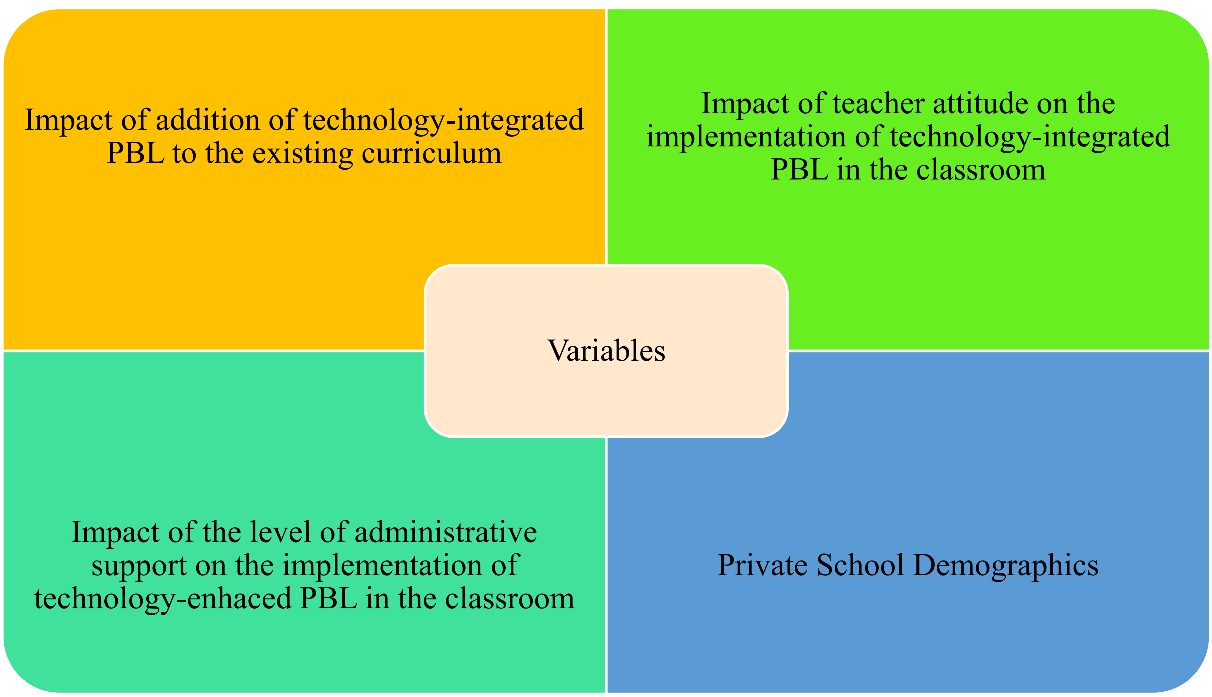


Figure 20. Study Variables

Independent Variables

- The survey (teacher, student and administrator)
- Instructions Provided to study Participants
- Implementation of technology- integrated PBL in a science classroom
- Lesson plans
- Teacher Willingness to implement technology-integrated PBL in the classroom
- Administrative support for implementation of technology enhanced PBL in the classroom

Dependent Variables

- Level of teacher/administrator participation
- Private school demographics
  -) pupil-teacher ratio
  - availability of adequate electronic digital devices and technological infrastructure in the classroom
  - school's standardized testing scores in reading, language arts, mathematics and science
- Student artifacts
- CTP4 test scores
- Administrative support for implementation (including provision of funding)
- Level of available technology infrastructure in the classroom
- Student aptitude/attitude toward school in general
- Level of student English proficiency
- Student Prior knowledge
- Student Fatigue
- Test Anxiety
- Formative /Summative test Scores
- Level of technological expertise of the individual students
- The degree of scientific ability

Controls

- The control site observations
- Control site CTP4 Results
- Control Site Teacher Interview
- Control sites student artifacts and criterion-referenced assessment results

Figure 21. List of Study Variables

Before beginning the data analysis (*Figure 22*), the researcher prepared the data set by assigning numeric values to the variables within the dataset. The researcher ensured that the values for variables were standardized and managed missing data points. A codebook was developed to assist with the inventory of individual variables within the dataset and their corresponding values. The codebook included a list of data collected along with the description of each type of data collected and the numerical values assigned by the researcher.

To complete the quantitative data analysis, the researcher identified the variables. Variables were further defined as categorical or interval. Data generated during the study were analyzed using descriptive statistics to identify patterns and trends. Data were also analyzed for measures of central tendency, deviance from the mean, sample variation, population variance, range, and frequency. The data generated was examined to see if the data was parametric or non-parametric to determine the appropriate type of inferential statistical test for data analysis. Subsequently, the data was uploaded and analyzed quantitively using statistical analysis tests found in the Excel 2018 Data Analysis Tool Pack and Real Statistics Resource Pack for Excel 2018 (Zaiontz, 2019).

Inferential statistical tests chosen helped the researcher to identify the relationships between variables and to determine if one variable can influence another variable. The use of inferential statistics allowed the researcher to generalize the interpretation of the quantitative study data to a larger population, thus allowing the researcher to assess the impact of the variables on a more significant population as the means of predicting outcomes. The researcher employed a normal curve distribution to determine whether to accept or reject the null hypothesis using a 0.5 alpha level to identify statistically significant findings.

Data for this study was further analyzed using triangulation and nested mixed-method designs to achieve an accurate and valid estimate of qualitative results. Through reviewing classroom observation notes, and participation data, a picture of the impact of the teacher's professional development on the enactment of PBL and integration of interfaced electronic probes in a middle school science classroom emerged (Guo & Yang, 2012).

The researcher examined the data collected by reading and looking through all the field notes, student artifacts, and photographs taken during the study to obtain an overall view of the information while writing memos ideas that helped her think about the organization of the data and bring to light areas where more data was needed. Student standardized assessment data were analyzed, considering factors such as individual needs status and limited English proficiency. The researcher consolidated, reduced, and interpreted the data gathered in a continuous process throughout the life of the study. The factors that contributed to the achievement levels of middle school students in a science classroom were identified to help the researcher understand the data collected (Creswell, 2013). The researcher analyzed the data gathered based on the observational notes and artifacts collected from an emic perspective to develop organizational categories and themes by grouping similar codes using a conventional coding method that allowed for the elimination of redundancy and overlap of codes. Photographs were also tagged and coded similarly. Axial coding was used to connect strategies that allow for an understanding of contextual relationships between themes and larger conceptual models (Creswell, 2013). The data collected in this study was validated to achieve an 80% intercoder agreement (Maxwell, 2013). The researcher used computer data analysis software, Microsoft Excel 2018, and Word 2018, to order the data and generate coding categories (Creswell, 2013). As themes emerged in the analysis, collected data was reviewed and cross-referenced for the existence of similar patterns, grouped, and classified into themes that followed the direction of the recurring ideas. Additional evidence was gathered deductively to support the researcher's arguments and interpretations to develop an overall cultural analysis (Creswell, 2013). Types of Inferential Statistics used in the study and their relationship to the study question and variables could be found in Table 1.

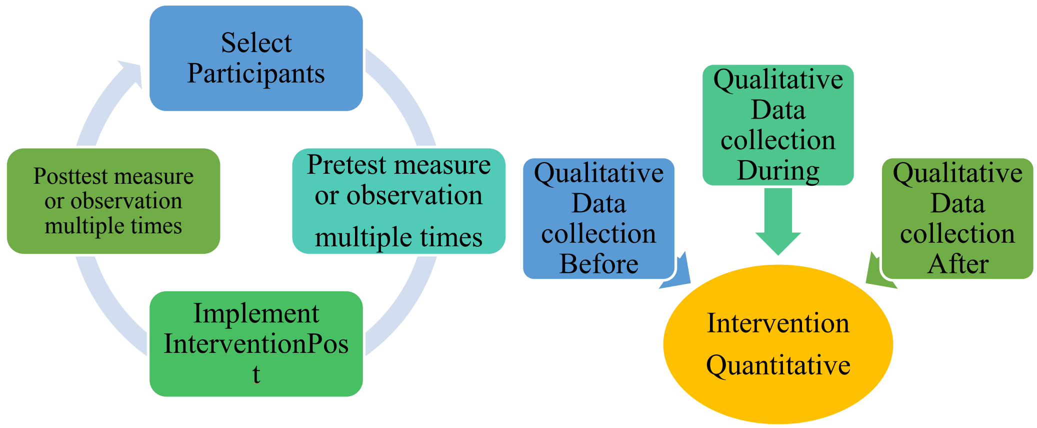


Figure 22. Quasi-Experimental, Nested Mixed Method Design

Table 1

Types of Inferential Statistics used in the study and their relationship to the study questions and Variables (Creswell, 2013, Lattimer & Riordan, 2011)

Questions	Variables	Instruments and Measures	Statistical test
1. How could technology-integrated PBL be implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines?	The survey (teacher, student, and administrator) Instructions provided to study participants Implementation of technology-integrated PBL in a science classroom Lesson plans Teacher willingness to implement technology-integrated PBL in the classroom Administrative support for the implementation of technology-integrated PBL in the classroom	Student artifacts, Student survey results Staff survey results CTP4 Test Scores Lesson plan & evaluation rubric Informal and formal observations	Spearman's Rank Correlation (Spearman Rho), Wilcoxon Signed Rank test
2. How could the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science?	Teacher willingness to implement technology-integrated PBL in the classroom Implementation of technology-integrated PBL in a science classroom Student aptitude/attitude toward school in general Level of student English proficiency Student prior knowledge Student fatigue Test anxiety Formative /summative test scores Level of the technological expertise of the individual students The degree of scientific ability	Lesson plans, student artifacts student and staff survey results Lesson plan evaluation rubric	Spearman's Rank Correlation (Spearman Rho), Wilcoxon Signed Rank test
3. What would be the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement?	Teacher & administration participation Administrative support for the implementation of technology-integrated PBL in the classroom	Teacher Survey, Administration survey Lesson plan evaluation rubric Classroom formal observation rubric	Spearman's Rank Correlation (Spearman Rho), Wilcoxon Signed Rank test

Narrative Structure

The narrative structure of this study was based on realist ethnography defined as a way of studying a culture-sharing group, immersing oneself in the day-to-day lives of participants by observing (Creswell, 2013). Ethnography requires the continued presence of the researcher within the filed to build connections and trust needed for the collection of rich data including mundane facts, objectively from the third person's perspective by obtaining the data from the participants at the research site (Reeves, Peller, & Kitto, 2013). The researcher relayed the information uncontaminated by individual predisposition, political objectives, and judgment, giving a detailed report of the actions and words of participants under study using standard categories for cultural description (e.g., family life, the communication network). The researcher established a perspective on how the culture was interpreted and presented regarding demographics and context of the research by the culture-sharing group through verbatim quotations in the final report (Creswell, 2013).

Ethical Issues

The Concordia University Institutional Review Board (Appendix A) gave prior approval for the data collection process involved in the research study to ensure compliance with the Standards for Ethical Conduct of Research. Furthermore, the school site administrators gave the researcher prior permission to research with little or no disruption to the activities at the school (Creswell, 2013).

The purpose of the study, what the participants were required to do, and how the data collected would be used, was disclosed to the participants to obtain informed consent from adult participants and parents of minor participants. A letter of consent indicated that participation in the study was voluntary and would not place the participants at undue risk. The researcher ensured confidentiality by making sure that the data could not be linked to individual participants by name through the anonymous surveys, pseudonyms, group data reporting, and destruction of the data collected for the study at the end of the study (Creswell, 2013).

The researcher established a supportive and respectful relationship with the participants by taking the time to learn about cultural and religious differences that would need to be considered and respected during this study. The researcher participated in the study as an observer studying students and teachers whose voices were represented in the report of the results of this investigation. During the study, the researcher-avoided leading questions withheld sharing personal opinions and impressions and protecting sensitive information learned about participants (Creswell, 2013).

The researcher has a professional relationship with the participating teachers in the study. The researcher and her colleagues have worked collaboratively together in various capacities in an environment that does not provide rewards for educational program development or teaching achievement. Teachers and administrators involved in this study shared a passion and love for education.

Even though the researcher did not hold an administrative position within her school organization, teacher participants risked having the researcher scrutinize their professional perceptions and attitudes. Teacher participants were assured that the researcher would only share group results of the research with the schools' administration in a manner that would protect the identity of individual participants. The researcher further assured the teacher participant of privacy protection through the use of aliases and composite profiles in the future publication of the research findings (Maxwell, 2013).

Students participating in this study risked not knowing how the results of the student survey would impact their grades. Students were allowed to take the survey anonymously without the researcher being present to minimize risk. Furthermore, the surveys were not conducted the week before or the week after the due dates for progress reports, parent-teacher conferences, or semester report cards (Maxwell, 2013).

To give back to participants in the study, the researcher provided educational services such as tutoring and training to the teacher and student participants. Following the completion of the research, the researcher reported multiple perspectives as well as contrary findings. The privacy of the participants was protected through the use of aliases, composite profiles, and group reporting so that individuals could not be identified. Data collected was reported honestly following APA (2010) guidelines for obtaining permission to reprint and adapt the work of others. Participants were provided with copies of the final data report (Maxwell, 2013).

Summary

The purpose of implementing technology-integrated PBL in a middle school science classroom was to learn if the use of this method of teaching would enhance the existing science curriculum while adhering to the curriculum standards and lesson pacing guidelines. Furthermore, the purpose of this realist ethnographic study was to see if the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom could lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science. An additional purpose of this study was to learn if access to an easy to use, lesson-planning platform, along with administrative support, could serve to change the attitude of teachers with basic knowledge of technology toward implementation of technology-integrated PBL in their classrooms to improve students' levels of academic achievement.

The unique ethnographic methodologies and processes influenced this mixed-method study by allowing the researcher to use firsthand knowledge gained through long-term presence to paint a vivid picture of a culture-sharing group in a science classroom (Creswell, 2013). The researcher established a perspective on how the culture was interpreted and presented regarding demographics and context of the research by the culture-sharing group through verbatim quotations in the final report (Creswell, 2013).

The researcher purposefully selected the middle school studied from a private school organization located in Orange County, Southern California. The letters of consent indicated that the researcher would only collect and use data from students who voluntarily consented to be participants in the study (Maxwell, 2013) and would not place the participants at undue risk. Furthermore, the destruction of the data collected at the end of the study meant that the data collected could not be linked to individual participants.

Students who agreed to be participants completed an online survey created using Google Forms (Appendix D) at the beginning and the end of the study. Student participant survey was developed to collect data on student general background information, how students learn, attitude toward the use of technology in the classroom, attitude toward working in collaborative groups, attitude, and aptitude toward science education and students' understanding of PBL (Blair, Czaja, & Blair, Harrigan, 2014, Frank & Barzilai, 2004).

The primary sources of data (Figure 3) collected included classroom researcher observations, structured student and staff surveys, classroom and standardized testing assessments, classroom artifacts, extensive note-taking, and developed written forms for recording the information gathered (Creswell, 2013).

PBL lesson plans (Appendix I) were developed based on the essential elements' checklist (Appendix J) required for a PBL Lesson plan. The administrator evaluators observed and examined the physical setting of the experimental classroom, the participants' activities and interactions, conversations, attitudes, and demeanors and even the researcher's behavior using the Classroom observation protocol (Appendix R).

The researcher used the classroom observation protocol (Appendix R) during each of the three informal observations conducted at the control site. The researcher collected data daily and weekly using the classroom observation protocol (Appendix R). The researcher (ethnographer) conducted observations of the control classroom using the Classroom Observation Protocol (Appendix R). Before the introduction of a new unit of study, the researcher assessed students' prior knowledge by using diagnostic pretests (Appendix X1) (Thornton et al., 2013) provided by the currently used science curriculum. Using the problem development checklist (Appendix N), students were asked to develop problems (questions) that were developmentally appropriate, utilize student personal knowledge and experiences, consider student skills and resources and support classroom curriculum goals (Bluemenfeld, Fishman, Krajcik, et al., 1999, Krajcik, Marx, & Solloway, 2000). As part of their plan, students were required to submit a timeline (Figure 12) for project completion, presentation of the final product, and individual student self-evaluation. In preparation for project presentations, the students worked collaboratively with the teacher to review and evaluate the whole project, select materials to share, find creative ways to share their knowledge and make a purposeful transition between the conclusion of the project and the topic of study in the current as well as the next project (Ozdemir, 2006). Student reflections provided the researcher with insight into how the groups were functioning and any necessary future changes that needed to be made (Frank & Barzilai, 2004).

In developing rubrics for the assessments (Appendices S & T), the researcher considered classroom climate, students' background knowledge, engagement with the problem, participation and collaboration, creativity, technology skills, ability to work collaboratively, determination of mastery, assessment of mastery, ability to provide constructive feedback, student involvement in the assessment process as well as how assessment data could be used to improve classroom teaching (Oberg, 2010). At the completion of chapter, criterion-referenced tests (chapter posttest and benchmark summative unit posttest) available as part of the teacher resources(Appendices X2 & X4) that accompany the existing curriculum (Thornton et al., 2013) were administered by the researcher as part of the classroom assessment practices to measure comprehension of materials and ensure content knowledge proficiency. Criterion-referenced tests provided by the publisher of the curriculum used in the researcher's school were used as part of this study. The stability of data collected was analyzed using an intercoder agreement of 80% between multiple coders of data sets based on the code names, coding of the same passages the same way, and the agreement on the themes of the study (Creswell, 2013).

Upon completion of the study, the teachers, and administrators from all school sites within the organization were invited to participate in online surveys created using Google Forms (Appendices E & F) following a presentation by the researcher at a regularly scheduled in-service meeting. Administrators continually supported the research by providing the researcher with adequate planning time, physical classroom resources, and time for teacher collaboration, classroom observations, and lesson plan evaluations to ensure that PBL lesson plans developed by the researcher met the standards and aligned with other school initiatives (Poulos, 2016). This survey was designed to help the researcher with collecting data about opinions on achievement, attitudes toward science, collaborative workgroups, learning styles, use of technology in the classroom and PBL in the class as a whole (Frank & Barzilai, 2004, Blair, Czaja, & Blair, Harrigan, 2014, McCright, 2012). The survey contained groups of items on general background information, attitude toward collaborative groups, views on benefits of working in groups, opinions on challenges of working in groups, knowledge of learning style, attitude toward the use of technology in the classroom, understanding of PBL, open-ended questions about teacher attitude towards implementation of technology in the classroom, and teachers' and administrators perceptions of benefits and challenges involved in implementation of technology-integrated PBL (McCright, 2012).

Before beginning the data analysis (Figure 22), the researcher prepared the data set by assigning numeric values to the variables within the dataset. The codebook included a list of data collected along with the description of each type of data collected and the numerical values assigned by the researcher. The data generated was examined to see if the data was parametric or non-parametric to determine the appropriate type of inferential statistical test for data analysis. Subsequently, the data was uploaded and analyzed quantitively using statistical analysis tests found in the Excel 2018 Data Analysis Tool Pack and Real Statistics Resource Pack for Excel 2018 (Zaiontz, 2019). As themes emerged in the qualitative analysis, collected data was reviewed and cross-referenced for the existence of similar patterns, grouped, and classified into themes that followed the direction of the recurring ideas.

Inferential statistical tests chosen helped the researcher to identify the relationships between variables and to determine if one variable can influence another variable. The use of inferential statistics allowed the researcher to generalize the interpretation of the quantitative study data to a larger population, thus allowing the researcher to assess the impact of the variables on a more significant population as the means of predicting outcomes. The researcher examined the data collected by reading and looking through all the field notes, student artifacts, and photographs taken during the study to obtain an overall view of the information while writing memos ideas that helped her think about the organization of the data and bring to light areas where more data was needed. Student standardized assessment data were analyzed, considering factors such as individual needs status and limited English proficiency. The researcher consolidated, reduced, and interpreted the data gathered in a continuous process throughout the life of the study.

To establish internal validity researcher addressed how well the research instruments measured what they were expected to measure through evaluation of formative and summative criterion-referenced tests used for this study to make sure all the relevant areas of the topic studied were represented in the tests. To further overcome researcher bias, the data was collected but not examined or analyzed until after the study data collection phase had been completed. To avoid bias in the data collected, the researcher used an intercoder agreement of 80% between multiple coders of data sets based on the code names, coding of the same passages the same way, and the agreement on the themes of the study. Additionally, the researcher triangulated control classroom data with other sources of data collected and checked for alternative explanations. The data collected in this study was validated to achieve an 80% intercoder agreement (Maxwell, 2013).

CHAPTER 4: RESULTS

Introduction

The researcher conducted a Quasi-experimental (Nested design) ethnographic study to explore if the implementation of technology-integrated PBL in a middle school science classroom would enhance the existing science curriculum while adhering to the curriculum standards and lesson pacing guidelines. Furthermore, this study sought to find if the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom would lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science. Additionally, this study attempted to determine if access to an easy to use, lesson-planning platform along with administrative support, could serve to change the attitude of teachers with basic knowledge of technology toward implementation of technology-integrated PBL in their classrooms to improve students' levels of academic achievement.

The purpose of this study was achieved by examining the results of the data analyzed from surveys, criterion-referenced tests, CTP4 standardized testing, observations, field notes & reflections, lesson plans and rubrics, interactive science journals, and student artifacts.

The findings of this study were presented according to the types of data collected as well as the three research questions that guided this study. The data collected was quantitatively analyzed using a statistical analysis tool pack in Excel 2018 as well as Real Statistics Resource Pack for Excel 2018 (Zaiontz, 2019). The data collected was qualitatively analyzed and coded using Excel 2018 and Word 2016. Achievement in science was measured by the 2018-2019 Comprehensive Testing Program (CTP4) test. The CTP4 test scores for academic years 2016-

2017 and 2017-2018 measured by the Educational Records Bureau (ERB) were obtained and served as comparison data to establish pre-experimental equivalence.

Research Questions

1. How could technology-integrated PBL be implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines?
2. How could the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science?
3. What would be the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement?

Quantitative Data Analysis

Demographic Information

The population for this study was comprised of approximately 22 sixths (earth science), 27 seventh (life science) and, 22 eighth grade (physical science) students at the experimental site, approximately 40 eighth grade students at the control site, one science teacher as a participant-observer (realist ethnographer) at the experimental site, and one science teacher at the control site. The researcher invited 161 teachers and 12 administrators to participate in a survey as part of the study.

Demographic Data (Categorical Data)

Categorical data (i.e., degree, position, and gender, years served at current school) was collected from students and staff who completed the study surveys. However, not all student participants responded to the Pre-study survey. Thus the demographic information collected from the sample of 46 student respondents based on the data provided on the participant consent forms has been presented in Table 2. The demographic information collected from the 38 students who responded to the Pre-study survey has been presented in Table 3. The demographic information collected from 34 students who responded to the Post-study online survey has been presented in Table 4.

Table 2

Student Participant Demographics (Based on Consent Forms)

	6th Grade Participants		7th Grade Participants		8th Grade Participants	
Gender	Male	Female	Male	Female	Male	Female
	8	8	7	9	9	5

Table 3

Student Participant Demographics (Based Pre-study Online Survey Participation)

	6th Grade Participants		7th Grade Participants		8th Grade Participants	
Gender	Male	Female	Male	Female	Male	Female
	8	7	4	9	7	3

Table 4

Student Participant Demographics (Based Post-study Online Survey Participation)

	6th Grade Participants		7th Grade Participants		8th Grade Participants	
Gender	Male	Female	Male	Female	Male	Female
	7	8	2	8	5	4

The demographic information collected from the 12 teachers who responded to the study survey has been presented in Table 5. One female participant (NA*) did not provide years in practice. The demographic information collected from the three administrators who responded to the study survey has been presented in Table 6.

Table 5

Teacher Demographic Information

Gender	Years in Current Position	Years as an Educator	Highest Degree	Current Grade Levels.	Academic Subjects
Female	7	10	BA English Teaching Credential	12	Literature
Male	7	8	Masters in Teaching	12	Science Art
Female	16	18	MA	10	Language Arts
Male	21	24	Ph. D.	10	Science
Male	16	18	B.A.	11;12	Literature
Female	15	26	Master's	9;10;11;12	Science
Male	8	10	Master's	9;10;11;12	Mathematics Science
Female	12	16	MS	9;10;11;12	Science
Male	8	8	Master's	10	Mathematics
Female	7	10	Masters in TESOL	9;10	Language Arts
Male	17	35	MS	9;10;11;12	Mathematics
Female	NA*	17	Credential	9;10;11;12	Art

Table 6

Administrators Demographic Information

Gender	Same School as last year	Years in current position	Years as an educator	Highest Degree
Male	Yes	2	22	BA in Physics and Management
Male	Yes	1	11	Masters
Female	Yes	2	21	MA Educational Administration

Statistical Tests

The quantitative statistical analysis was conducted first, followed by qualitative statistics. Descriptive statistical tests, including measures of central tendency (mean, mode, median) as well as measures of spread (range, variance, and standard deviation) were used to analyze the study results. Since many of the statistical tests considered for data analysis were parametric, it was essential to check the assumptions required of parametric tests to avoid the risk of making wrong decisions. Due to the small sample size, the study data did not meet the underlying assumptions (normally distributed data, homogeneity of variance, interval data, and independence) required for parametric tests. Therefore, the results of this study were analyzed using a non-parametric inferential statistical test, including Spearman's Rank Correlation (Spearman Rho), Wilcoxon Signed Rank test.

Spearman's rank correlation coefficient or Spearman's rho (r) was used to measure the strength of dependence between two variables (pretests vs. posttest scores) using a monotonic (linear or not linear) function. A value of r= +1 or close +1 would have represented a perfect or a high level of a positive correlation between two variables. Whereas a value of r= -1 or close to -1 would have represented a complete or high level of a negative relationship between two variables. The Wilcoxon signed-rank test was for a comparison of the matched pretests and posttests scores to determine whether or not there were differences in their values "before" and "after" the intervention. The requirements and null hypothesis for each test have been listed in Table 7.

Table 7

Requirements for Statistical Tests Used

	Requirements	Null Hypothesis
Spearman's Rank Correlation (Spearman Rho)	The scale of measurement must be ordinal (or interval, ratio) Requires matched pairs The association between variables must be monotonic +1 = a perfect positive correlation between ranks -1 = a perfect negative correlation between ranks 0 = no correlation between ranks.	There is no correlation between the two data sets.
Wilcoxon Signed Rank test	Requires matched data The dependent variable must be continuous	The medians for both samples are Equal.

Data Collection Methods

The Survey. In the quantitative phase, data were collected in part through the administration of surveys to students, teachers, and administrators. The surveys were distributed to a total of 161 teachers, 12 administrators in the four schools within the researcher's organization. The 71 student participants from the school serving as the experimental site received individual hard copies of the informed consent and confidentiality information with an option to give consent, as well as the option to exit the survey at any time (Appendices C, C2, C3). The 46 student participants who consented to be in the study were provided with a link to access to a secure URL address for the online Google Forms survey at the beginning and the end of the study via email (Appendix G).

All eligible teacher and administrator participants were provided with a detailed description of informed consent and confidentiality information with an option to give consent, as well as the option to exit the survey at any time (Appendix C1) via email, thus making recruitment and consent easier. The 15 staff (teachers and administrators) participants who consented to be in the study received a link to access a secure URL address for the online Google Forms survey at the end of the study via email (Appendix H). The survey response rate for teachers, administrators, and students have been presented in Table 8.

Table 8

Survey Responses Rate

	Administrators	Teachers	Students (Pre-study survey)	Students (Post-study survey)
Total Number of participants	3	12	46	46
Total number of participants who responded to the survey	3	12	38	34
Survey Response Rate	100%	100%	82.60%	73.91%

Criterion-Referenced Test. Criterion-referenced tests (diagnostic unit pretest, chapter tests, and benchmark summative unit posttest) provided by the publisher of the curriculum used in both the experimental as well as the control school sites were used as part of this study. Each test was available as a version A or a version B test that measured the same concepts at the same level of difficulty, thus ensuring internal consistency and reliability. Both version A (posttest) and version B (pretest) tests included multiple-choice, fill-in-blank, true, or false, short answer, essay questions (Appendices X1, X2, X3, X4).

Additionally, as part of the classroom assessment practices to measure comprehension of materials and ensure content knowledge proficiency, the researcher administered diagnostic (used before the start of a new unit) and benchmark (used after a unit) criterion-referenced tests (Thornton et al., 2013). The tests included multiple choice and short answer questions.

CTP4 Test. The results for the Comprehensive Testing Program (CTP4) standardized science achievement test given during the 2018-2019 academic year were compared with the results of the 2016-2017 and 2017-2018 CTP4 standardized science achievement test scores in the same content area to determine if the implementation of PBL had led to an increase in the students' performance levels on the standardized tests. The Educational Records Bureau (ERB) analyzed the CTP4 scores based on the information provided by the school site regarding the level of the student's English proficiency and learning challenges. Testing accommodations were made for students with testing anxiety. Student fatigue was mitigated by dividing the CTP4 test along curriculum topic areas to be administered over two weeks in three-hour blocks. Also, all students became familiar with the testing format during a practice session before the start of the CTP testing.

Based on the information provided by ERB, science scores were considered statistically significant if they fall ten percent above or below the suburban norm. Scores above ten percent of the suburban norms were considered advanced. Scores that fall within ten percent of the suburban norm (above or below) were considered proficient, and scores that fall ten percent below the proficient range were considered basic. Scores below basic were considered minimal (K. Robinette, personal communication, July 19, 2017). CTP4 standardized science test scores from 2016-2017, 2017-2018, and 2018-2019 academic years were collected for the experimental study participants. A composite CTP4 score was collected for each of the testing cycles at the control site.

Testing the Research Questions

Consistency of Analysis

To establish consistency of analysis researcher addressed how well the research instruments measured what they were expected to measure through evaluation of formative and summative criterion-referenced tests used for this study. The formative and summative criterion-referenced tests were compared for the content taught versus content tested based on the information provided in the student science textbooks to ensure representation of all relevant areas of study. The similarity between these areas indicated high content validity.

The use of criterion-referenced tests (version A and Version B provided by the textbook publisher) ensured the reliability of the test even if participants read the items on a test differently based on their experiences and backgrounds (Appendices X3 & X4). Split-half reliability was used to calculate internal consistency based on the concept of dividing a test into two halves to find the correlation between the two halves to establish validity and reliability of the whole test as well as each half-evaluated (Sprinthall, 2012). Each test was copied before being graded. Each test was graded once, and then one-half of the tests were chosen at random to be re-graded on a different day using a fresh copy of the same test. The comparison of the test grades proved that the split-half reliability for the criterion-referenced tests was 100%.

The scorer/rater reliability was conducted to ensure consistent and equitable scoring of tests considering scorer fatigue, external influences on scorers that may cause differences in scoring. Each test was copied before being graded. New copies of the same test, tests were chosen at random to be re-graded on a different day. The scores were compared to establish a scorer/rater reliability of 100% (Sprinthall, 2012).

The scores for CTP4 science standardized tests administered in 2016-2017, 2017-2018, and 2018-2019 academic years were correlated to evaluate the consistency of the results across alternate versions. New students admitted during the 2018-2019 academic year were excluded from parallel reliability analysis due to a lack of available CTP4 testing scores from the 2016-2017 and 2017-2018 academic years.

Descriptive and Inferential Statistics

The descriptive and inferential statistics used to investigate the three research questions for this study have been presented in Table 9.

Table 9

Types of Descriptive and Inferential Statistics used in the study and their Relationship to the Study Questions and Variables (Creswell, 2013, Lattimer & Riordan, 2011)

Questions	Variables	Instrumentations and Measures	Descriptive Statistical test	Inferential Statistics
1. How could technology-integrated PBL be implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines?	The survey (teacher, student, and administrator) Instructions provided to study participants Implementation of technology-integrated PBL in a science classroom Lesson plans Teacher willingness to implement technology-integrated PBL in the classroom Administrative support for the implementation of technology-integrated PBL in the classroom	Student artifacts, Student survey results staff survey results CTP4 Test Scores lesson plan & evaluation rubric Informal and formal observations	Mean Standard Error Median Mode Standard Deviation Sample Deviance Range	Spearman's Rank Correlation (Spearman Rho), Wilcoxon Signed Rank test
2. How could the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science?	Teacher willingness to implement technology-integrated PBL in the classroom Implementation of technology-integrated PBL in a science classroom Student aptitude/attitude toward school in general Level of student English proficiency Student prior knowledge Student fatigue Test Anxiety Formative /summative test scores Level of the technological expertise of the individual students The degree of scientific ability	Lesson Plans, student artifacts student and staff survey results Lesson plan evaluation rubric	Mean Standard Error Median Mode Standard Deviation Sample Deviance Range	Spearman's Rank Correlation (Spearman Rho), Wilcoxon Signed Rank test
3. What would be the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement?	Teacher & administration participation Administrative support for the implementation of technology-integrated PBL in the classroom	Teacher survey, Administration survey Lesson plan evaluation rubric Classroom formal observation rubric	Mean Standard Error Median Mode Standard Deviation Sample Deviance Range	Spearman's Rank Correlation (Spearman Rho), Wilcoxon Signed Rank test

Study Variables

The independent, dependent, and control variables relative to each of the study questions have been presented in Table 10.

Table 10

Research Questions Variables

Study Questions	Independent Variables	Dependent Variables	Control Variables
1. How could technology-integrated PBL be implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines?	The survey (student) Instructions provided to study participants Implementation of technology-integrated PBL in a science classroom Lesson plans Teacher willingness to implement technology-integrated PBL in the classroom Administrative support for the implementation of technology-integrated PBL in the classroom	Level of teacher/administrator participation Private school demographics pupil-teacher ratio Availability of adequate electronic digital devices and technological infrastructure in the classroom school's standardized testing scores in reading, language arts, mathematics, and science Student artifacts CTP4 test scores Administrative support for implementation (including the provision of funding) Student aptitude/attitude toward school in general Level of student English proficiency Student Prior knowledge Student fatigue & Test anxiety Formative /summative test scores Level of the technological expertise of the individual students The degree of scientific ability	The control site observations Control site CTP4 Results Control Site Teacher Interview Control sites student artifacts and criterion-referenced assessment results
2. How could the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science?	The survey (student) Instructions provided to study participants Implementation of technology-integrated PBL in a science classroom Lesson plans Teacher willingness to implement technology-integrated PBL in the classroom Administrative support for the implementation of technology-integrated PBL in the classroom	Level of teacher/administrator participation Private school demographics pupil-teacher ratio Availability of adequate electronic digital devices and technological infrastructure in the classroom school's standardized testing scores in reading, language arts, mathematics, and science Student artifacts	The control site observations Control sites student artifacts and criterion-referenced assessment results

3. What would be the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement?	The survey (teacher, and administrator) Instructions provided to study participants Implementation of technology-integrated PBL in a science classroom Lesson plans Teacher willingness to implement technology-integrated PBL in the classroom Administrative support for the implementation of technology-integrated PBL in the classroom	Level of teacher/administrator participation Private school demographics pupil-teacher ratio Availability of adequate electronic digital devices and technological infrastructure in the classroom school's standardized testing scores in reading, language arts, mathematics, and science CTP4 test scores Administrative support for implementation (including the provision of funding) Student aptitude/attitude toward school in general Level of student English proficiency Level of the technological expertise of the individual students	The control site observations Control Site Teacher Interview

Discussion of the Quantitative Survey Results

In this study, descriptive and inferential statistics were used to form the basis of the quantitative analysis of data and help the researcher to provide summaries about the samples and the measures used during the data collection window. The level of significance of 0.05 was set for each statistical analysis test used in this study. The data was uploaded and analyzed quantitively using non-parametric inferential statistical analysis tests consisting of Spearman's Rank Correlation (Spearman Rho), and Wilcoxon Signed Rank test found in the Excel 2018 Data Analysis Tool Pack and Real Statistics Resource Pack for Excel 2018 (Zaiontz, 2019).

The Survey

The data generated by the Likert-style survey used for this study was ordinal data. The data collected could only say one score was higher than another, but could not provide the distance between the two points. The results of the student participants favorites academic subjects, as stated in the Pre-study and Post-study surveys presented in Table 11 show a 15.2% decrease for mathematics, a 2.5% increase for Spanish, a 7.9% decrease for Literature, a 2.2%

increase for Art, a 0.8% increase for science and a 3.4% decrease for Language arts during the life of the study.

Table 11

Student Participants Favorite Academic Subjects as Stated in the Pre-study and Post-study Surveys

	Pre-study Survey (% Liked)	Post-study Survey (% Liked)
Mathematics	74	58.8
Spanish	21	23.5
Literature	55	47.1
Art	36	38.2
Science	58	58.8
Language Arts	21	17.6
History	47	50

The summary of the results of the student participants' pre-study survey has been presented in Table 12.

Table 12

Summary of the Results of the Student Participants Pre-study Survey

Question		Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
	How Students Learn					
6	I learn best in a traditional classroom with a teacher directing the learning.	5.30	31.60	52.60	10.50	0
7	I learn best when allowed to use a variety of materials in addition to the textbook to research and learn the information I need to know about the subject.	28.90	44.70	15.80	10.50	0
8	I learn best by talking and thinking about topics during whole-class discussions.	21.10	36.80	28.90	10.50	2.60
9	I learn best when I can gather the information myself working in collaborative groups instead of a teacher just giving the information.	21.10	31.60	26.30	18.40	2.60

	Use of Technology					
10	I am comfortable using an iPad, a laptop computer, and an iPhone.	71.10	15.80	10.50	0	2.60
11	I like using personal digital devices in the classroom.	52.60	26.30	18.40	2.60	0
12	I learn more when I use personal digital devices in the classroom.	28.90	23.70	28.90	18.40	0
13	I am distracted when allowed to use personal digital devices in the classroom.	5.30	7.90	26.30	36.80	23.70
	Working in Collaborative Groups & Assessment					
14	I like working in groups.	42.10	21.10	18.40	13.20	5.30
15	I like having jobs & responsibilities as part of working with a small group.	26.30	57.90	13.20	0	2.60
16	Completing a group project requires that all the group members participate in the process.	73.70	15.80	7.90	2.60	0
17	I like working towards creating a final product in class to show I have mastered the concepts studied.	47.40	39.50	13.20	0	0
18	I like it when the projects involve the investigation of real-world topics as they relate to the community and the concepts taught.	40.50	37.80	18.90	2.70	0
19	I like going beyond the classroom to gain real-life experience and do hands-on activities.	59.90	16.20	21.60	2.70	0
20	I like writing and reflecting about what I learn in class.	2.70	13.50	40.50	29.70	13.50
21	I like receiving short lessons from my teacher based on my needs.	27	35.10	32.40	5.40	0
22	I like being evaluated based on my ongoing collection of completed work rather than relying only on tests.	37.80	37.80	16.20	5.40	2.70
23	I like it when my teacher models' different roles and acts as more than just a teacher.	51.40	35.10	13.50	0	0
	Attitude and Aptitude					
26	I like to set personal goals.	43.20	37.80	18.90	0	0
27	I have the potential to achieve my personal goals.	40.50	45.90	13.50	0	0
28	I like being able to have a choice and voice over how I learn.	62.20	29.70	5.40	0	3
29	I like to take responsibility for my success.	51.40	35.10	13.50	0	0

30	I am curious about the world around me and like to learn new things.	59.50	24.30	13.50	2.70	0
31	I believe that academic success is essential.	48.60	43.20	8.10	0	0
32	My parents expect me to be successful at school.	89.20	10.80	0	0	0
33	I like to win in a competitive environment.	40.50	37.80	18.90	0	2.70
34	I like to be academically challenged.	27	43.20	27	2.70	0
35	I believe that my ability and confidence grow with my effort.	40.50	40.50	16.20	2.70	0
36	I believe that my teachers show enthusiasm about the subjects they teach.	48.60	32.40	18.90	0	0
37	I believe that my school is a place where I accepted and valued as part of a community of learners.	40.50	32.40	27	0	0
38	I like working collaboratively in a supportive environment with authentic problems.	40.50	37.80	18.90	2.70	0
	Attitudes Towards Science Education					
39	I like to learn by doing an activity or an experiment rather than by reading about the topic.	70.30	10.80	10.80	5.40	2.70
40	I believe that my science lessons are relevant to my everyday life.	27	37.80	27	8.10	0
41	The science curriculum at my grade level has an appropriate level of difficulty.	32.40	51.40	13.50	2.70	0
42	I believe that science lessons are fun.	32.40	43.20	21.60	2.70	0
43	I am considering a career in a scientific field after I complete my education.	21.60	18.90	32.40	21.60	5.40
	Project-based Learning					
44	PBL is when students work on a project assigned by the teacher to help them learn.	18.90	32.40	45.90	2.70	0
45	PBL is when students choose a project to work on to show that they have learned the lesson.	29.70	21.60	43.20	5.40	0
46	PBL is when students can do a project in place of a test.	35.10	27	29.70	8.10	0
47	PBL is when students learn by investigating an interesting problem presented by the teacher.	27	37.80	32.40	2.70	0
48	PBL is when students learn by investigating a problem with real-life applications.	27	35.10	35.10	2.70	0

A summary of the student's Post-study survey data has been presented in Table 13, shown below.

Table 13

Summary of the Results of the Student Participants Post-Study Survey

Question		Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
		How Students Learn				
6	I learn best in a traditional classroom with a teacher directing the learning.	11.80	26.50	32.40	20.60	9
7	I learn best when allowed to use a variety of materials in addition to the textbook to research and learn the information I need to know about the subject.	23.50	50.00	20.60	5.90	0
8	I learn best by talking and thinking about topics during whole-class discussions.	14.70	47.10	32.40	5.90	0
9	I learn best when I can gather the information myself working in collaborative groups instead of a teacher just giving the information.	20.60	26.50	35.30	11.80	5.90
		Use of Technology				
10	I am comfortable using an iPad, a laptop computer, and an iPhone.	58.80	29.40	11.80	0	0
11	I like using personal digital devices in the classroom.	50.00	32.40	14.70	2.90	0
12	I learn more when I use personal digital devices in the classroom.	14.70	47.10	29.40	5.90	3
13	I am distracted when allowed to use personal digital devices in the classroom.	0	2.90	38.20	50.00	8.80
		Working in Collaborative Groups & Assessment				
14	I like working in groups.	38.20	35.30	11.80	11.80	2.90
15	I like having jobs & responsibilities as part of working with a small group.	35.30	47.10	14.70	2	0
16	Completing a group project requires that all the group members participate in the process.	64.70	32.40	2.90	0	0
17	I like working towards creating a final product in class to show I have mastered the concepts studied.	23.50	52.90	20.60	0	3
18	I like it when the projects involve the investigation of real-world topics as they relate to the	29.40	41.20	26.50	2.90	0

	community and the concepts taught.					
19	I like going beyond the classroom to gain real-life experience and do hands-on activities.	38.20	35.30	23.50	2.90	0
20	I like writing and reflecting about what I learn in class.	8.80	23.50	29.40	26.50	11.80
21	I like receiving short lessons from my teacher based on my needs.	29	26.50	41.20	2.90	0
22	I like being evaluated based on my ongoing collection of completed work rather than relying only on tests.	44.10	41.20	14.70	0	0
23	I like it when my teacher models' different roles and acts as more than just a teacher.	32.40	50.00	14.70	3	0
	Attitude and Aptitude					
26	I like to set personal goals.	32.40	44.10	20.60	3	0
27	I have the potential to achieve my personal goals.	39.40	45.50	12.10	3	0
28	I like being able to have a choice and voice over how I learn.	47.10	47.10	5.90	0	3
29	I like to take responsibility for my success.	55.90	29.40	14.70	0	0
30	I am curious about the world around me and like to learn new things.	50.00	41.20	8.80	0	0
31	I believe that academic success is essential.	55.90	35.30	8.80	0	0
32	My parents expect me to be successful at school.	70.60	29.40	0	0	0
33	I like to win in a competitive environment.	50.00	26.50	23.50	0	0
34	I like to be academically challenged.	35	44.10	18	2.90	0
35	I believe that my ability and confidence grow with my effort.	44.10	38.20	17.60	0	0
36	I believe that my teachers show enthusiasm about the subjects they teach.	29.40	47.10	23.50	0	0
37	I believe that my school is a place where I accepted and valued as part of a community of learners.	38.20	35.30	21	6	0
38	I like working collaboratively in a supportive environment with authentic problems.	41.20	44.10	14.70	0	0
	Attitudes towards Science Education					
39	I like to learn by doing an activity or an experiment rather than by reading about the topic.	50.00	23.50	11.80	11.80	2.90
40	I believe that my science lessons are relevant to my everyday life.	15	44.10	29	11.80	0

41	The science curriculum at my grade level has an appropriate level of difficulty.	20.60	55.90	17.60	5.90	0
42	I believe that science lessons are fun.	23.50	44.10	26.50	5.90	0
43	I am considering a career in a scientific field after I complete my education.	20.60	17.60	29.40	20.60	11.80
	Project-based Learning					
44	PBL is when students work on a project assigned by the teacher to help them learn.	11.80	44.10	44.10	0.00	0
45	PBL is when students choose a project to work on to show that they have learned the lesson.	20.60	32.40	38.20	5.90	3
46	PBL is when students can do a project in place of a test.	32.40	24	35.30	5.90	3
47	PBL is when students learn by investigating an interesting problem presented by the teacher.	21	32.40	41.20	2.90	3
48	PBL is when students learn by investigating a problem with real-life applications.	18	38.20	41.20	0	3

The results of a comparative analysis of pre-study and post-study surveys for questions six through nine (how students learn) have been presented in *Figure 23.* As shown in *Figure* 23 52.6% of students stated a "neutral" position, and zero percent stated a "strongly disagree" position towards learning in a traditional classroom with a teacher directing the learning (question 6). In the Post-study survey, 32.4% of students stated a "neutral" position, and nine percent reported a "strongly disagree" opinion towards learning in a traditional classroom with a teacher directing the learning. Students' opinions about the use of a variety of materials in addition to the textbook to research and learn the information needed did not show significant levels of change based on the data collected from the pre-study and post-study survey (question 7). Students' opinions about gathering information independently and working in collaborative groups instead of the teacher providing the information did not show significant levels of change from the pre-study phase to the post-study period (question 9). In the pre-study step, 21.1% of students strongly agreed, and 36.8% agreed that they learned best by talking and thinking about topics during whole-class discussions (question 8). In the post-study phase, 14.7 of students strongly agreed, and 47.1% of students agreed that they learned best by talking and thinking about topics during whole-class discussions. Despite the shifting of student opinions from one category to another, the data showed that students believed strongly in the value of talking and thinking about topics during whole-class discussions.

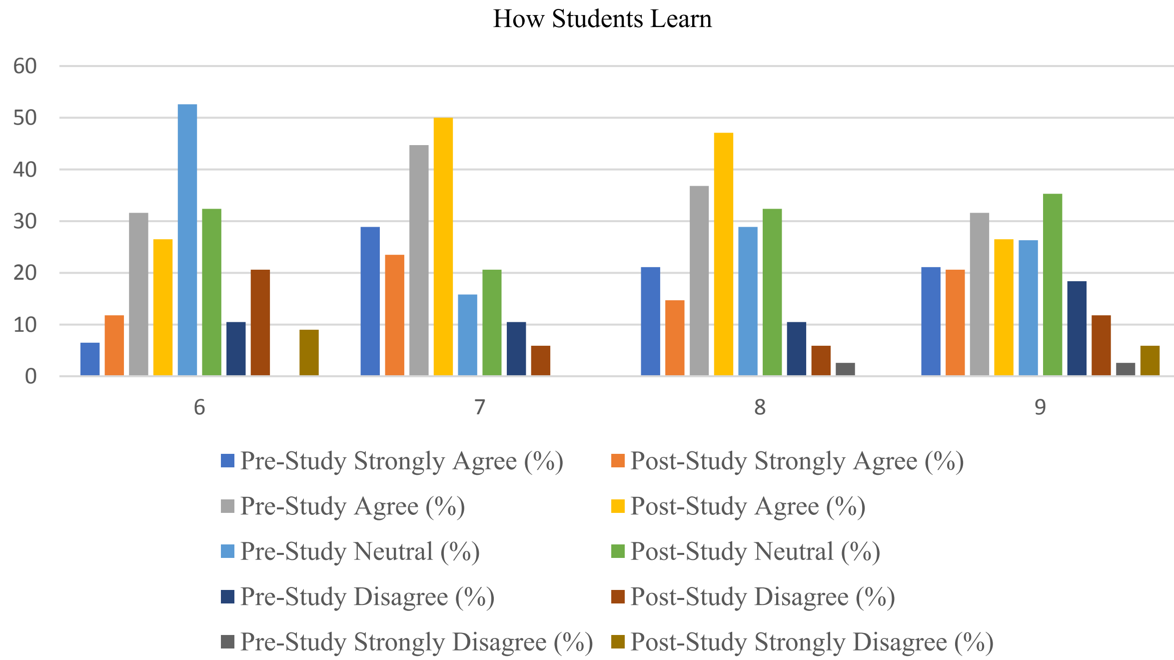


Figure 23. A Comparative Analysis of Pre-study and Post-study Surveys for Question Six Through Nine (How Students Learn)

The results of a comparative analysis of pre-study and post-study surveys for questions 10 through 13 (Use of Technology) has been presented in *Figure 24.* As shown in *Figure 24.* in the pre-study phase, 71.1% of students strongly agreed that they were comfortable using an iPad, a laptop computer, and an iPhone (question 10). In the post-study phase, 58.8 of students strongly agreed that they were comfortable using an iPad, a laptop computer, and an iPhone. Despite the shifting of student opinions from one category to another, the data showed the students believed that they were comfortable using an iPad, a laptop computer, and an iPhone.

Students' opinions did not show the significant change between the pre-study and post-study phase with regards to liking to use digital devices in the classroom (question 11). Despite the shifting of student opinions from strongly agree to agree between the pre-study and the post-study phase, the data showed the students believed that they learned more when using their digital devices in the classroom (question 12). In the post-study phase, zero percent of students strongly agreed, and 8.8% of students strongly disagreed that the use of technology in the classroom is a distraction, thus showing that students did not consider the use of technology to be a distraction in the classroom (question 13).

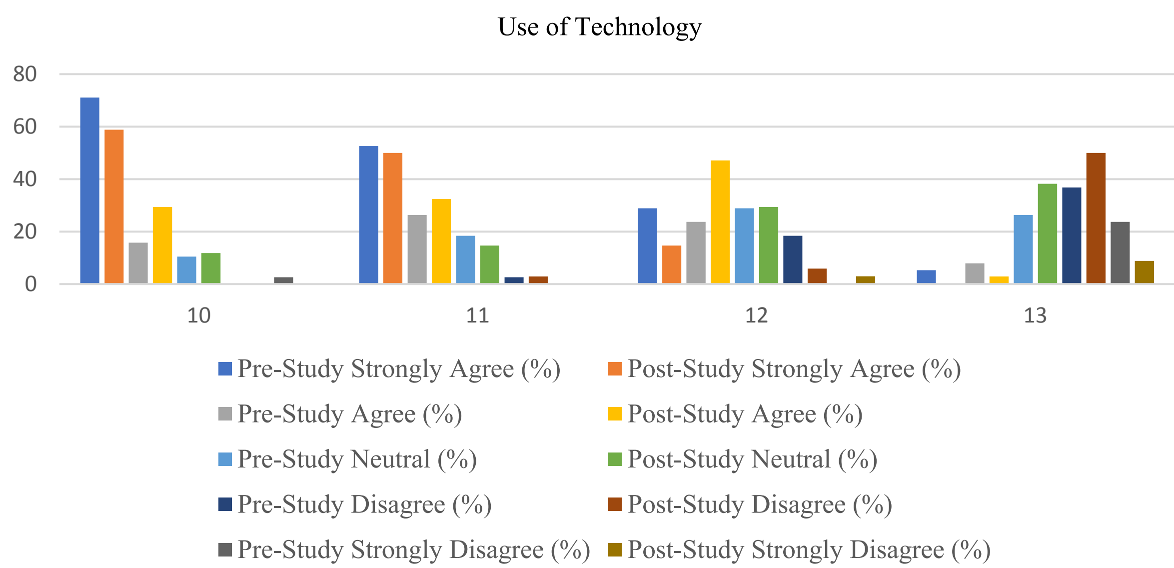


Figure 24. A Comparative Analysis of Pre-study and Post-study Surveys for Question 10 Through 13 (Use of Technology)

The results of a comparative analysis of pre-study and post-study surveys for questions 14 through 23 (working in collaborative groups and assessment) has been presented in *Figure 25*. As shown in *Figure 25*, the data collected showed that despite the shifting of student opinions from one category to another, the students liked working in collaborative groups (question 14) with jobs and responsibilities (question 15). Data for question 16 showed that students agreed that the completion of a successful group project required the participation of all group members. Despite the shifting of student opinions from strongly agree to agree between the pre-study and the post-study phase, the data showed the students liked working towards creating a final product in class that demonstrated proficiency in the concepts learned. Data for questions 18 and 19 show that students enjoy doing hands-on activities that allow them to go beyond the classroom and gain real-world experience. Data collected for question 20 showed that in the post-study phase most students were either neutral (29.4%), disagreed (26.5%) or strongly disagreed (11.8%) with the idea of writing and reflecting about the projects as the means of further learning. Data for question 21 showed that although many students liked receiving short lessons from the teacher based on their needs, most students (41.2%) were neutral in the post-study phase. Data collected for question 22 indicated that despite the shifting of student opinions from one category to another, overall, students liked being evaluated based on their ongoing collection of completed work rather than relying only on tests. Data for question 23 indicated that most of the students either strongly agreed or agreed that they liked having the teacher model different roles and act as more than just a teacher.

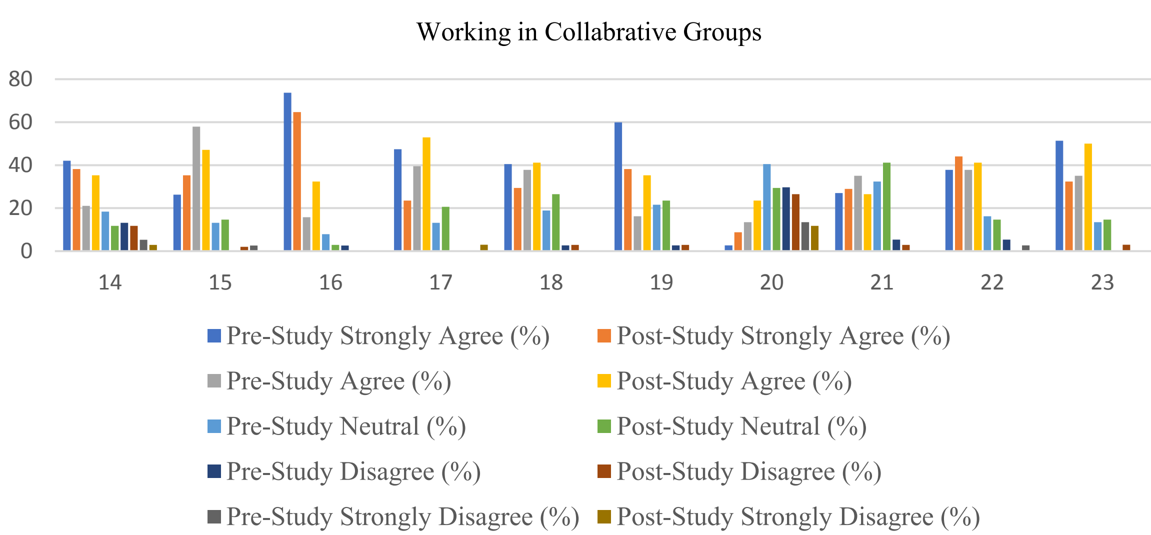


Figure 25. A Comparative Analysis of Pre-study and Post-study Surveys for Question 14 Through 23 (Working in Collaborative Groups & Assessment)

The results of a comparative analysis of pre-study and post-study surveys for questions 26 through 38 (attitude and aptitude) have been presented in *Figure 26*. As shown in *Figure 26,* the data collected for questions 26 through 31 do not show significant changes between the pre-study and the post-study phase. The data collected showed despite the shifting of student opinions from one category to another, the students liked to set personal goals (question 26) because they have the potential to achieve their goals (question 27). Data for question 28 & 29 showed that students agreed that they like having a voice and choice and taking responsibility for their learning and success. Data for questions 30 and 31 showed that students were generally curious about the world around them and believed that academic success was critical. Most students strongly agreed (pre-study= 89.2 and post-study=70.6) that their parents expected them to be successful in school. Data for questions 33 and 34 show that students like to work in a competitive environment that was academically challenging.

Furthermore, students indicated that their ability and confidence grew proportional to their effort (question 35). Most students either strongly agreed (48.6) in the pre-study phase and agreed (47.1%) in the post-study phase that their teachers were enthusiastic about the subjects they taught (question 36). The data for questions 37 and 38 showed that students believed that their school was a safe and supportive community of learners where they could work collaboratively with authentic problems.

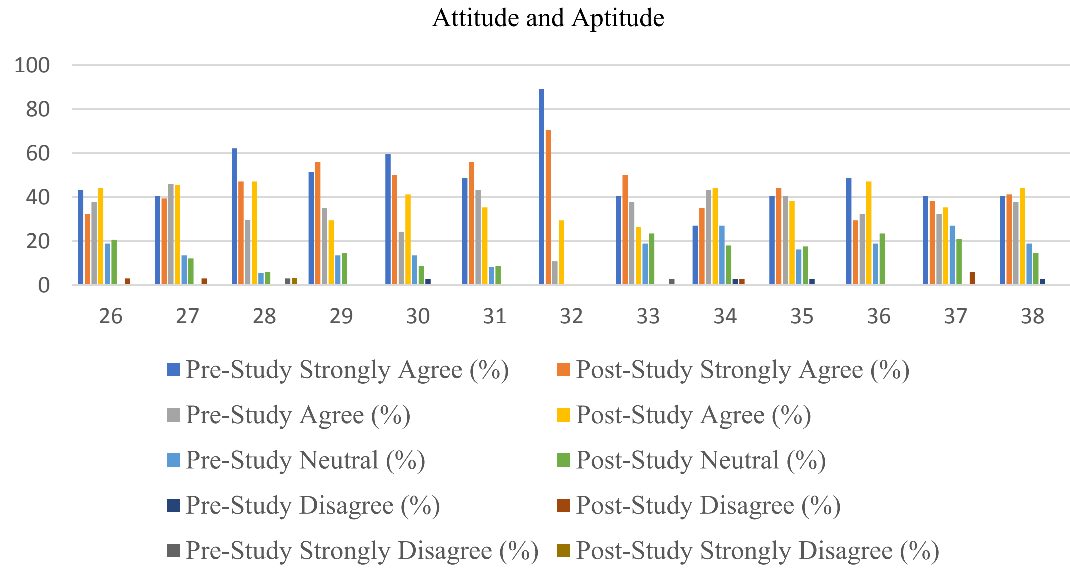


Figure 26. A Comparative Analysis of Pre-study and Post-study Surveys for Question 26 Through 38 (Attitude and Aptitude)

The results of a comparative analysis of pre-study and post-study surveys for questions 39 through 43 (attitudes towards science education) has been shown in *Figure 27*. As shown in *Figure 27*, the data collected for questions 39 showed that most of the students (70.3% pre-study and 50% post-study) strongly agreed that they liked to learn by doing an activity or an experiment rather than by reading about the topic. Most students strongly agreed or agreed that their science lessons were relevant to everyday life and had the appropriate level of difficulty (questions 40 and 41). Most students either strongly agreed or agreed that science lessons were fun (question 42). Most students were neutral about considering scientific careers in the future (Question 43).

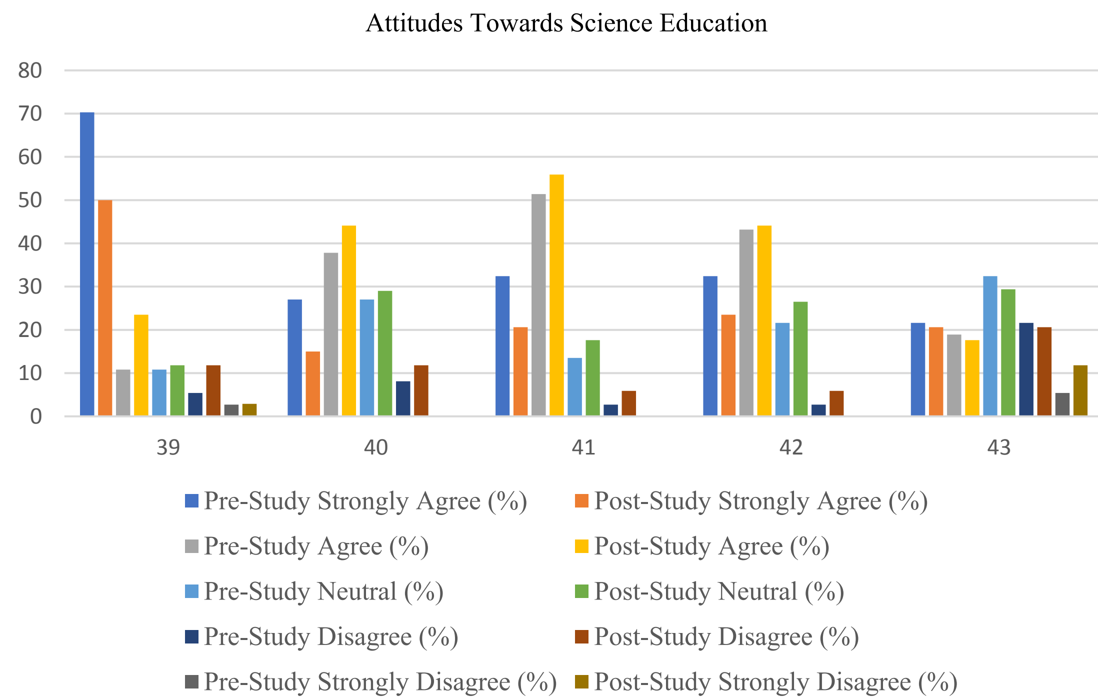


Figure 27. A Comparative Analysis of Pre-study and Post-study Surveys for Question 39 Through 43 (Attitudes towards Science Education)

The results of a comparative analysis of pre-study and post-study surveys for questions 44 through 48 (project-based learning) have been presented in *Figure 28*. As shown in *Figure 28,* the data collected for questions 44 showed that most of the students either agreed (pre-study=32.4 and post-study=44.1) or were neutral (pre-study=45.9 and post-study=44.1) about the definition of PBL as presented in the question (PBL is when students work on a project assigned by the teacher to help them learn). The data collected for question 45 showed that most of the students were neutral (pre-study= 43.2 and post-study=38.2) about PBL being "when students choose a project to work on to show that they have learned the lesson." Despite the shifting of student opinions from between the pre-study and the post-study phase, the data showed that overall, students thought that PBL was "when students can do a project in place of a test," as stated in question 46. Furthermore, students believed that PBL was "when students learn by investigating an interesting problem presented by the teacher" (question 47). Additionally, students believed that PBL was "when students learn by investigating a problem with real-life applications" (question 48).

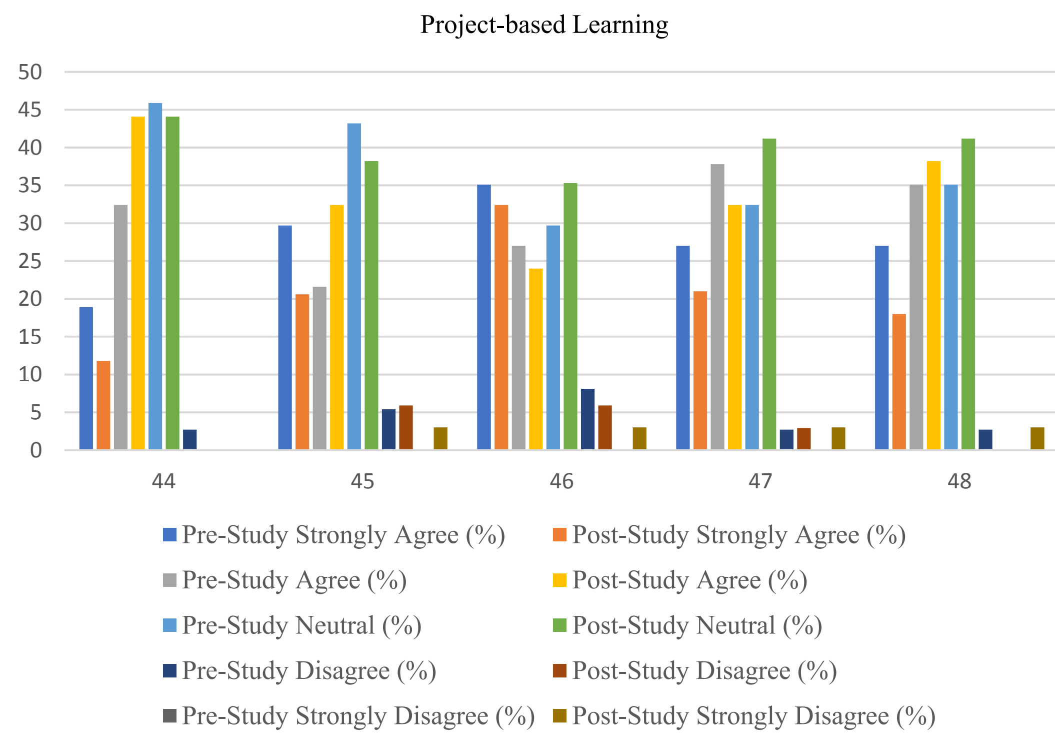


Figure 28. A Comparative Analysis of Pre-study and Post-study Surveys for Question 44 Through 48 (Project-based Learning)

A summary of the teacher participant survey results has been presented in Table 14. It is important to note that all survey respondents were teachers in grades 9-12 despite all 161 teachers (K-12) in the organization having been invited to participate in the survey.

Table 14

Teacher Participant Survey (N=12) Summary

Question	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Perceptions and Attitudes Towards Collaborative Work					
8. I like to use complex tasks with multiple solutions.	41.66	8.33	33.33	8.33	8.33
9. I like to teach in a class in which students execute experiments or complete projects.	50	25	16.66	8.33	0
10. I like to assign group work that encourages discussion.	66.66	25	8.33	0	0

11. I like to use activities that encourage students to reflect on their learning.	83.33	16.66	0	0	0
12. I like to use a variety of teaching materials in addition to the textbook.	100	0	0	0	0
13. I like to have my students go beyond the classroom to gain real-life, hands-on experience.	66.66	25	8.33	0	0
14. I believe that students gain insight by doing experiments and hands-on activities.	66.66	33.33	0	0	0
15. I believe that working in groups helps students to develop their social skills.	58.33	33.33	8.33	0	0
16. It is challenging to assess group projects and determine if everyone has contributed and participated in the project completion.	8.33	33.33	16.66	41.66	0
Understanding of Students' Learning Style					
19. Students learn best in a traditional classroom with a teacher directing the learning.	8.33	25	25	33.33	8.33
20. Students learn best when allowed to use a variety of materials in addition to the textbook to research and learn the information they need to know about the subject.	66.66	25	8.33	0	0
21. Students learn best by talking and thinking about topics during whole-class discussions.	8.33	66.66	25	0	0
22. Students learn best when they gather the information themselves working in collaborative groups instead of a teacher just giving the information.	33.33	0	50	16.66	0
Use of Technology in the Classroom					
23. I am comfortable using an iPad, a laptop computer, and an iPhone.	75	16.66	8.33	0	0
24. I like using personal digital devices in the classroom.	33.33	16.66	41.66	8.33	0
25. I believe that students learn more when they use personal digital devices in the classroom.	16.66	25	33.33	0	25
26. I believe that students' understanding increases when allowed to link technological, mathematical & scientific concepts.	16.66	50	33.33	0	0
Use of PBL in the Classroom					
28. I am familiar with the project-based learning pedagogy.	16.66	41.66	41.66	0	0
29. I have implemented projects in my classroom.	58.33	33.33	8.33	0	0
30. I am skilled at searching for projects to use in my classroom.	41.66	16.66	33.33	8.33	0
31. I am confident in my ability to design effective and engaging projects.	41.66	33.33	8.33	16.66	0
32. I like it when my students produce a final product that demonstrates an understanding of the concepts taught.	75	16.66	8.33	0	0
33. I think that technology-integrated PBL contributes to student learning.	25	66.66	8.33	0	0
34. I am motivated to implement technology-integrated PBL in my classroom.	16.66	33.33	50	0	0

Role of Administrative Support for Teachers					
36. Administrative support is imperative to the implementation of innovative teaching strategies such as technology-integrated PBL in my classroom.	25	58.33	16.66	0	0
37. The administrators at my school site have always supported my decisions and role as an educator.	58.33	41.66	0	0	0
38. The administrators at my school site make me feel like I am making a difference.	58.33	41.66	0	0	0
39. The administrators at my school site are interested in my professional development and give me opportunities to grow.	50	50	0	0	0
40. I receive constructive feedback about my work from my school site administrators.	33.33	50	16.66	0	0
41. I can easily access my administrators to discuss problems and concerns.	41.66	58.33	0	0	0
42. My school site administrators ensure that I have adequate planning time.	33.33	41.66	16.66	0	8.33
43. My school site administrators encourage the use of innovative teaching strategies to engage students better.	41.66	50	8.33	0	0
44. My administrators make sure that I have space, time, and equipment I need to plan and teach.	58.33	41.66	0	0	0

A summary of the administrator participant survey Likert question results has been presented in Table 15. The teacher vs. administrator level of interest in learning about the implementation of PBL results has been shown in Table 16.

Table 15

Administrator Participant Survey (N=3) Summary

Question	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Perceptions and Attitudes Towards Collaborative Work					
8. I like to see teachers use complex tasks with multiple solutions	66.66	33.33	0	0	0
9. I like classes in which students execute experiments or complete projects.	100	0	0	0	0
10. I like group work that encourages discussion.	100	0	0	0	0
11. I like activities that encourage students to reflect on their learning.	100	0	0	0	0
12. I like to see teachers use a variety of teaching materials in addition to the textbook.	100	0	0	0	0
13. I like to have students go beyond the classroom to gain real-life, hands-on experience.	66.66	0	33.33	0	0

14. I believe that students gain insight by doing experiments and hands-on activities.	66.66	33.33	0	0	0
15. I believe that working in groups helps students to develop their social skills.	100	0	0	0	0
16. It is challenging to assess group projects and determine if everyone has contributed and participated in the project completion.	0	33.33	33.33	33.33	0
Understanding of Students' Learning Style					
19. Students learn best in a traditional classroom with a teacher directing the learning.	33.33	0	66.66	0	0
20. Students learn best when allowed to use a variety of materials in addition to the textbook to research and learn the information they need to know about the subject.	33.33	66.66	0	0	0
21. Students learn best by talking and thinking about topics during whole-class discussions.	33.33	33.33	33.33	0	0
22. Students learn best when they gather the information themselves working in collaborative groups instead of a teacher just giving the information.	33.33	33.33	33.33	0	0
Use of Technology in the Classroom					
23. I am comfortable using an iPad, a laptop computer, and an iPhone.	66.66	33.33	0	0	0
24. I like to see teachers and students using personal digital devices in the classroom.	33.33	66.66	0	0	0
25. I believe that students learn more when they use personal digital devices in the classroom.	33.33	0	66.66	0	0
26. I believe that students' understanding increases when allowed to link technological, mathematical & scientific concepts.	33.33	66.66	0	0	0
Use of PBL in the Classroom					
28. I am familiar with the project-based learning pedagogy.	0	66.66	33.33	0	0
29. I have previously personally implemented projects in a classroom.	33.33	33.33	33.33	0	0
30. I am personally skilled at searching for projects to use in the classroom.	0	66.66	33.33	0	0
31. I am confident in my ability to help teachers design effective and engaging projects.	0	66.66	33.33	0	0
32. I like a student-generated final product that demonstrates an understanding of the concepts taught.	66.66	33.33	0	0	0
33. I think that technology-integrated PBL contributes to student learning.	33.33	66.66	0	0	0
34. I would like to see teachers implement technology-integrated PBL in the classroom.	33.33	66.66	0	0	0
Role of Administrative Support in the Classroom					
36. Administrative support is imperative to the implementation of innovative teaching strategies such as technology-integrated PBL in the classroom.	66.66	0	33.33	0	0
37. I have always supported the teacher's decisions and role as an educator.	100	0	0	0	0
38. I believe that educators at my school site make a difference.	100	0	0	0	0

39. I strive to provide teachers with opportunities for growth and professional development.	66.66	0	33.33	0	0
40. I routinely provide constructive feedback to my staff.	33.33	33.33	33.33	0	0
41. Teachers and staff can easily reach me as needed.	66.66	33.33	0	0	0
42. I actively engage with my staff to ensure that they have adequate planning time.	33.33	33.33	0	33.33	0
43. I encourage the use of innovative teaching strategies to engage students better.	33.33	66.66	0	0	0

Table 16

Teacher vs. Administrator Level of Interest in Learning About Implementation of PBL

Question	Teacher		Administrators	
	Yes	No	Yes	No
35. I would be interested in learning more about how I could implement technology-integrated PBL in my classroom using the existing curriculum.	83.33	16.66	100	0

Comparative analysis of data collected from the surveys administered to the teachers and administrators (Tables 14 and 15) has been presented in Table 17. Comparison of data generated by the students' pre-study and post-study survey (Tables 12 and 13) and the teacher and administrators' surveys (Tables 14 and 15) has been shown in Table 18.

As shown in Table 17, 99.99% of administrators responding to the survey either strongly agreed or agreed that they liked to see teachers use more complex tasks in the classroom, whereas only 49.99% of teachers agreed with them. The survey results showed that 99.99% of administrators were motivated to implement technology-integrated PBL in the classroom, whereas 49.99% of teachers agreed with them. As shown in Table 18, an average of 30.9% of students either strongly agreed or agreed that they learned more when they used their digital devices as opposed to 18.74 of teachers and administers who agreed with them.

Table 17

Comparative Analysis of Teachers vs. Administrators

	Teachers	**Administrators**
	Strongly Agreed or Agreed (%)	**Strongly Agreed or Agreed (%)**
Liked to use complex tasks with multiple solutions in their classroom.	49.99	99.99
I liked to use a variety of teaching materials in addition to the textbook.	100	100
Challenging to assess group projects and determine if everyone has contributed and participated in the project completion.	41.63	33.33
They were familiar with project-based learning pedagogy.	58.32	66
They had implemented projects in their classrooms.	99	66
They were skilled in searching for projects to use in the classroom.	58.32	66
They were motivated to implement technology integrated PBL in the classroom.	49.99	99.99
Administrative support is imperative to the implementation of innovative teaching strategies such as technology-integrated PBL in my classroom.	83.3	66
The school site administrators support educators.	99	100
The school site administrators believe that teachers make a difference.	99	100
The school site administrators are interested in their professional development and provide them with adequate opportunities.	100	66
They were provided with constructive feedback about their work.	83.3	66.66
They have adequate planning time.	74.99	66.66
They were encouraged to use innovative teaching strategies to engage students better	91.66	99.99
They had adequate space, time, and equipment needed to plan and teach.	99.99	NA

Table 18

Comparison of the Average Percent Value for Strongly Agree and Agree in Students, Teachers, and Administrators Surveys

The questions in the Teacher and Administrator Survey	**Average of Total Scores (%) for Strongly Agree and Agree (Teacher and Administrator Survey)**	**The questions in the Student Survey**	**Average of Total Scores (%) for Strongly Agree and Agree (Students)**
19. Students learn best in a traditional classroom with a teacher directing the learning.	16.66	6. I learn best in a traditional classroom with a teacher directing the learning.	19.15
20. Students learn best when allowed to use a variety of materials in addition to the textbook to research and learn the information they need to know about the subject.	47.91	7. I learn best when allowed to use a variety of materials in addition to the textbook to research and learn the information I need to know about the subject.	36.75

21. Students learn best by talking and thinking about topics during whole-class discussions.	35.41	8. I learn best by talking and thinking about topics during whole-class discussions.	30.9
22. Students learn best when they gather the information themselves working in collaborative groups instead of a teacher just giving the information.	24.99	9. I learn best when I can gather the information myself working in collaborative groups instead of a teacher just giving the information.	23.55
23. I am comfortable using an iPad, a laptop computer, and an iPhone.	47.91	10. I am comfortable using an iPad, a laptop computer, and an iPhone.	44.1
24. I like using personal digital devices in the classroom.	37.49	11. I like using personal digital devices in the classroom.	38.7
25. I believe that students learn more when they use personal digital devices in the classroom.	18.74	12. I learn more when I use personal digital devices in the classroom.	30.9
10. I like to assign group work that encourages discussion.	47.91	14. I like working in groups.	36.75
15. I believe that working in groups helps students to develop their social skills.	47.91	15. I like having jobs & responsibilities as part of working with a small group.	41.2
32. I like it when my students produce a final product that demonstrates an understanding of the concepts taught.	47.91	17. I like working towards creating a final product in class to show I have mastered the concepts studied.	38.2
13. I like to have my students go beyond the classroom to gain real-life, hands-on experience.	39.58	19. I like going beyond the classroom to gain real-life experience and do hands-on activities.	36.75

Criterion-Referenced Tests

Sixth-grade. Criterion-referenced tests were considered ordinal data as indicators of the students' performance. Diagnostic (pretest) and benchmark (posttest) sixth-grade results for chapters one to five have been presented in Table 19, shown below. The data has been presented in both the actual raw score as well as the percentage of the total number of points represented.

Table 19

Sixth-grade Criterion-referenced Diagnostic and Benchmark Tests

Participant Code	Diagnostic test Ch 1-5	Diagnostic test Ch 1-5 Split-Half	Diagnostic test Ch 1-5 (%)	Benchmark Test Ch.1-5	Benchmark Test Ch.1-5 Split Half	Benchmark Test Ch 1-5 (%)
NA6F1	19	19	63	32		80
NA6M2	19		63	32	32	80
KC6M3	22	22	73	33.5		83
RD6M4	19		63	32	32	80
SK6M5	21	21	70	32.5		81
HP6M6	22		73	37.5	37.5	93
NP6M7	20	20	66	31		77
MR6M8	19		63	27	27	67
AS6F9	20	20	66	35.5		88
IS6F10	23		76	29.5	29.5	73
AT6F11	19	19	63	34		85
SV6F12	19		63	28.5	28.5	71
SA6F13	13	13	43	32		80
AH6M14	23		76	32	32	80
AN6F15	16	16	53	29.5		73
ST6F16	18		60	25	25	62

The descriptive data analysis results for the sixth-grade criterion-referenced diagnostic test has been presented in Table 20 According to the data analysis, most of the non-normally distributed (*Figure 29*) sample (SD= 8.452810184) scores fell to the right of the center (Mdn=63, skewness= -0.949860594) with a skinny-tailed distribution (Kurtosis = 1.787350752).

Table 20

Descriptive Data Analysis Results for Sixth-grade Diagnostic Test Ch 1-5 (%)

Sixth-grade Diagnostic Test Ch 1-5 (%)	
Mean	64.625
Standard Error	2.113202546
Median	63
Mode	63
Standard Deviation	8.452810184
Sample Variance	71.45
Kurtosis	1.787350752
Skewness	-0.949860594
Range	33
Minimum	43
Maximum	76
Sum	1034
Count	16
Largest (1)	76
Smallest (1)	43
Confidence Level (95.0%)	4.504184606

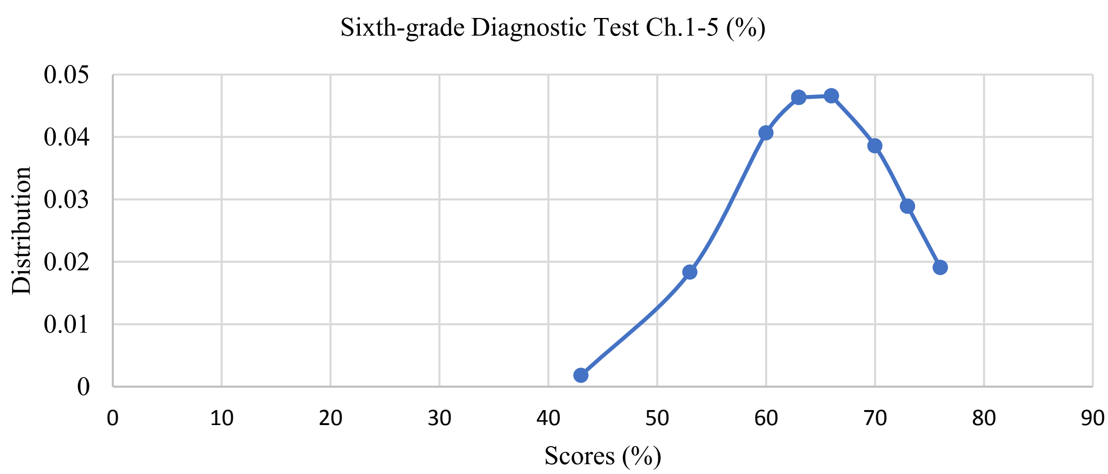


Figure 29. Sixth-grade Diagnostic Test (Ch.1-5)

The descriptive data analysis results for the sixth-grade criterion-referenced benchmark test has been presented in Table 21 According to the data analysis, most of the non-normally distributed (*Figure 30*) sample (SD= 7.760745239) scores fell to the right of the center (Mdn=80, skewness = -0.319231192) with a skinny-tailed distribution (Kurtosis = 0.398984701).

Table 21

Descriptive Data Analysis Results for Sixth-grade Benchmark Test Ch 1-5 (%)

Sixth-grade Benchmark Test Chapter 1-5 (%)	
Mean	78.3125
Standard Error	1.94018631
Median	80
Mode	80
Standard Deviation	7.760745239
Sample Variance	60.22916667
Kurtosis	0.398984701
Skewness	-0.319231192
Range	31
Minimum	62
Maximum	93
Sum	1253
Count	16
Largest (1)	93
Smallest (1)	62
Confidence Level (95.0%)	4.135409228

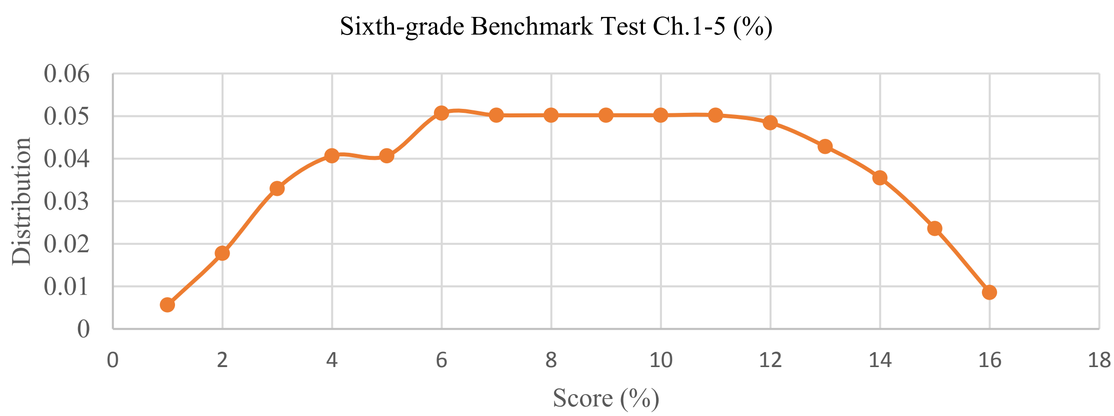


Figure 30. Sixth-grade Benchmark Test (Ch.1-5)

A comparative analysis of the results of diagnostic and benchmark tests showed that ninety-four percent (15 out of 16) of the participants demonstrated measurable gains, as shown in *Figure 31* below. Participant ST6F16 demonstrated a positive gain of two percentage points.

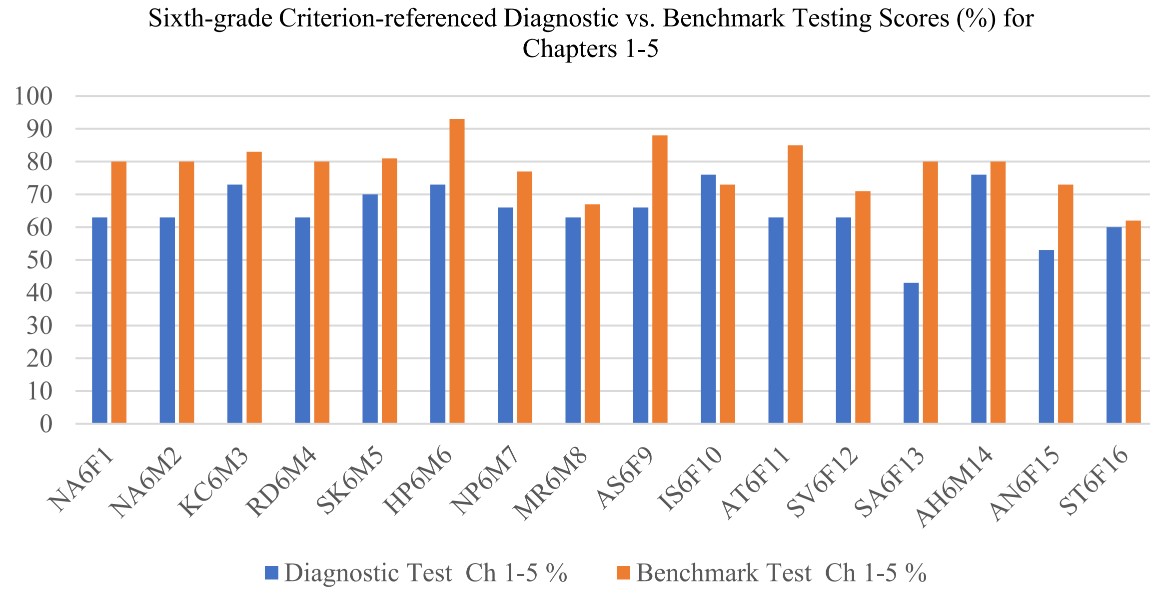


Figure 31. Sixth-grade Diagnostic and Benchmark Criterion-referenced Testing Scores(%)

The sixth-grade criterion-referenced diagnostic and benchmark test results were further analyzed using the Wilcoxon Signed-Rank Test. Because of the small sample size (n=16), the data analysis for the evaluation of the hypothesis required the use of the W-value. The results of the Wilcoxon Signed-Rank test (Table 22) for diagnostic and benchmark tests indicate that the test results were significant at $p < 0.05$.

Table 22

Sixth-grade Wilcoxonon Signed-Rank Test for Diagnostic and Benchmark Tests

W-value	2
Mean Difference	-15.38
Sum of positive ranks	2
Sum of negative ranks	134
Mean (*W*)	68
Standard Deviation (*W*)	19.34
Sample Size (*N*)	16

The value of W is 2. The critical value for W at $N = 16$ ($p < .05$) is 23.
The result is significant at $p < .05$.

A comparative analysis was conducted (Table 23) between the results of the sixth-grade diagnostic and benchmark test using the Spearman Rho non-parametric test showed that the association between the two variables (r=0.39742) was not considered statistically significant.

Table 23

Sixth-grade Spearman Rho Test for Diagnostic and Benchmark Tests

X Ranks Mean	8.5
X Ranks Standard Deviation	4.63
Y Ranks Mean	8.5
Y Ranks Standard Deviation	4.69
Combined	
Covariance = 129.25 / 15 = 8.62	
R = 8.62 / (4.63 * 4.69) = 0.397	
r_s = 0.39742, p (2-tailed) = 0.12743.	
By normal standards, the association between the two variables would not be considered statistically significant.	

The sixth-grade Introducing the Earth pretest and posttest results have been presented in Table 24. The data has been presented in both the actual raw score as well as the percentage of the total number of points represented.

Table 24

Sixth-grade Criterion-Referenced Pretests and Posttests (Introducing the Earth)

Participant Code	Introducing Earth-Pre test	Introducing Earth-Pretest Split-half Reliability	Introducing Earth-Pretest (%)	Introducing Earth-Post test	Introducing Earth-Post-Split-half Reliability	Introducing Earth-Post (%)
NA6F1	8		62	10		100
NA6M2	6	6	46	10	10	100
KC6M3	10		77	10		100
RD6M4	7	7	54	10	10	100
SK6M5	10		77	9		90
HP6M6	10	10	77	10	10	100
NP6M7	8		62	10		10
MR6M8	6	6	46	7	7	70
AS6F9	9		69	9		90
IS6F10	9	9	69	10	10	100
AT6F11	6		46	10		100
SV6F12	6	6	46	10	10	100
SA6F13	8		62	6		60
AH6M14	6	6	46	7	7	70
AN6F15	7		54	7		70
ST6F16	6	6	46	7	7	70

The descriptive data analysis results for the sixth-grade criterion-referenced Introducing, the Earth pretest, has been presented in Table 25 According to the data analysis, most of the non-normally distributed (*Figure 32*) sample (SD= 12.27853819) scores fell to the left of the center (Mdn=58, skewness = 0.340200022) with a skinny-tailed distribution (Kurtosis = -1.443433103).

Table 25

Sixth-grade Criterion-referenced Introducing the Earth Pretest

Sixth-grade Introducing the Earth Pretest (%)	
Mean	58.6875
Standard Error	3.069634547
Median	58
Mode	46
Standard Deviation	12.27853819
Sample Variance	150.7625
Kurtosis	-1.443433103
Skewness	0.340200022
Range	31
Minimum	46
Maximum	77
Sum	939
Count	16
Largest (1)	77
Smallest (1)	46
Confidence Level (95.0%)	6.542771159

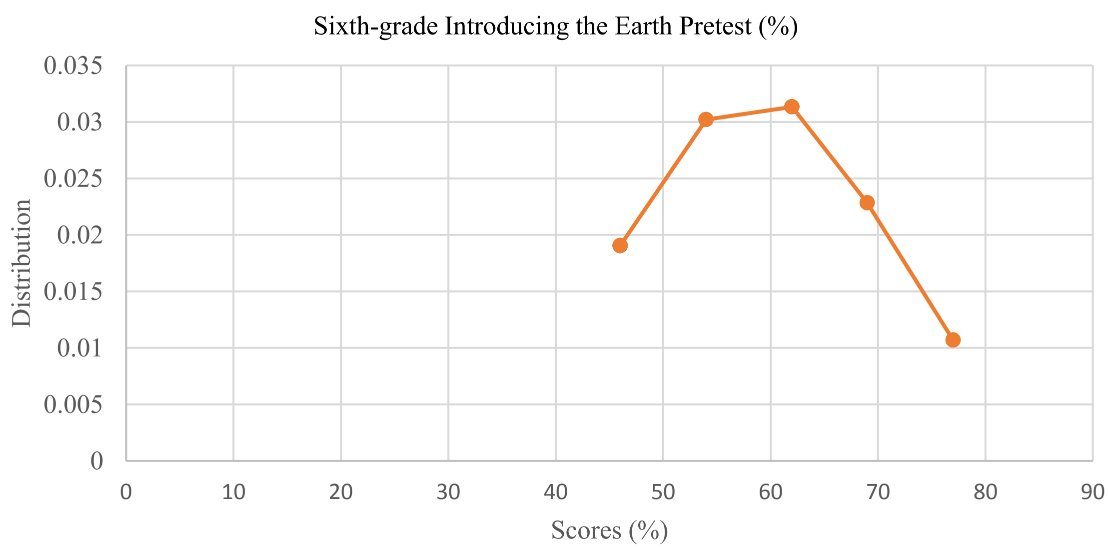


Figure 32. Sixth-grade Criterion-referenced Introducing the Earth Pretest

The descriptive data analysis results for the sixth-grade criterion-referenced Introducing the Earth posttest has been presented in Table 26. According to the data analysis, most of the non-normally distributed (*Figure 33*) sample (SD= 24.418231) scores fell to the right of the center (Mdn=95, skewness = -1.9537001) with a fat-tailed distribution (Kurtosis = 4.6010104).

Table 26

Sixth-grade Criterion-referenced Introducing the Earth posttest

Sixth-grade Introducing the Earth Posttest (%)	
Mean	83.125
Standard Error	6.1045577
Median	95
Mode	100
Standard Deviation	24.418231
Sample Variance	596.25
Kurtosis	4.6010104
Skewness	-1.9537001
Range	90
Minimum	10
Maximum	100
Sum	1330
Count	16
Largest (1)	100
Smallest (1)	10
Confidence Level (95.0%)	13.011557

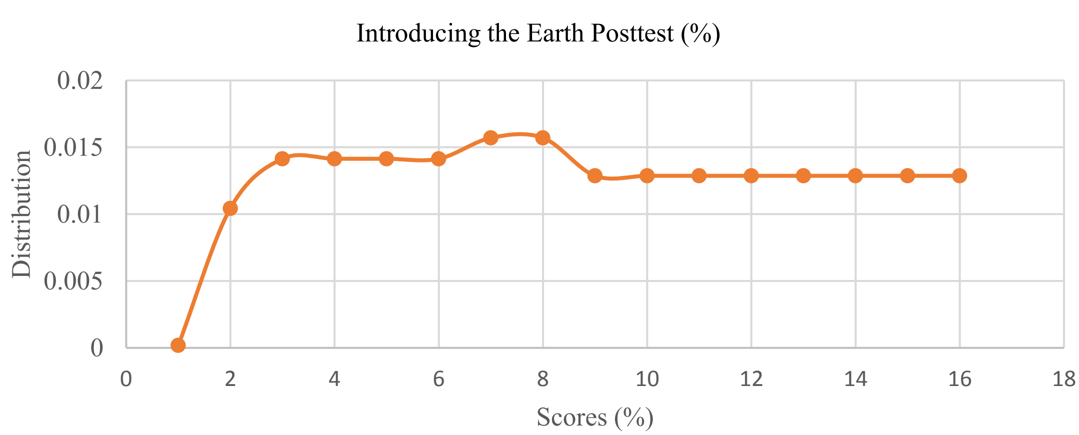


Figure 33. Sixth-grade Criterion-referenced Introducing the Earth Posttest

A comparative analysis of the results of Introducing the Earth pretest and posttest showed that eighty-eight percent (14 out of 16) of the participants demonstrated measurable gains, as shown in *Figure 34*. Participant NP6M7 demonstrated a substantial adverse change of 52 percentage points, as seen in *Figure 34,* due to a prolonged absence from school that led to a considerable loss of academic time. Participant SA6F13 demonstrated a negligible negative change of two percentage points.

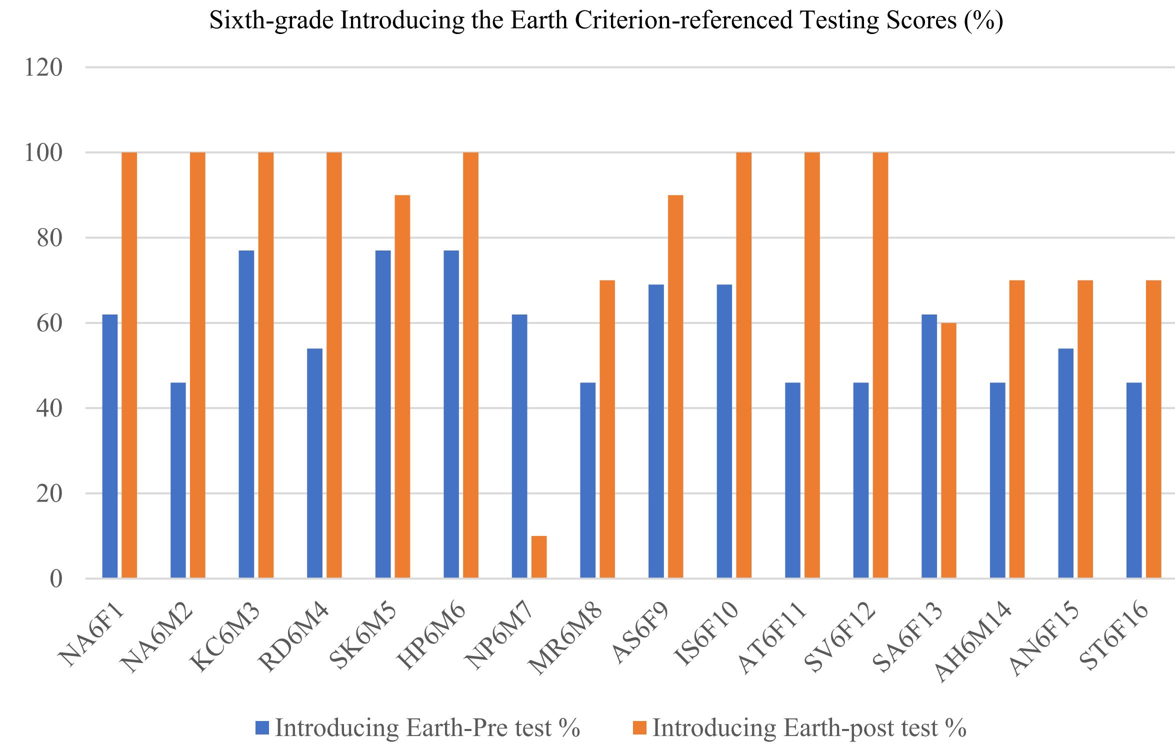


Figure 34. Sixth-grade Introducing the Earth Criterion-referenced Testing Score (%)

Wilcoxon Signed-Rank Test result details for sixth-grade criterion-referenced Introducing the Earth pretest and posttest have been presented in Table 27. The W-value was used to evaluate the hypothesis because of the small sample number (n=16). The results of the Wilcoxon Signed-Rank test (Table 27) for Introducing the Earth criterion-referenced test indicated that the results were significant at $p < 0.05$.

Table 27

Sixth-grade Wilcoxon Signed-Rank Test for Introducing the Earth Criterion-referenced Test

W-value	14
Mean Difference	-41.31
Sum of positive ranks	14
Sum of negative ranks	122
Mean (*W*)	68
Standard Deviation (*W*)	19.34
Sample Size (*N*)	16

The value of *W* is 14. The critical value for *W* at $N = 16$ ($p < .05$) is 23.
The result is significant at $p < .05$.

A comparative analysis of the data was conducted between the results of the sixth-grade Introducing the Earth criterion-referenced test using the Spearman Rho non-parametric test (Table 28) showed that the association between the two variables (r=0.13946) was not considered statistically significant.

Table 28

Sixth-grade Spearman Rho Introducing the Earth Criterion-referenced Test

X Ranks Mean	8.5
X Ranks Standard Deviation	4.6
Y Ranks Mean	8.5
Y Ranks Standard Deviation	4.42

Combined
Covariance = 42.5 / 15 = 2.83
R = 2.83 / (4.6 * 4.42) = 0.139
r_s = 0.13946, p (2-tailed) = 0.60647.
By normal standards, the association between the two variables would not be considered statistically significant.

The sixth-grade Plate Tectonics pretest and posttest results have been presented in Table 29, shown below. The data has been presented in both the actual raw score as well as the percentage of the total number of points represented.

Table 29

Sixth-grade Criterion-referenced Introducing Plate Tectonics Pretests and Posttests

Participant Code	Plate Tectonics Pretest	Plate Tectonics Pretest Split-half Reliability	Plate Tectonics Pretest (%)	Plate Tectonics Posttest	Plate Tectonics Posttest Split-half Reliability	Plate Tectonics Posttest (%)
NA6F1	5		50	6	6	85
NA6M2	4	4	40	6		85
KC6M3	7		70	5	5	71
RD6M4	5	5	50	7		100
SK6M5	6		60	7	7	100
HP6M6	7	7	70	7		100
NP6M7	7		70	6	6	85
MR6M8	4	4	40	6		85
AS6F9	7		70	6	6	85
IS6F10	6	6	60	5		71
AT6F11	6		60	6	6	85
SV6F12	7	7	70	5		71
SA6F13	4		40	6	6	85
AH6M14	8	8	80	5		71
AN6F15	6		60	7	7	100
ST6F16	8	8	80	5		71

The descriptive data analysis results for the sixth-grade criterion-referenced Introducing Plate Tectonics pretest has been presented in Table 30. According to the data analysis, most of the non-normally distributed (*Figure 35*) sample (SD= 13.40087062) scores fell to the right of the center (Mdn=60, skewness = -0.318324615) with a skinny-tailed distribution (Kurtosis = -0.962867861).

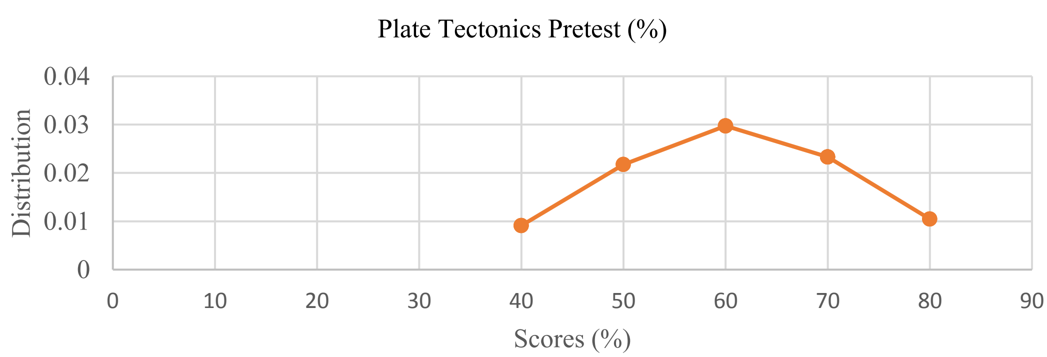


Figure 35. Sixth-grade Criterion-referenced Introducing Plate Tectonics Posttest

Table 30

Sixth-grade Criterion-referenced Introducing Plate Tectonics Posttest

	Plate Tectonics Pretest (%)
Mean	60.625
Standard Error	3.350217655
Median	60
Mode	70
Standard Deviation	13.40087062
Sample Variance	179.5833333
Kurtosis	-0.962867861
Skewness	-0.318324615
Range	40
Minimum	40
Maximum	80
Sum	970
Count	16
Largest (1)	80
Smallest (1)	40
Confidence Level (95.0%)	7.140819897

The descriptive data analysis results for the sixth-grade Introducing Plate Tectonics criterion-referenced posttest has been presented in Table 31. According to the data analysis, most of the non-normally distributed (*Figure 36*) sample (SD= 11.17661) scores fell to the left of the center (Mdn=85, skewness = 0.179934) with a skinny-tailed distribution (Kurtosis = -1.1648).

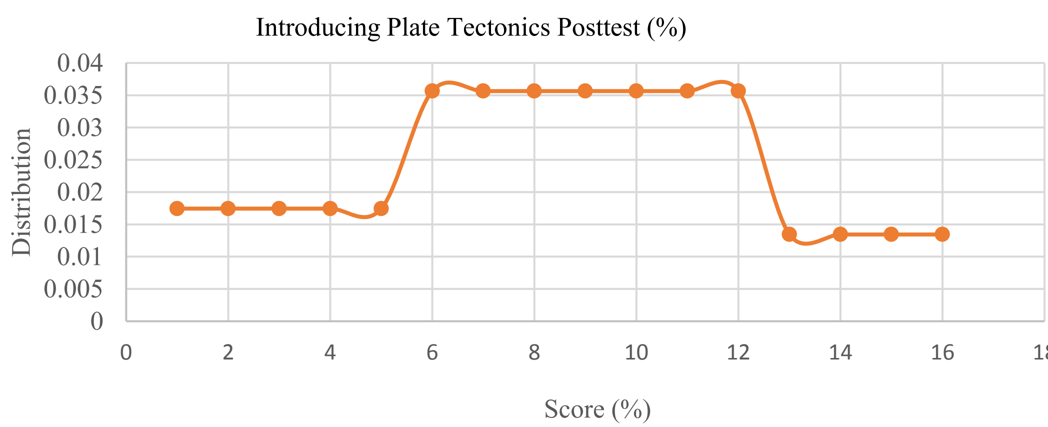


Figure 36. Sixth-grade Criterion-referenced Introducing Plate Tectonics Posttest

Table 31

Sixth-grade Introducing Plate Tectonics Criterion-referenced Posttest

	Introducing Plate Tectonics Posttest (%)
Mean	84.375
Standard Error	2.794153
Median	85
Mode	85
Standard Deviation	11.17661
Sample Variance	124.9167
Kurtosis	-1.1648
Skewness	0.179934
Range	29
Minimum	71
Maximum	100
Sum	1350
Count	16
Largest (1)	100
Smallest (1)	71
Confidence Level (95.0%)	5.955596

A comparative analysis of the results of Plate Tectonics pretest and posttest showed that seventy-five percent (12 out of 16) of the participants demonstrated measurable gains, as shown in *Figure 37* below. Participant SV6F12 demonstrated a negligible positive change of one percentage point, as seen in *Figure 37*. Participant ST6F16 demonstrated a negative adjustment of nine percentage points, as seen in *Figure 37*.

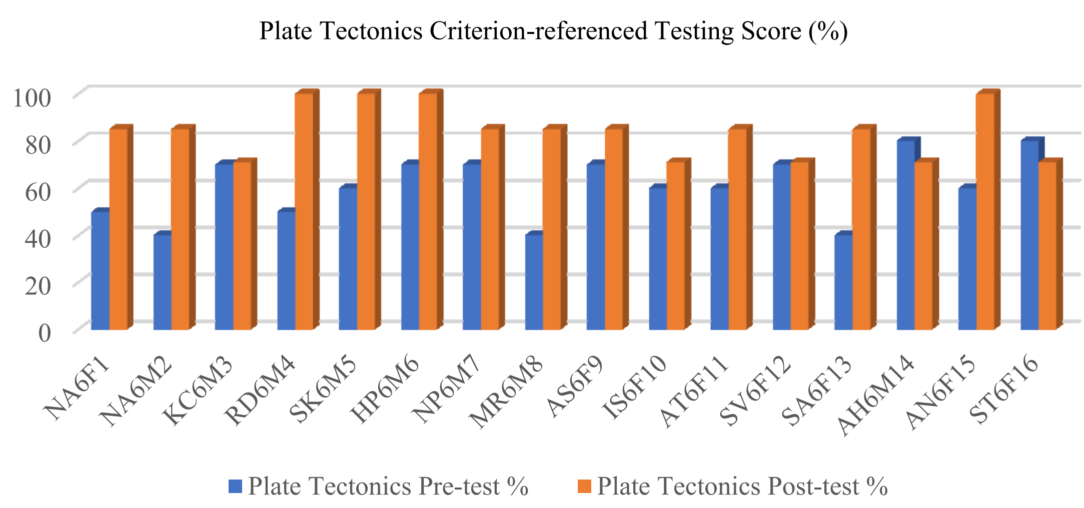


Figure 37. Plate Tectonics Criterion-referenced Testing Score (%)

Wilcoxon Signed-Rank Test results for the sixth-grade criterion-referenced Introducing Plate Tectonics pretest and posttest have been presented in Table 32. Because of the small sample size (N=16), the W-value was used to evaluate the hypothesis. The results of the Wilcoxon Signed-Rank test (Table 32) for Introducing Plate Tectonics tests indicated that the test results were significant at $p < 0.05$.

Table 32

Sixth-grade Wilcoxon Signed-Rank Test for Introducing Plate Tectonics Tests

W-value	7
Mean Difference	-24.38
Sum of positive ranks	7
Sum of negative ranks	129
Mean (*W*)	68
Standard Deviation (*W*)	19.34
Sample Size (*N*)	16

The value of W is 7. The critical value for W at $N = 16$ ($p < .05$) is 23.
The result is significant at $p < .05$.

A comparative results analysis was conducted between the data collected for the sixth-grade Introducing Plate Tectonics test using the Spearman Rho non-parametric test (Table 33) showed that the association between the two variables (r= -0.4325) was not considered statistically significant.

Table 33

Sixth-grade Spearman Rho Test for Introducing Plate Tectonics Tests

X Ranks Mean	8.5
X Ranks Standard Deviation	4.63
Y Ranks Mean	8.5
Y Ranks Standard Deviation	4.45

Combined
Covariance = -133.75 / 15 = -8.92
R = -8.92 / (4.63 * 4.45) = -0.433
$r_s = -0.4325$, p (2-tailed) = 0.09429.
By normal standards, the association between the two variables would not be considered statistically significant.

The sixth-grade Wilcoxon Signed-Rank Test for the criterion-referenced tests showed that the difference between the pretests and posttest were statistically significant at $p < .05$. However, testing results using the Spearman Rho showed that by normal standards, the association between the implementation of PBL and test scores was not considered statistically significant.

The sixth-grade Pangea, Continents Adrift, Plate Tectonics, Rocks and Mineral Identification, and the Rock Cycle project results were presented in Table 34. Students designed and created projects to demonstrate the movement of Tectonic plates through geological time. As part of the Continents Adrift projects, students were asked to use the information they gathered when completing their Pangea projects to predict where the Tectonic plates may move to in the next 1,000,000 years of geological time. Examples of students creating their Pangea and Continents Adrift projects can be seen in *Figure 38*.

Figure 38. Students' Pangea and Continents Adrift Projects

Examples of students creating their Plate Tectonics projects and a sample of a project in progress can be seen in *Figure 39*. Students were expected to design a project with "moving parts" that could demonstrate the causes of Tectonic Plates movements. This particular group chose to create an animation.

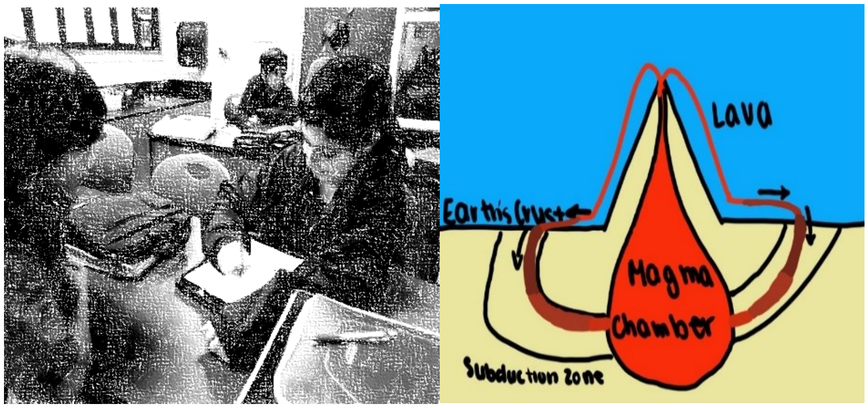


Figure 39. Student's Plate Tectonic Projects

A sample of a student's final Rock Cycle Project presentation has been presented in *Figure 40*. The students were asked to design a project that would allow them to demonstrate their understanding of the Rock Cycle process.

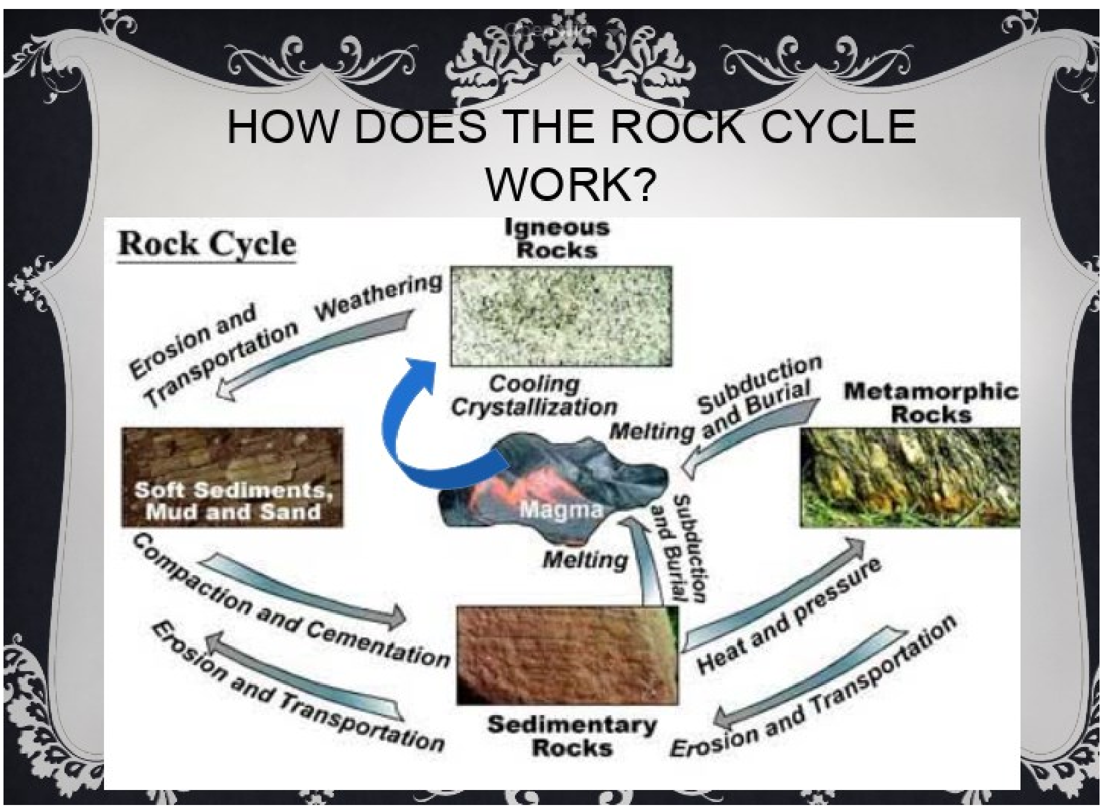


Figure 40. Sample of Student's Final presentation for the Rock Cycle Project

Participant NP6M7 did not complete the documentation needed for the Pangea project and therefore lost points for the Pangea project. Participant NP6M7 was unable to complete and submit the Continents Adrift project (NA*=Not able to submit) due to illness and prolonged absence from school. Participants marked with an asterisk did not submit part of the required documentation for the projects they were working on and therefore lost points. The number of points students lost varied depending on the nature of missing documentation.

Table 34

Sixth-grade PBL Projects Final Assessment Scores

Participant Code	Pangea Project (%)	Continents Adrift (%)	Plate Tectonic Project (%)	Rock and Mineral Identification Projects (%)	Rock Cycle Skits (%)
NA6F1*	100	90	90	100	100
NA6M2*	100	100	86	95	100
KC6M3*	100	90	100	100	100
RD6M4*	100	50	80	95	100
SK6M5*	100	70	86	100	100
HP6M6*	100	90	96	100	100
NP6M7*	80	NA*	70	100	100
MR6M8*	100	80	86	100	100
AS6F9*	100	70	90	95	100
IS6F10*	100	70	76	100	100
AT6F11*	100	80	76	88	100
SV6F12*	100	100	90	100	100
SA6F13	100	100	100	100	100
AH6M14*	100	80	50	100	75
AN6F15*	100	100	50	100	75
ST6F16*	100	70	50	100	100

The descriptive data analysis results for the sixth-grade Pangea project has been presented in Table 35. According to the data analysis, most of the non-normally distributed (*Figure 41*) sample (SD= 5) scores fell to the right of the center (Mdn=100, skewness = -4).

Table 35

Pangea Project

	Pangea Projects %
Mean	98.75
Standard Error	1.25
Median	100
Mode	100
Standard Deviation	5
Sample Variance	25
Kurtosis	16
Skewness	-4
Range	20
Minimum	80
Maximum	100
Sum	1580
Count	16
Largest (1)	100
Smallest (1)	80
Confidence Level (95.0%)	2.664311932

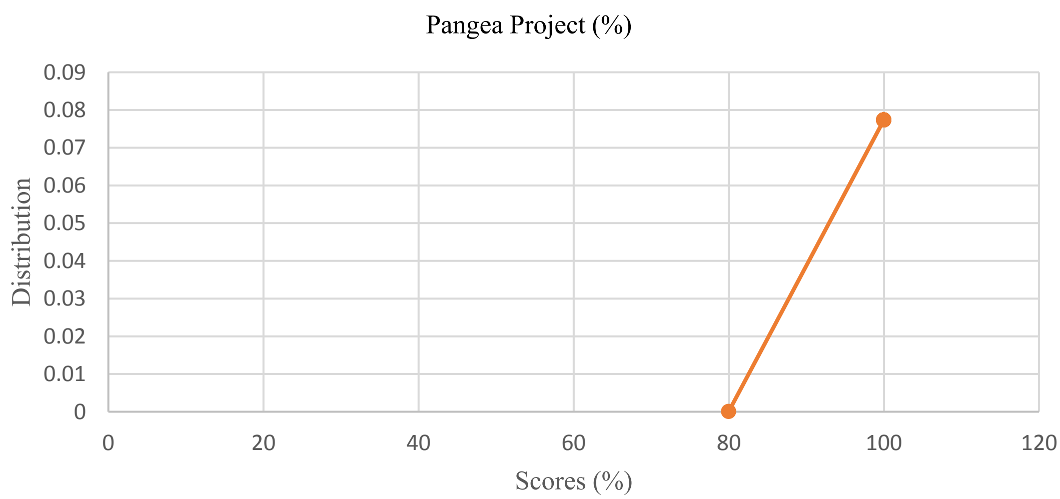


Figure 41. Pangea Project

The descriptive data analysis results for the sixth-grade Continents Adrift project has been presented in Table 36. According to the data analysis, most of the non-normally distributed (*Figure 42*) sample (SD= 25.1661) scores fell to the right of the center (Mdn=80, skewness = -2.0866) with a fat-tailed distribution (Kurtosis=16). Participant NP6M7 was not able to complete and submit this project due to illness.

Table 36

Sixth-grade Continents Adrift project

	Continents Adrift %
Mean	77.5
Standard Error	6.29153
Median	80
Mode	70
Standard Deviation	25.1661
Sample Variance	633.333
Kurtosis	5.67011
Skewness	-2.0866
Range	100
Minimum	0
Maximum	100
Sum	1240
Count	16
Largest (1)	100
Smallest (1)	0
Confidence Level (95.0%)	13.4101

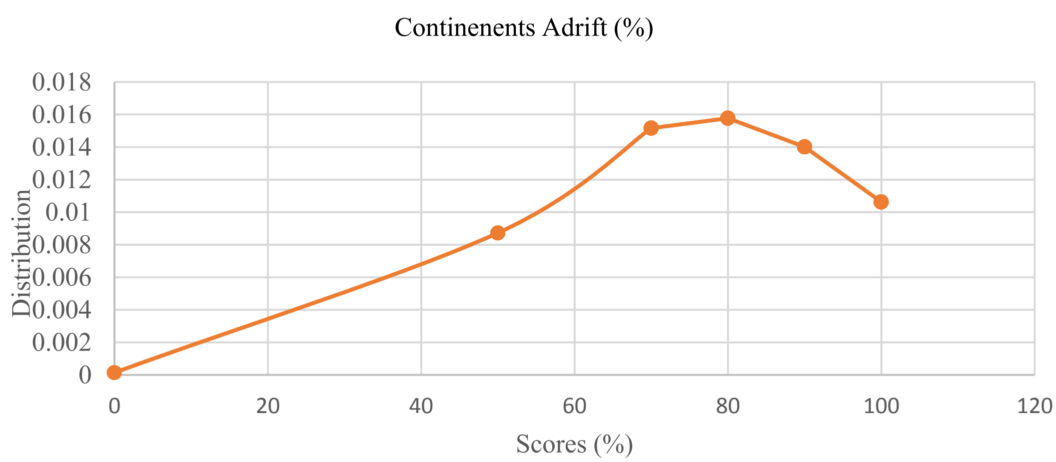


Figure 42. Sixth-grade Continents Adrift project

The descriptive data analysis results for the sixth-grade Plate Tectonics project has been presented in Table 37. According to the data analysis, most of the non-normally distributed (*Figure 43*) sample (SD= 16.9214) scores fell to the right of the center (Mdn=86, skewness = -0.8674) with a skinny-tailed distribution (Kurtosis= -0.3023).

Table 37

Sixth-grade Plate Tectonics Project

	Plate Tectonic Project (%)
Mean	79.75
Standard Error	4.23035
Median	86
Mode	50
Standard Deviation	16.9214
Sample Variance	286.333
Kurtosis	-0.3023
Skewness	-0.8674
Range	50
Minimum	50
Maximum	100
Sum	1276
Count	16
Largest (1)	100
Smallest (1)	50
Confidence Level (95.0%)	9.01677

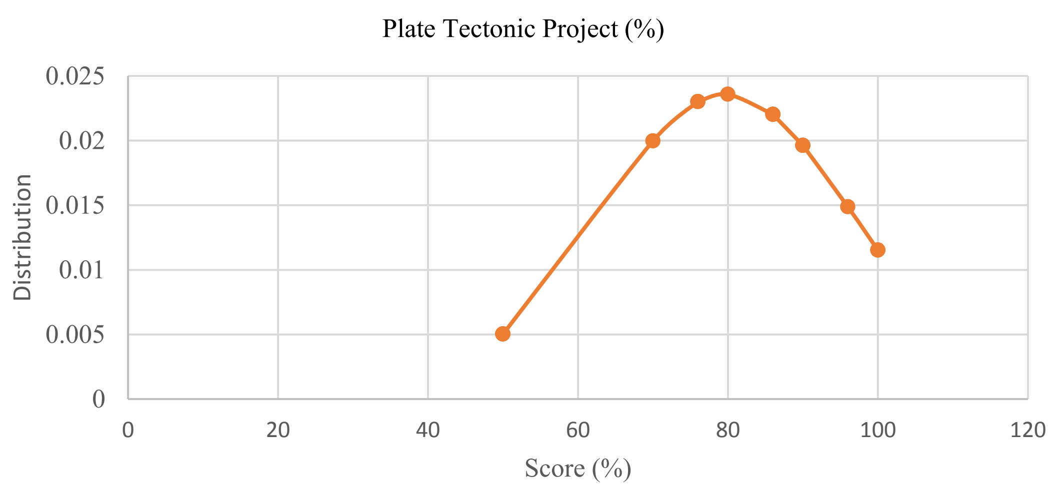


Figure 43. Sixth-grade Plate Tectonics Project

The descriptive data analysis results for the sixth-grade Rock and Mineral Identification project has been presented in Table 38. According to the data analysis, most of the non-normally distributed (*Figure 44*) sample (SD= 3.4003676) scores fell to the right of the center (Mdn=86, skewness = -2.224833) with a fat-tailed distribution (Kurtosis= 5.0615735).

Table 38

Sixth-grade Rock and Mineral Identification Project

	Rock and Mineral Identification Project (%)
Mean	98.3125
Standard Error	0.8500919
Median	100
Mode	100
Standard Deviation	3.4003676
Sample Variance	11.5625
Kurtosis	5.0615735
Skewness	-2.224833
Range	12
Minimum	88
Maximum	100
Sum	1573
Count	16
Largest (1)	100
Smallest (1)	88
Confidence Level (95.0%)	1.811928

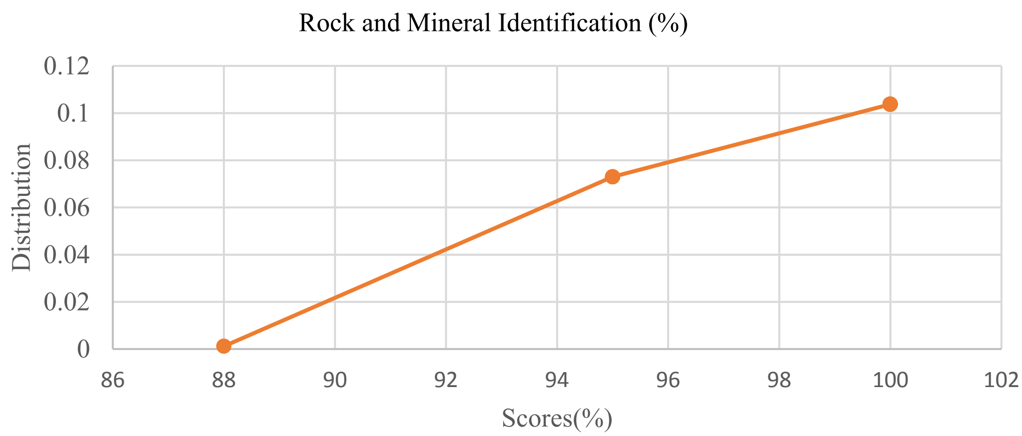


Figure 44. Sixth-grade Rock and Mineral Identification Project

The descriptive data analysis results for the sixth-grade Rock Cycle project has been presented in Table 39. According to the data analysis, most of the non-normally distributed (*Figure 45*) sample (SD= 8.53913) scores fell to the right of the center (Mdn=100, skewness = -2.5095) with a fat-tailed distribution (Kurtosis= 4.89796).

Table 39

Sixth-grade Rock Cycle Project

	Rock Cycle (%)
Mean	96.875
Standard Error	2.13478
Median	100
Mode	100
Standard Deviation	8.53913
Sample Variance	72.9167
Kurtosis	4.89796
Skewness	-2.5095
Range	25
Minimum	75
Maximum	100
Sum	1550
Count	16
Largest (1)	100
Smallest (1)	75
Confidence Level (95.0%)	4.55018

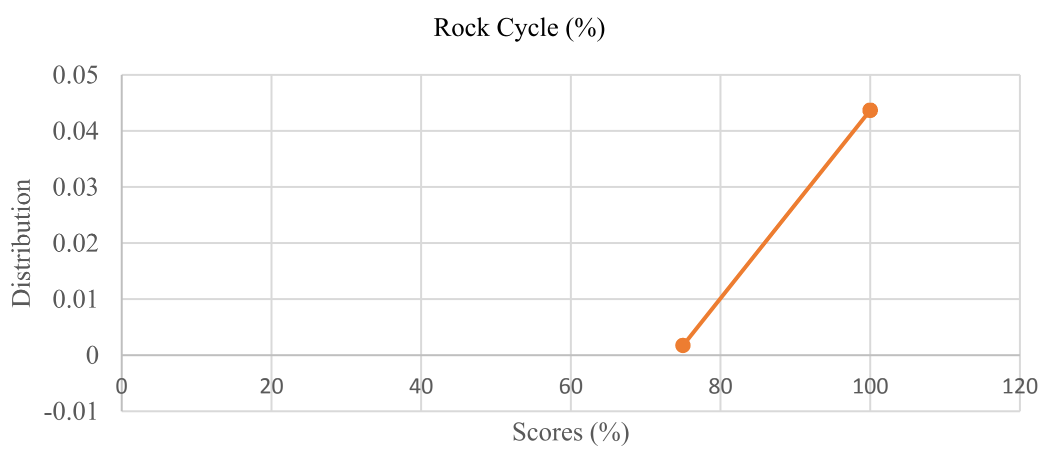


Figure 45. Sixth-grade Rock Cycle Project

A comparative analysis of the sixth-grade project scores showed that the most frequent score earned by students was 100 percent, as can be seen in *Figure 46*.

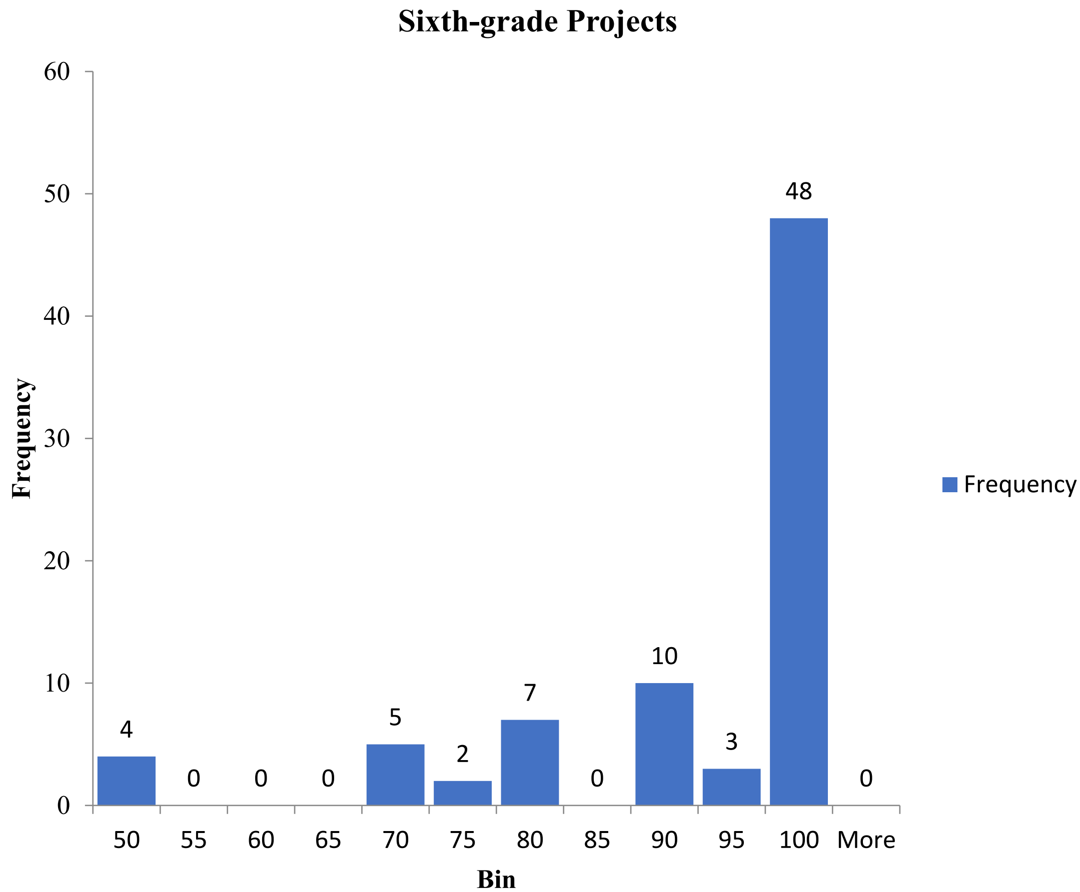


Figure 46. Sixth-grade Projects Histogram

Seventh-grade. The seventh-grade diagnostic (pretest) and benchmark (posttest) tests (chapter 1-3) results have been presented in Table 40. The data has been presented in both the actual raw score as well as the percentage of the total number of points represented.

Table 40

Seventh-grade Criterion-Referenced Diagnostic and Benchmark Tests

Participant Code	Diagnostic Test: Chapters 1-3	Diagnostic Test Chapters 1-3 Split-half Reliability	Diagnostic Test Chapters 1-3 %	Benchmark Test Chapters 1-3	Benchmark Test Chapters 1-3 Split-half Reliability	Benchmark Test Chapters 1-3 %
MA7F17	22		73	24	24	80
AG7F18	20	20	67	20.5		68
JG7M19	19	19	63	17	17	56
CH7M20	18		60	29		96
DK7F21	13	13	43	23	23	76
IN7F22	14		46	18		60
IT7F23	11	11	37	5	5	16
KA7M24	23	23	77	28		93
SB7F25	21		70	23.5	23.5	78
BC7M26	21	21	70	30		100
VG7F27	15	15	50	26.5	26.5	88
AJ7F28	15		50	26		86
AM7M29	21	21	70	29	29	96
MN7F30	17	17	57	28		93
DS7F31	15		50	24.5	24.5	82
TS7M32	21	21	70	26		87
RT7M33	15	15	50	27.5	27.5	92

The descriptive data analysis results for the seventh-grade criterion-referenced diagnostic test have been presented in Table 41. According to the data analysis, most of the non-normally distributed (*Figure 47)* sample (SD= 12.0467838) scores fell to the right of the center (Mdn=60, skewness = -0.218299086) with a skinny-tailed distribution (Kurtosis= -1.231649121).

Table 41

Seventh-grade Criterion-referenced Diagnostic Test

	Seventh-grade Diagnostic Test: Chapters 1-3 (%)
Mean	59
Standard Error	2.921774239
Median	60
Mode	50
Standard Deviation	12.0467838
Sample Variance	145.125
Kurtosis	-1.231649121
Skewness	-0.218299086
Range	40
Minimum	37
Maximum	77
Sum	1003
Count	17
Largest (1)	77
Smallest (1)	37
Confidence Level (95.0%)	6.193884693

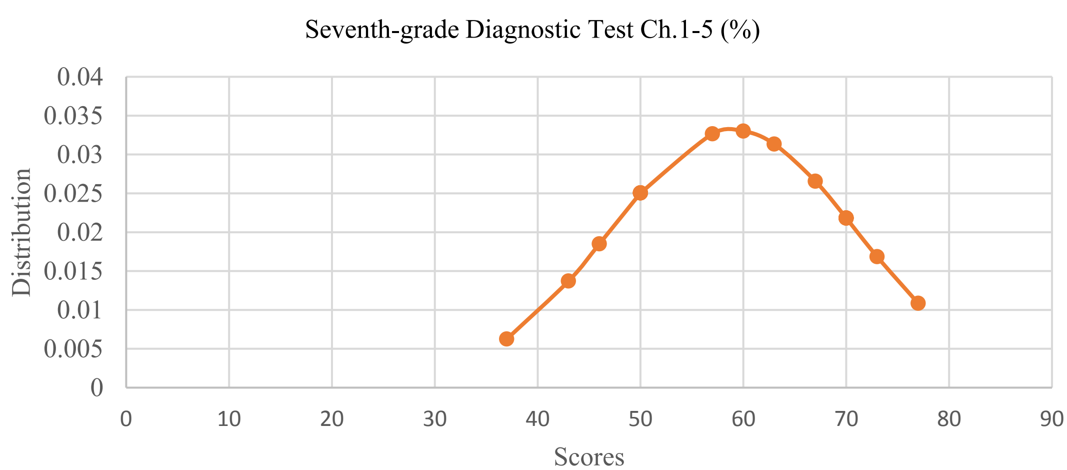


Figure 47. Seventh-grade Criterion-referenced Diagnostic Test

The descriptive data analysis results for the seventh-grade criterion-referenced benchmark test have been presented in Table 42. According to the data analysis, most of the non-normally distributed (*Figure 48)* sample (SD= 20.5746) scores fell to the right of the center (Mdn=86, skewness = -2.0074) with a fat-tailed distribution (Kurtosis= 4.92567).

Table 42

Seventh-grade Criterion-referenced Benchmark Test

Seventh-grade Benchmark Test (%)	
Mean	79.2353
Standard Error	4.99009
Median	86
Mode	93
Standard Deviation	20.5746
Sample Variance	423.316
Kurtosis	4.92567
Skewness	-2.0074
Range	84
Minimum	16
Maximum	100
Sum	1347
Count	17
Largest (1)	100
Smallest (1)	16
Confidence Level (95.0%)	10.5785

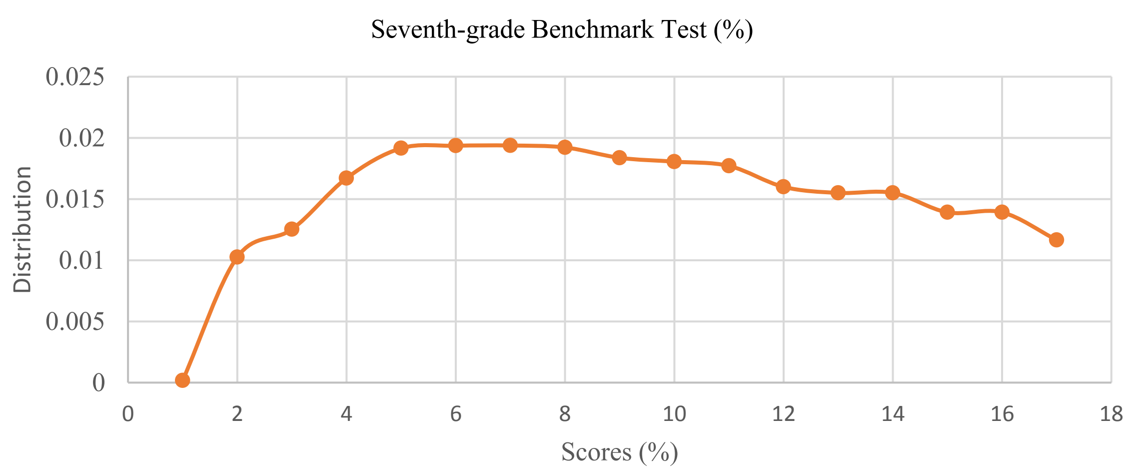


Figure 48. Seventh-grade Criterion-referenced Benchmark Test

A comparative analysis of the results of criterion-referenced diagnostic and benchmark tests showed that ninety-four percent (16 out of 17) of the participants demonstrated measurable gains, as shown in *Figure 49* below. Participant MA7F17 showed a loss of 21 percentage points, possibly due to illness and loss of academic time due to absence.

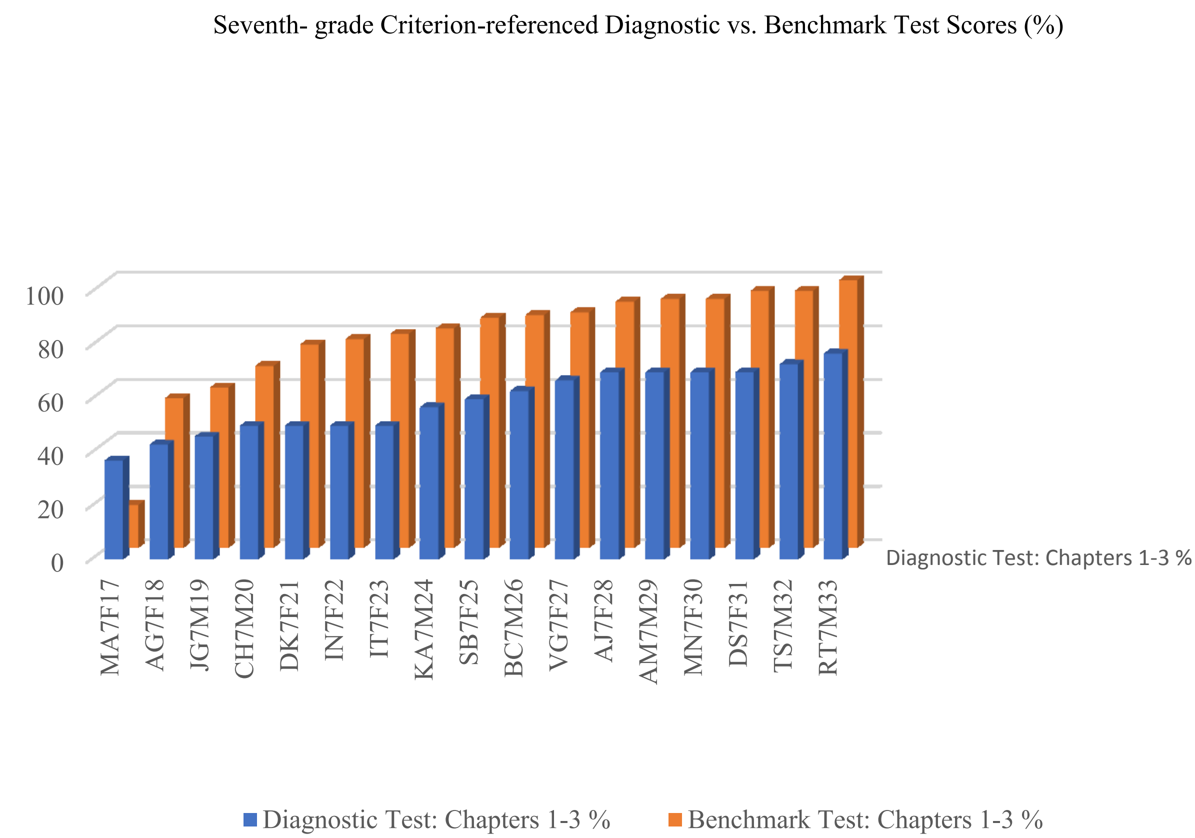


Figure 49. Seventh-grade Criterion-referenced Diagnostic vs. Benchmark Testing Scores (%)

Wilcoxon Sign Rank test results for the seventh-grade criterion-referenced diagnostic and benchmark tests have been presented in Table 43. The small sample size (N=17), meant that the W-value had to be used to evaluate the hypothesis. The results of the Wilcoxon Signed-Rank test (Table 43) for diagnostic vs. benchmark tests were significant at $p < 0.05$.

Table 43

Wilcoxon Signed-Rank Test for Diagnostic vs. Benchmark Tests

W-value	4.5
Mean Difference	3
Sum of positive ranks	4.5
Sum of negative ranks	148.5
Mean (*W*)	76.5
Standard Deviation (*W*)	21.12
Sample Size (*N*)	16

The value of W is 4.5. The critical value for W at $N = 17$ ($p < .05$) is 27.
The result is significant at $p < .05$.

Comparative data analysis was conducted between the results of the seventh-grade diagnostic vs. benchmark tests using the Spearman Rho non-parametric test (Table 44) showed that the association between the two variables (r= 0.98578) was considered statistically significant.

Table 44

Seventh-grade Spearman Rho Test for Diagnostic vs. Benchmark Tests

X Ranks Mean	9
X Ranks Standard Deviation	4.99
Y Ranks Mean	9
Y Ranks Standard Deviation	5.04

Combined
Covariance = 396.75 / 16 = 24.8
R = 24.8 / (4.99 * 5.04) = 0.986
$r_s = 0.98578$, p (2-tailed) = 0.
By normal standards, the association between the two variables would be considered statistically significant.

The results for the seventh-grade criterion-referenced Introduction to Living Things pretest and posttest has been presented in Table 45. The data has been shown in both the actual raw score as well as the percentage of the total number of points represented.

Table 45

Seventh-grade Criterion-referenced Introduction to Living Things Test

Participant Code	Introduction to Living Things-Pretest	Introduction to Living Things-Pretest Split-half Reliability	Introduction to Living Things-Pretest (%)	Introduction to Living Things-Posttest	Introduction to Living Things-Posttest Split-half Reliability	Introduction to Living Things-Posttest %
MA7F17	7	7	70	17		94
AG7F18	4		40	17	17	94
JG7M19	5	5	50	6		33
CH7M20	7		70	18	18	100
DK7F21	6	6	60	17		94
IN7F22	2		20	12	12	66
IT7F23	2	2	20	6		33
KA7M24	8		80	18	18	100
SB7F25	7	7	70	18		100
BC7M26	8		80	18	18	100
VG7F27	8	8	80	16		89
AJ7F28	3		30	15	15	83
AM7M29	10	10	100	18		100
MN7F30	6		60	18	18	100
DS7F31	6	6	60	18		100
TS7M32	6		60	16	16	89
RT7M33	5	5	50	15		83

The descriptive data analysis results for the seventh-grade criterion-referenced Introduction to Living Things pretest has been presented in Table 46. According to the data analysis, most of the non-normally distributed (*Figure 50*) sample (SD= 22.04607475) scores fell to the right of the center (Mdn=60, skewness = -0.307566561) with a skinny-tailed distribution (Kurtosis= -0.227306473).

Table 46

Seventh-grade Criterion-referenced Introduction to Living Things pretest

	Introduction to Living Things Pretest (%)
Mean	58.82352941
Standard Error	5.346958518
Median	60
Mode	60
Standard Deviation	22.04607475
Sample Variance	486.0294118
Kurtosis	-0.227306473
Skewness	-0.307566561
Range	80
Minimum	20
Maximum	100
Sum	1000
Count	17
Largest (1)	100
Smallest (1)	20
Confidence Level (95.0%)	11.3350457

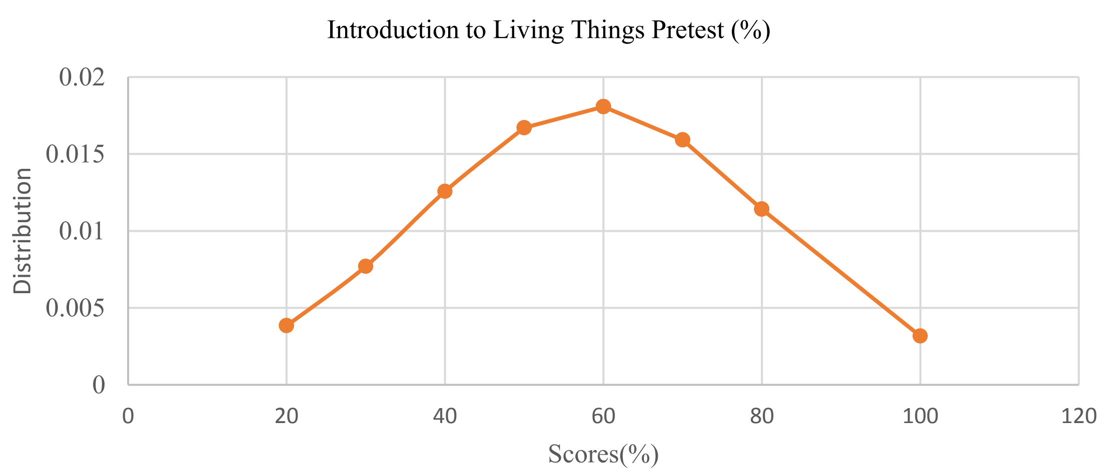


Figure 50. Seventh-grade Criterion-referenced Introduction to Living Things Pretest

The descriptive data analysis results for the seventh-grade criterion-referenced Introduction to Living Things posttest has been presented in Table 47. According to the data analysis, most of the non-normally distributed (*Figure 51*) sample (SD= 21.81894) scores fell to the right of the center (Mdn=94, skewness = -1.90689) with a skinny-tailed distribution (Kurtosis= 2.754843).

Table 47

Seventh-grade Criterion-referenced Introduction to Living Things Posttest

Introduction to Living things Posttest (%)	
Mean	85.76471
Standard Error	5.29187
Median	94
Mode	100
Standard Deviation	21.81894
Sample Variance	476.0662
Kurtosis	2.754843
Skewness	-1.90689
Range	67
Minimum	33
Maximum	100
Sum	1458
Count	17
Largest (1)	100
Smallest (1)	33
Confidence Level (95.0%)	11.21826

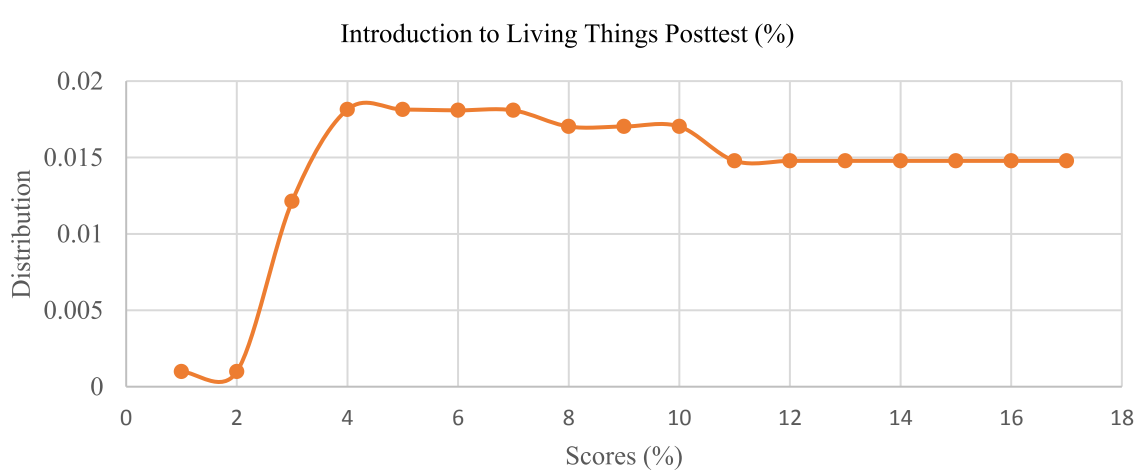


Figure 51. Seventh-grade Criterion-referenced Introduction to Living Things Posttest

A comparative analysis of the results of the Introduction to Living Things pretest and posttest showed that 100 percent (17 out of 17) of the participants demonstrated measurable gains, as shown in *Figure 52* below.

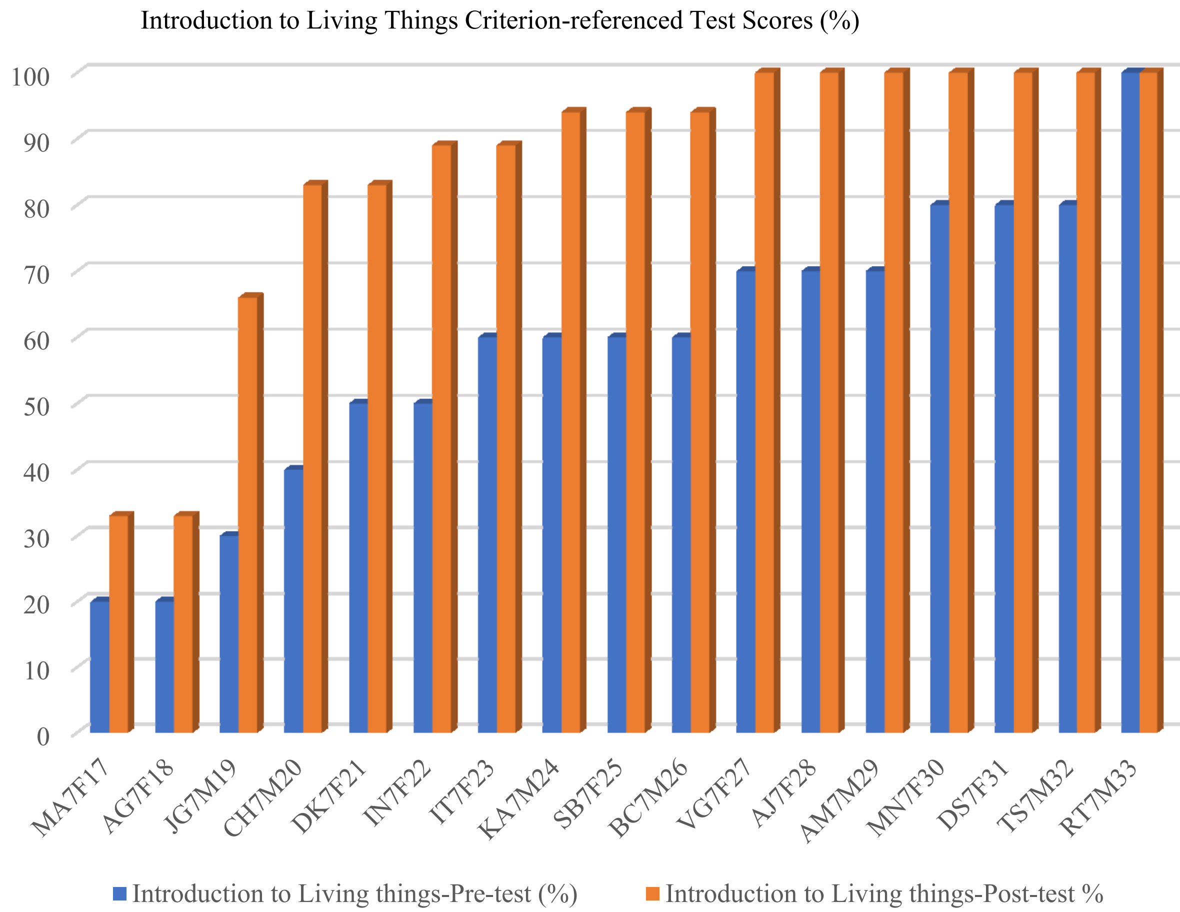


Figure 52. Introduction to Living Things Criterion-referenced Test Scores (%)

Wilcoxon Sign Rank test results for the seventh-grade criterion-referenced test Introduction to Living Things pretest and posttests have been presented in Table 48. The small sample size (N=16) required that the W-value be used to evaluate the hypothesis. The test results for one subject with the same score in both pretest and posttest were discarded and caused a reduction in sample size. The results of the Wilcoxon Signed-Rank test (Table 48) for

Introduction to Living Things pretest and posttest indicated that the results were significant at p < 0.05.

Table 48

Seventh-grade Wilcoxon Signed-Rank Test for Introduction to Living Things Pretest and Posttests

W-value	0
Mean Difference	27.44
Sum of positive ranks	0
Sum of negative ranks	136
Mean (*W*)	68
Standard Deviation (*W*)	19.34
Sample Size (*N*)	16

The value of W is 0. The critical value for W at $N = 16$ ($p < .05$) is 23.
The result is significant at $p < .05$.

A comparative analysis was conducted between the results of the seventh-grade Introduction to Living Things pretest and posttests using the Spearman Rho non-parametric test (Table 49) showed that the association between the two variables (r= 0.96034) was considered statistically significant.

Table 49

Seventh-grade Spearman Rho Test for Introduction to Living Things Pretest and Posttests

X Ranks Mean	9
X Ranks Standard Deviation	4.99
Y Ranks Mean	9
Y Ranks Standard Deviation	4.85

Combined
Covariance = 371.75 / 16 = 23.23
R = 23.23 / (4.99 * 4.85) = 0.96
$r_s = 0.96034$, p (2-tailed) = 0.
By normal standards, the association between the two variables would be considered statistically significant.

The results for the seventh-grade criterion-referenced test Introduction to cells pretest and posttest has been presented in Table 50. The data has been presented in both the actual raw score as well as the percentage of the total number of points represented.

Table 50

Seventh-grade Criterion-referenced Introduction to Cells Pretest and Posttest

Participant Code	Introduction to cells-Pretest	Introduction to cells-Pretest Split-half-Reliability	Introduction to cells-Pretest (%)	Introducing the Cell - Post Test	Introducing the Cell - Post Test Split-half Reliability	Introducing the Cell - Post Test %
MA7F17	7		70	8	8	80
AG7F18	6	6	60	8		80
JG7M19	5		50	3	3	30
CH7M20	10	10	100	6		60
DK7F21	6		60	8	8	80
IN7F22	4	4	40	5		50
IT7F23	5		50	5	5	50
KA7M24	8	8	80	10		100
SB7F25	7		70	9	9	90
BC7M26	7	7	70	7		70
VG7F27	7		70	5	5	50
AJ7F28	7	7	70	8		80
AM7M29	7		70	10	10	100
MN7F30	6	6	60	8		80
DS7F31	5		50	7	7	70
TS7M32	4	4	40	6		60
RT7M33	5		50	5	5	50

The descriptive data analysis results for the seventh-grade criterion-referenced Introduction to cells pretest have been presented in Table 51. According to the data analysis, most of the non-normally distributed (*Figure 53*) sample (SD= 15.21899) scores fell to the left of the center (Mdn=60, skewness = 0.63538) with a skinny-tailed distribution (Kurtosis= 0.9583).

Table 51

Seventh-grade Criterion-referenced Introduction to Cells Pretest

	Introduction to Cells Pretest (%)
Mean	62.35294
Standard Error	3.691147
Median	60
Mode	70
Standard Deviation	15.21899
Sample Variance	231.6176
Kurtosis	0.9583
Skewness	0.63538
Range	60
Minimum	40
Maximum	100
Sum	1060
Count	17
Largest (1)	100
Smallest (1)	40
Confidence Level (95.0%)	7.824882

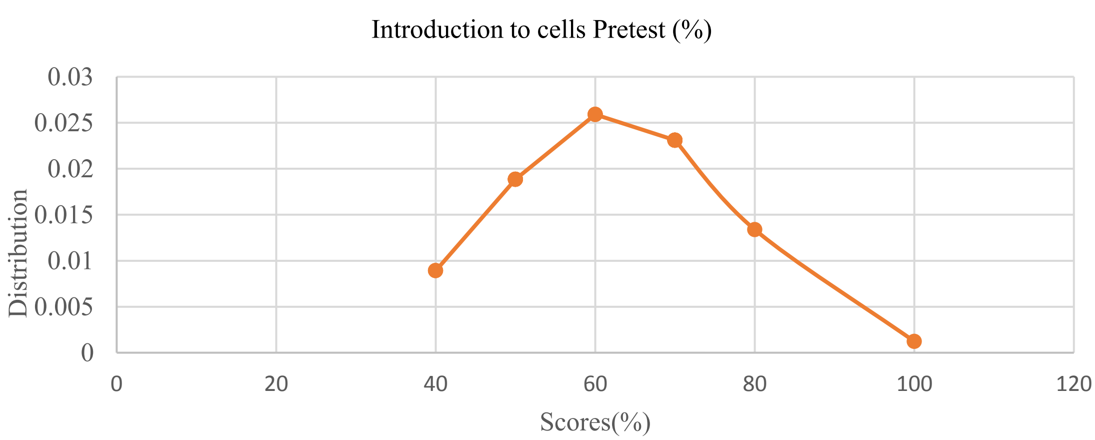


Figure 53. Seventh-grade criterion-referenced Introduction to cells Pretest

The descriptive data analysis results for the seventh-grade criterion-referenced Introduction to cells posttest has been presented in Table 52. According to the data analysis, most of the non-normally distributed (*Figure 54*) sample (SD= 15.21899) scores fell to the right of the center (Mdn=70, skewness = -0.1928899) with a skinny-tailed distribution (Kurtosis= -0.524749).

Table 52

Seventh-grade Criterion-referenced Introduction to cells Posttest

Introduction to Cells Posttest (%)	
Mean	69.411765
Standard Error	4.7333756
Median	70
Mode	80
Standard Deviation	19.516207
Sample Variance	380.88235
Kurtosis	-0.524749
Skewness	-0.1928899
Range	70
Minimum	30
Maximum	100
Sum	1180
Count	17
Largest (1)	100
Smallest (1)	30
Confidence Level (95.0%)	10.034308

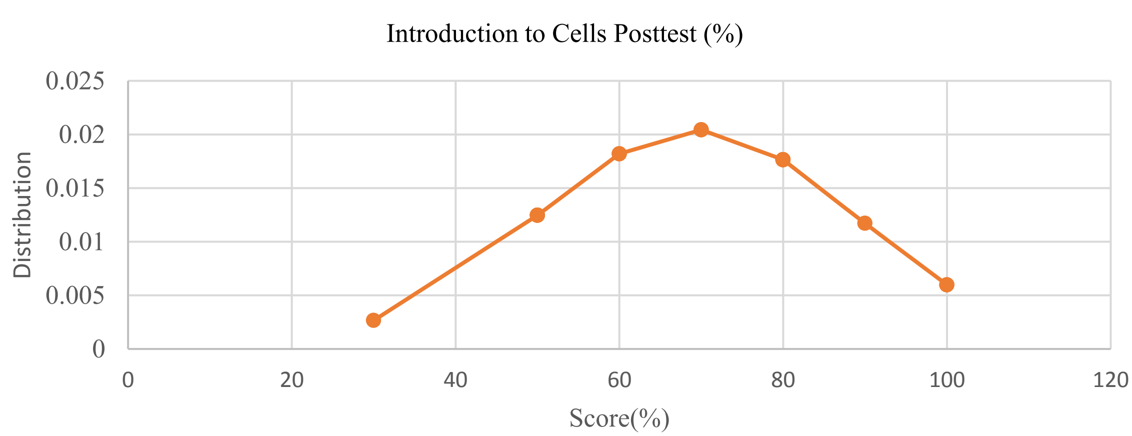


Figure 54. Seventh-grade Criterion-referenced Introduction to Cells Posttest

A comparative analysis of the results of Introduction to Cells criterion-referenced pretest and posttest showed that sixty-five percent (11 out of 17) of the participants demonstrated measurable gains, as shown in *Figure 55* below. The results showed no change for twenty-nine percent (five out of 17) of the participant. Participant MA7F17 demonstrated a loss of ten percentage points.

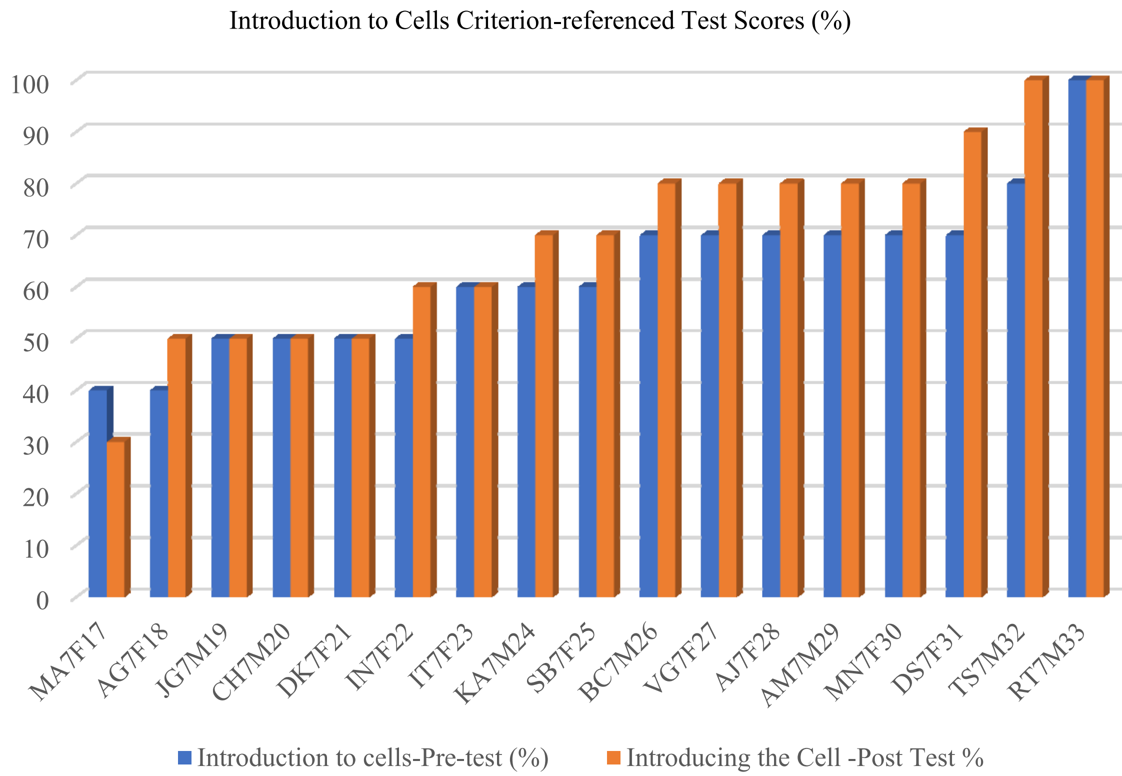


Figure 55. Introduction to Cells Criterion-referenced Test Scores (%)

Wilcoxon Sign Rank test result for the seventh-grade criterion-referenced Introduction to cells pretest and posttests were presented in Table 53. Because of the small sample size (N=12), the W-value was used to evaluate the hypothesis. The test results for five subjects with the same scores in both pretest and posttest were discarded as part of the data analysis. The discarding of the data may have caused a further reduction in sample size. The results of the Wilcoxon Signed-

Rank test (Table 53) for the Introduction to Cells test indicated that the test results were statistically significant at $p < 0.05$.

Table 53

Seventh-grade Wilcoxon Signed-Rank Test for Introduction to Cells

W-value	5.5
Mean Difference	17.5
Sum of positive ranks	5.5
Sum of negative ranks	72.5
Mean (*W*)	39
Standard Deviation (*W*)	12.75
Sample Size (*N*)	12

The value of *W* is 5.5. The critical value for *W* at $N = 12$ ($p < .05$) is 9.
The result is significant at $p < .05$.

Comparative data analysis conducted between the results of the seventh-grade Introduction to Cells tests using the Spearman Rho non-parametric test (Table 54) showed that the association between the two variables (r= 0.97165) was considered statistically significant.

Table 54

Seventh-grade Spearman Rho Test for Introduction to Cells

X Ranks Mean	9
X Ranks Standard Deviation	4.89
Y Ranks Mean	9
Y Ranks Standard Deviation	4.95

Combined
Covariance = 376.25 / 16 = 23.52
R = 23.
52 / (4.89 * 4.95) = 0.972
$r_s = 0.97165$, p (2-tailed) = 0.
By normal standards, the association between the two variables would be considered statistically significant

The seventh-grade Wilcoxon Signed-Rank Test for the criterion-referenced tests showed that the difference between the pretests and posttest was statistically significant at $p < .05$. Furthermore, testing results using the Spearman Rho showed that by normal standards, the association between the implementation of PBL and test scores was considered statistically significant.

The seventh-grade, "Is it really true?" Design and Build a Microscope, Cell Project, Photosynthesis Virtual Lab, and Cell Cycle Organizer results have been shown in Table 55. An example of one of the posters prepared by the students for the project presentation has been shown in *Figure 56*. Students were required to examine a common belief and design an experiment to test the truth behind the misconception. This group discussed whether eggs could support the weight of a seventh-grade girl. The objective of this project was to help the students to understand the Scientific Method better.

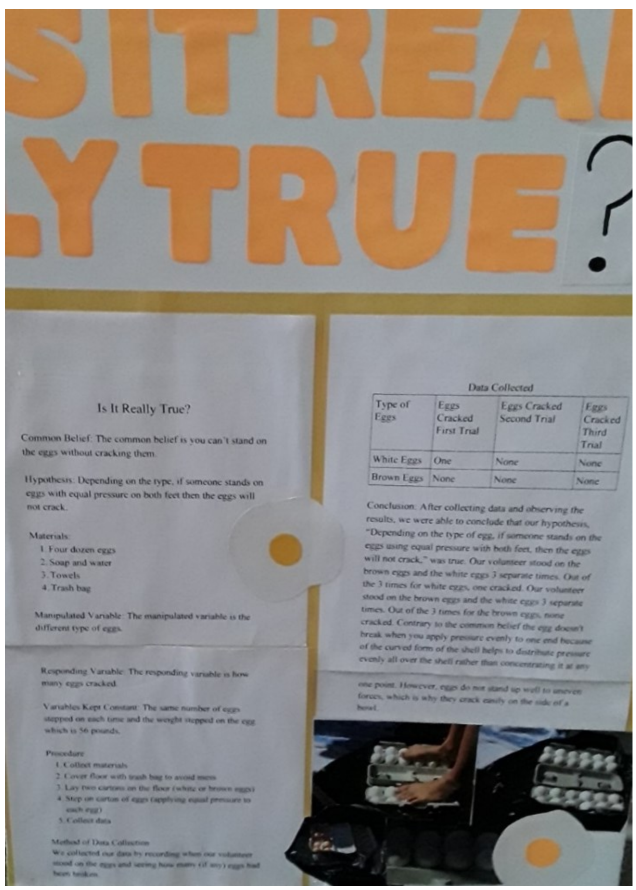


Figure 56. "Is It Really True?" Project Poster

Figure 57 showed an example of one of the seventh-grade participants demonstrating the student-created cell project that described the processes taking place within a cell

Figure 57. Cell Project Demonstration

Figure 58 showed an example of one of the students' cell cycle organizers. The organizers were developed by the students like a concept map (Appendix M) to show the relationship between the processes of the cell cycle, mitosis, and meiosis.

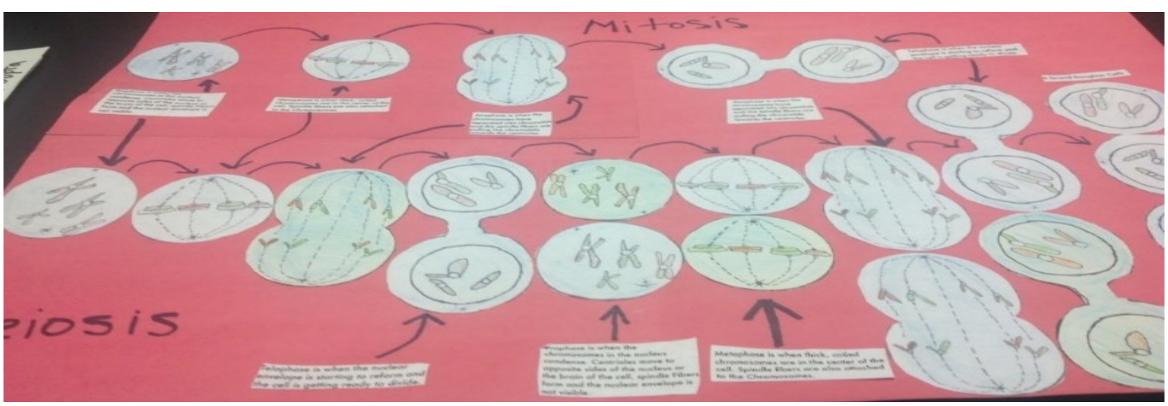


Figure 58. Cell Cycle Organizer

The data has been presented in both the actual raw score as well as the percentage of the total number of points represented. Participant CH7M20 and DK7F21 were unable to complete and submit projects (NA= not able to present) due to illness.

Table 55

Seventh-grade PBL Project Scores

Participant Code	"Is it really true?" project? (%)	Design and build a microscope project (%)	Cell Project (%)	Photosynthesis-Virtual Lab (%)	Cell Cycle Organizer (%)
MA7F17	92	100	70	58	100
AG7F18	100	100	76	80	100
JG7M19	100	100	70	52	66
CH7M20	NA*	100	86	90	100
DK7F21	NA*	100	90	84	100
IN7F22	100	100	60	80	66
IT7F23	100	80	76	80	100
KA7M24	100	100	100	87	100
SB7F25	100	100	94	100	100
BC7M26	100	100	100	90	66
VG7F27	100	100	100	87	100
AJ7F28	100	100	80	90	50
AM7M29	100	100	70	78	100
MN7F30	100	100	100	90	100
DS7F31	100	100	90	73	66
TS7M32	100	100	100	85	66
RT7M33	100	100	60	76	66

The descriptive data analysis results for the seventh-grade"Is it really true?" project has been presented in Table 56. According to the data analysis, most of the non-normally distributed (*Figure 59*) sample (SD= 2.065591) scores fell to the right of the center (Mdn=100, skewness = -3.87298) with a fat-tailed distribution (Kurtosis= 15).

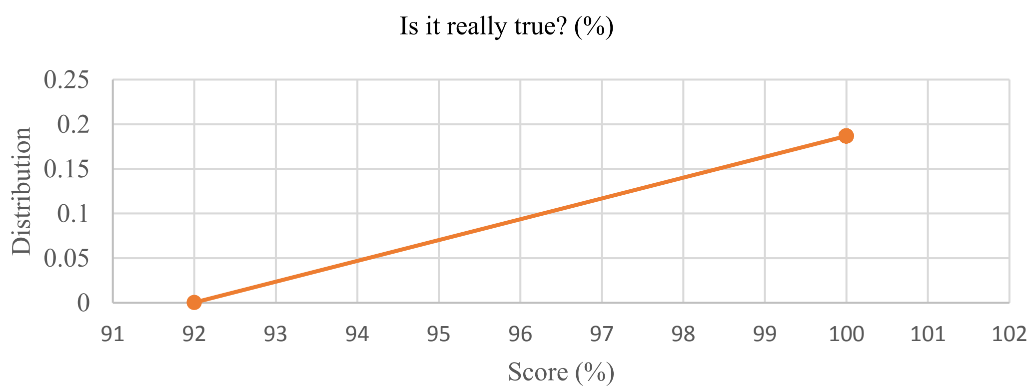


Figure 59. Seventh-grade, "Is it really true?"Project

Table 56

Seventh-grade"Is it really true?" Project

"Is it really true?" project? (%)	
Mean	99.46667
Standard Error	0.533333
Median	100
Mode	100
Standard Deviation	2.065591
Sample Variance	4.266667
Kurtosis	15
Skewness	-3.87298
Range	8
Minimum	92
Maximum	100
Sum	1492
Count	15
Largest (1)	100
Smallest (1)	92
Confidence Level (95.0%)	1.143886

The descriptive data analysis results for the seventh-grade Design and Build a Microscope project has been presented in Table 57. According to the data analysis, most of the non-normally distributed *(Figure 60*) sample (SD= 4.85071) scores fell to the right of the center (Mdn=100, skewness = -4.1231) with a fat-tailed distribution (Kurtosis= 17).

Table 57

Seventh-grade Design and Build a Microscope Project

Design and build a microscope project (%)	
Mean	98.8235
Standard Error	1.17647
Median	100
Mode	100
Standard Deviation	4.85071
Sample Variance	23.5294
Kurtosis	17
Skewness	-4.1231
Range	20
Minimum	80
Maximum	100
Sum	1680
Count	17
Largest (1)	100
Smallest (1)	80
Confidence Level (95.0%)	2.49401

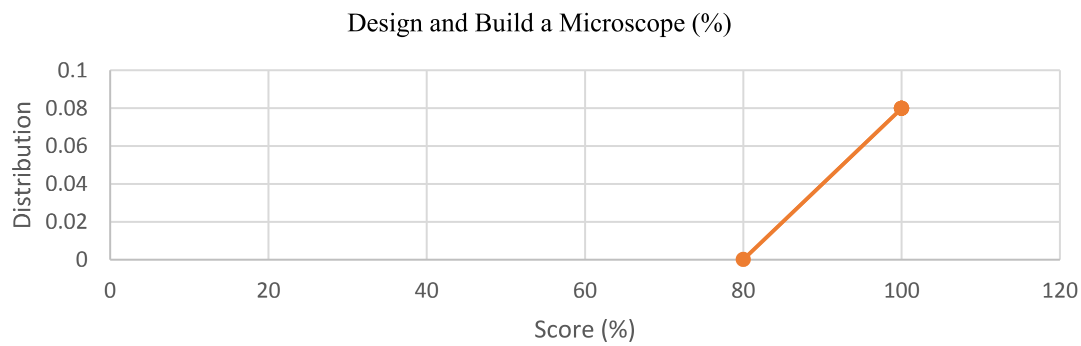


Figure 60. Seventh-grade Design and Build a Microscope Project

The descriptive data analysis results for the seventh-grade Cell project has been presented in Table 58. According to the data analysis, most of the non-normally distributed *(Figure 61)* sample (SD= 14.4436) scores fell to the right of the center (Mdn=86, skewness = -0.2706) with a skinny-tailed distribution (Kurtosis= -1.3369).

Table 58

Seventh-grade Cell Project

	Cell Project (%)
Mean	83.6471
Standard Error	3.50309
Median	86
Mode	100
Standard Deviation	14.4436
Sample Variance	208.618
Kurtosis	-1.3369
Skewness	-0.2706
Range	40
Minimum	60
Maximum	100
Sum	1422
Count	17
Largest (1)	100
Smallest (1)	60
Confidence Level (95.0%)	7.42622

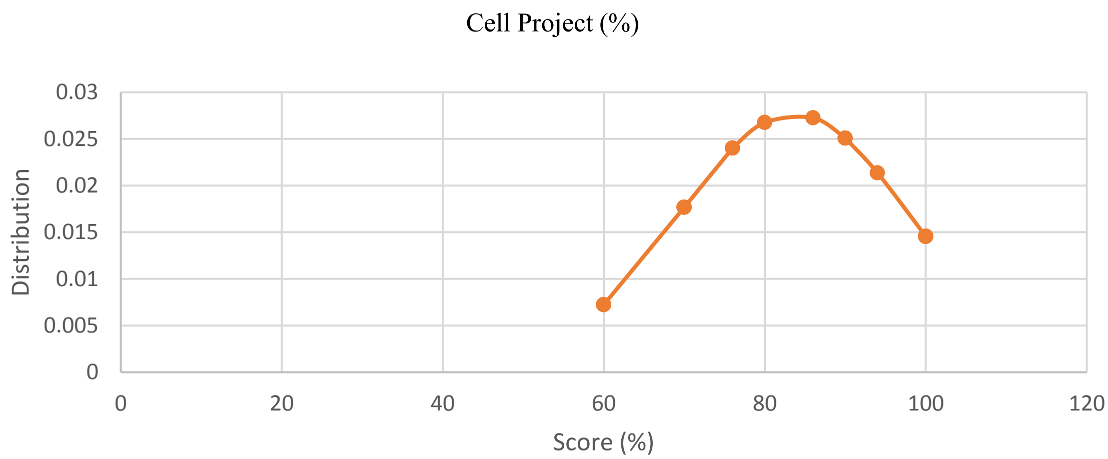


Figure 61. Seventh-grade Cell Project

The detailed data analysis results for the seventh-grade Photosynthesis Virtual Lab has been presented in Table 59. According to the data analysis, most of the non-normally distributed (*Figure 62*) sample (SD= 11.8651) scores fell to the right of the center (Mdn=84, skewness = -1.1924) with a skinny-tailed distribution (Kurtosis= 1.72313).

Table 59

Photosynthesis Virtual Lab

	Photosynthesis-Virtual Lab (%)
Mean	81.1765
Standard Error	2.8777
Median	84
Mode	90
Standard Deviation	11.8651
Sample Variance	140.779
Kurtosis	1.72313
Skewness	-1.1924
Range	48
Minimum	52
Maximum	100
Sum	1380
Count	17
Largest (1)	100
Smallest (1)	52
Confidence Level (95.0%)	6.10045

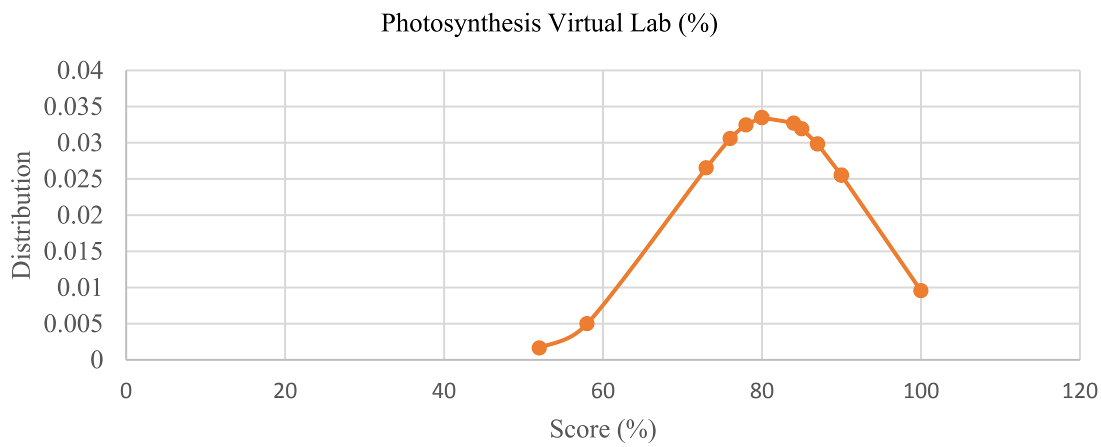


Figure 62. Photosynthesis Virtual Lab

The descriptive data analysis results for the seventh-grade Cell Cycle Organizer Project has been presented in Table 60. According to the data analysis, most of the non-normally distributed (*Figure 63*) sample (SD= 18.7765) scores fell to the right of the center (Mdn=100, skewness = -0.5486) with a skinny-tailed distribution (Kurtosis= -1.6051).

Table 60

Seventh-grade Cell Cycle Organizer Project

	Cell Cycle Organizer (%)
Mean	85.0588
Standard Error	4.55398
Median	100
Mode	100
Standard Deviation	18.7765
Sample Variance	352.559
Kurtosis	-1.6051
Skewness	-0.5486
Range	50
Minimum	50
Maximum	100
Sum	1446
Count	17
Largest (1)	100
Smallest (1)	50
Confidence Level (95.0%)	9.65401

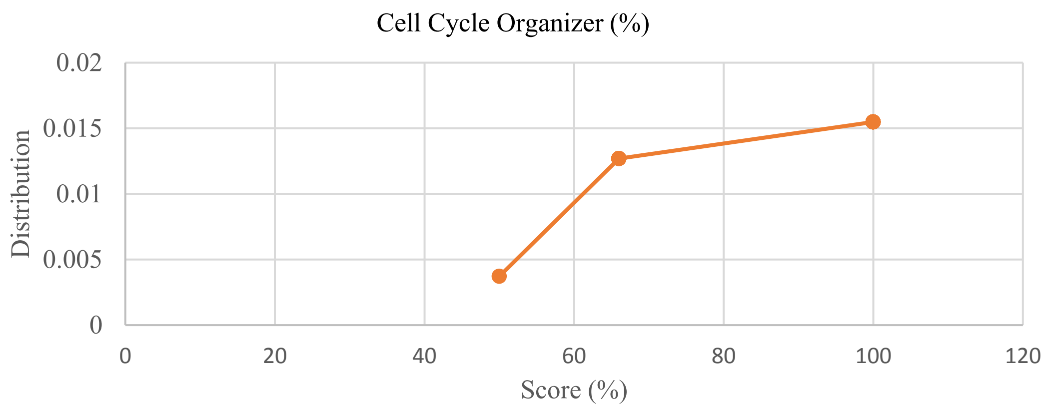


Figure 63. Seventh-grade Cell Cycle Organizer Project

A comparative analysis of the seventh-grade project scores showed that the most frequent score earned by students was 100 percent, as can be seen in *Figure 64* below.

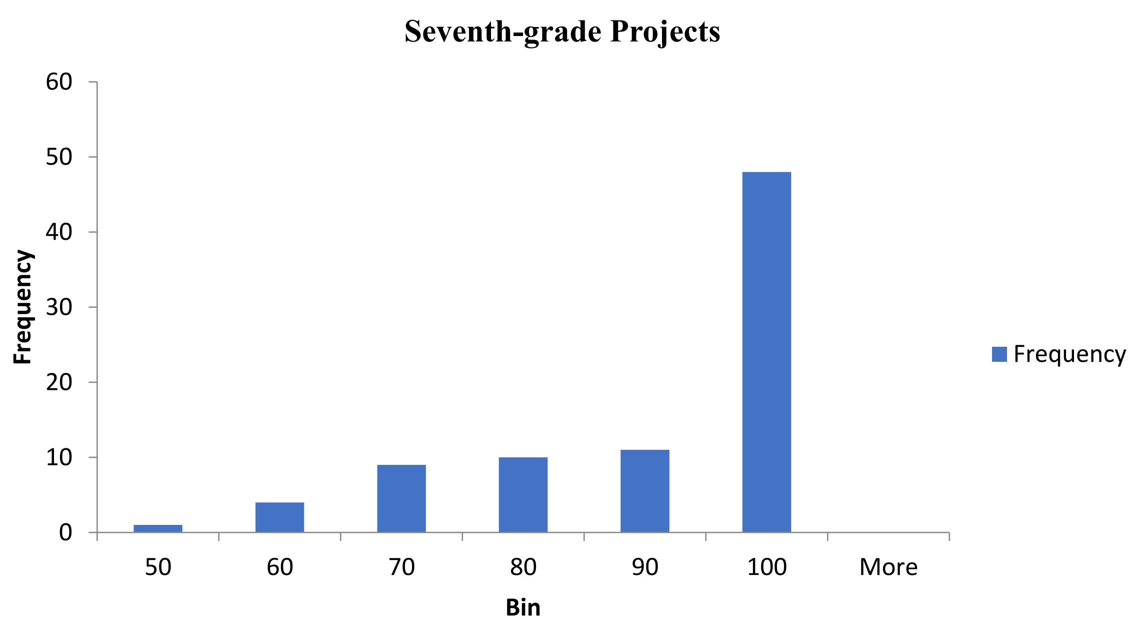


Figure 64. Seventh-grade Projects Histogram

Eighth-grade. The results for the eight-grade diagnostic (pretest) and benchmark (posttest) tests for chapters one through six have been presented in Table 61. The data has been presented in both the actual raw score as well as the percentage of the total number of points represented.

Table 61

Eight-grade Criterion-Referenced Diagnostic and Benchmark Tests (chapters one through six)

Participant Code	Diagnostic Test Chapters 1-6	Diagnostic Test Chapters 1-6 Split-Half Reliability	Diagnostic Test Chapters 1-6 (%)	Benchmark Test Chapters 1-6	Benchmark Test Chapters 1-6 Split-Half Reliability	Benchmark Test Chapters 1-6 (%)
JLB8M34	27		90	34	34	85
KD8M35	23	23	77	31.75		79
EF8F36	25		83	33	33	82
RG8M37	19	19	63	38		95
ZH8M38	22		73	26.25	26.25	65
RJ8M39	14	14	46	22.5		56
AL8F40	20		67	31	31	77
HL8M41	19	19	63	22		55
LP8M42	22		73	33.25	33.25	83
PP8F43	28	28	93	34.75		86
LS8M44	17		57	22.25	22.25	55
ES8F45	17	17	57	25.5		63
SV8M46	23		77	35.75	35.75	89

The descriptive data analysis results for the eighth-grade criterion-referenced diagnostic test for chapters one to six have been presented in Table 62. According to the data analysis, most of the non-normally distributed (*Figure 65*) sample (SD= 13.62831) scores fell to the right of the center (Mdn=73, skewness = -0.01791) with a skinny-tailed distribution (Kurtosis= -0.48186).

Table 62

Eight-grade Criterion-referenced Diagnostic Test for Chapters One To Six

Eight-grade Diagnostic Test: Chapters One to Six (%)	
Mean	70.69231
Standard Error	3.779812
Median	73
Mode	57
Standard Deviation	13.62831
Sample Variance	185.7308
Kurtosis	-0.48186
Skewness	-0.01791
Range	47
Minimum	46
Maximum	93
Sum	919
Count	13
Largest (1)	93
Smallest (1)	46
Confidence Level (95.0%)	8.2355039

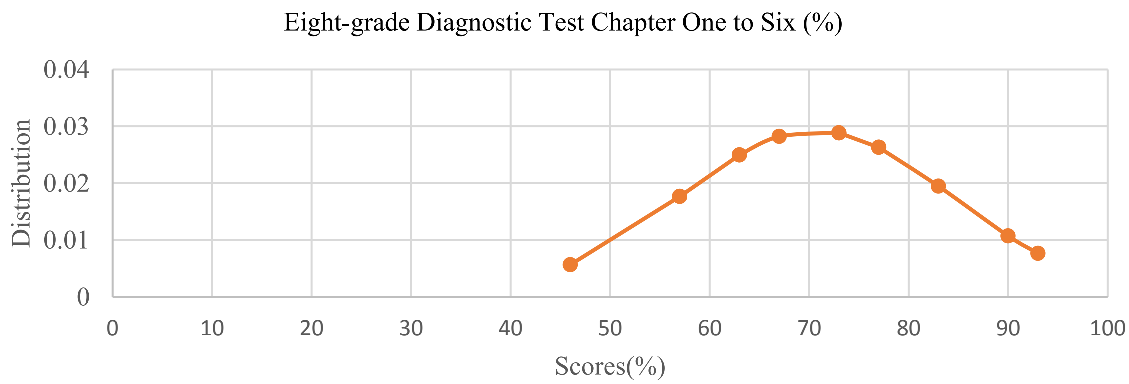


Figure 65. Eight-grade Criterion-referenced Diagnostic Test For Chapters One To Six

The descriptive data analysis results for the eight-grade criterion-referenced benchmark test for chapters one to six have been presented in Table 63. According to the data analysis, most of the non-normally distributed (*Figure 66*) sample (SD= 14.0032) scores fell to the right of the center (Mdn=79, skewness = -0.3181) with a skinny-tailed distribution (Kurtosis= -1.4346).

Table 63

Eight-grade Criterion-referenced Benchmark Test For Chapters One To Six

	Eight-grade Benchmark Test (%)
Mean	74.61538
Standard Error	3.88379
Median	79
Mode	55
Standard Deviation	14.0032
Sample Variance	196.0897
Kurtosis	-1.4346
Skewness	-0.3181
Range	40
Minimum	55
Maximum	95
Sum	970
Count	13
Largest (1)	95
Smallest (1)	55
Confidence Level (95.0%)	8.462052

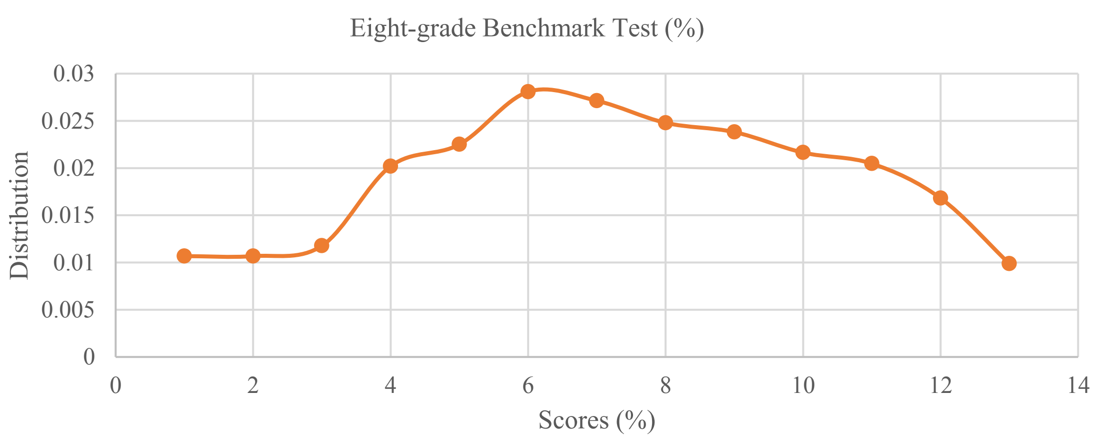


Figure 66. Eight-grade Criterion-referenced Benchmark Test For Chapters One To Six

A comparative analysis of the results of criterion-referenced diagnostic and benchmark tests showed that 54 percent (seven out of 13) of the participants demonstrated measurable gains, as shown in *Figure 67* below. Further analysis showed that forty-six percent (six out of 13) of the participants demonstrated no change or negligible change in testing results, as can be seen in *Figure 67* below.

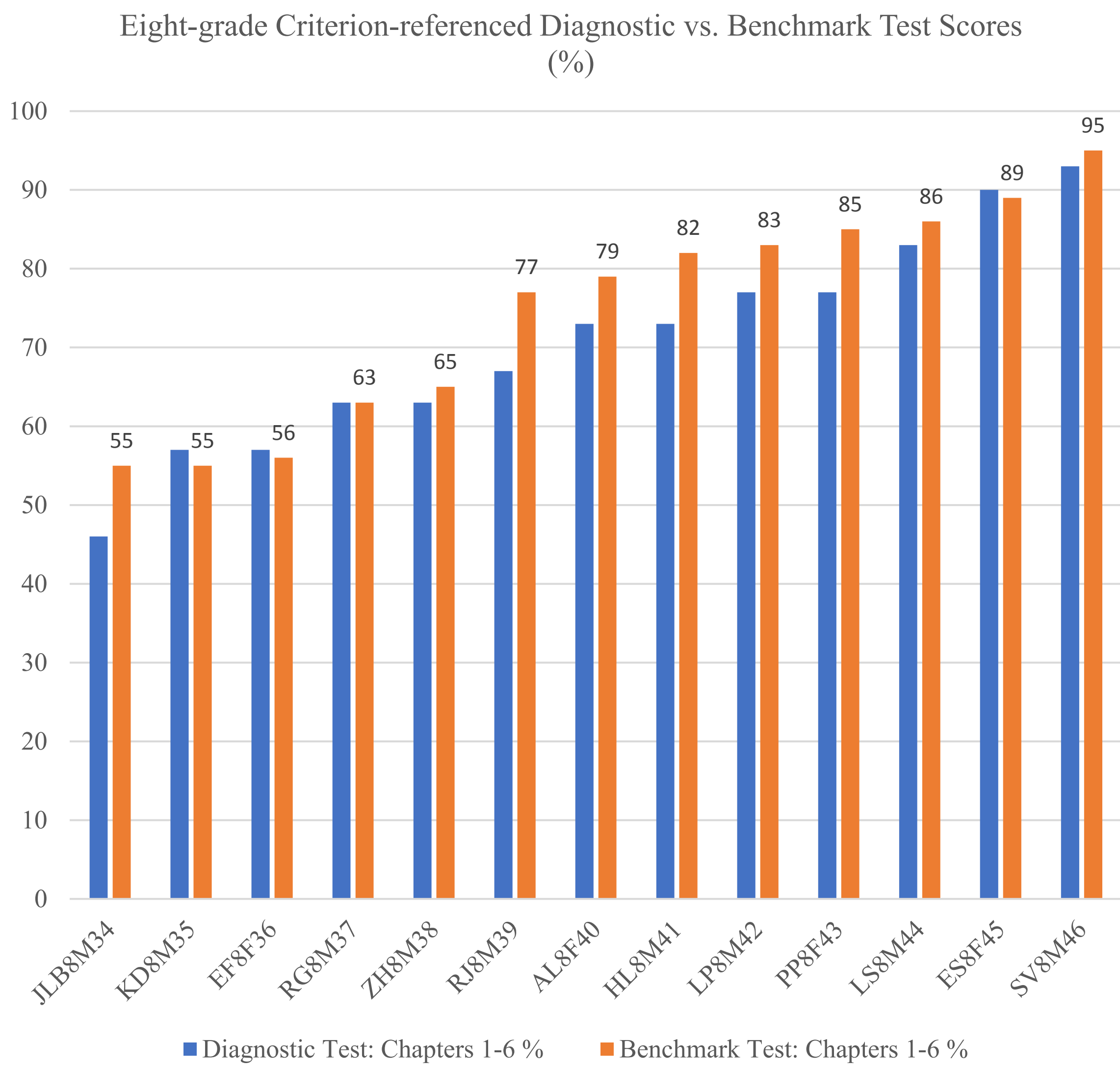


Figure 67. Eight-grade Criterion-referenced Diagnostic vs. Benchmark Test Scores (%)

Wilcoxon Sign Rank test results for the eight-grade criterion-referenced diagnostic vs.benchmark tests have been shown in Table 64. The small sample size (N=12) meant that the hypothesis had to evaluated using the W-value. The test results for one subject with the same scores in both pretest and posttest were discarded and caused a reduction in sample size. The results of the Wilcoxon Signed-Rank test (Table 64) for diagnostic vs. benchmark test indicated that the test results were considered significant at $p < 0.05$

Table 64

Eight-grade Wilcoxon Signed-Rank Test for Diagnostic vs. Benchmark Tests

W-value	7
Mean Difference	17
Sum of positive ranks	7
Sum of negative ranks	71
Mean (*W*)	39
Standard Deviation (*W*)	12.75
Sample Size (*N*)	12

The value of W is 7. The critical value for W at $N = 12$ ($p < .05$) is 9.
The result is significant at $p < .05$.

A comparative analysis conducted between the results of the eight-grade Diagnostic and Benchmark tests using the Spearman Rho non-parametric test (Table 65) showed that the association between the two variables (r= 0.99171) was considered statistically significant.

Table 65

Eight-grade Spearman Rho Test for Diagnostic vs. Benchmark Tests

X Ranks Mean	7
X Ranks Standard Deviation	3.87
Y Ranks Mean	7
Y Ranks Standard Deviation	3.89

Combined
Covariance = 179.25 / 12 = 14.94
R = 14.94 / (3.87 * 3.89) = 0.992
$r_s = 0.99171$, p (2-tailed) = 0.
By normal standards, the association between the two variables would be considered statistically significant.

The eighth-grade criterion-referenced Introduction to Matter pretest and posttest results have been presented in Table 66. The data has been presented in both the actual raw score as well as the percentage of the total number of points represented.

Table 66

Eight-grade Criterion-referenced Introduction to Matter Pretest and Posttest

Participant Code	Introduction to Matter pretest	Introduction to Matter pretest Split-half Reliability	Introduction to Matter pretest (%)	Introduction to Matter posttest	Introduction to Matter posttest Split-half Reliability	Introduction to Matter posttest (%)
JLB8M34	11		100	8		80
KD8M35	9	9	82	4	4	40
EF8F36	10		91	6	6	60
RG8M37	10	10	91	10		100
ZH8M38	8		73	6		60
RJ8M39	9	9	82	4	4	40
AL8F40	8		73	7	7	70
HL8M41	6	6	55	5		50
LP8M42	9		82	9		90
PP8F43	11	11	100	10	10	100
LS8M44	7		64	5	5	50
ES8F45	10	10	91	7		70
SV8M46	9		82	6		60

The descriptive data analysis results for the eight-grade criterion-referenced Introduction to Matter pretest has been presented in Table 67. According to the data analysis, most of the non-normally distributed (*Figure 68*) sample (SD= 13.24764) scores fell to the right of the center (Mdn=82, skewness = -0.55585) with a skinny-tailed distribution (Kurtosis= 0.008392).

Table 67

Eight-grade Criterion-referenced Introduction to Matter Pretest

	Introduction to Matter Pretest %
Mean	82
Standard Error	3.674235
Median	82
Mode	82
Standard Deviation	13.24764
Sample Variance	175.5
Kurtosis	0.008392
Skewness	-0.55585
Range	45
Minimum	55
Maximum	100
Sum	1066
Count	13
Largest (1)	100
Smallest (1)	55
Confidence Level (95.0%)	8.00547

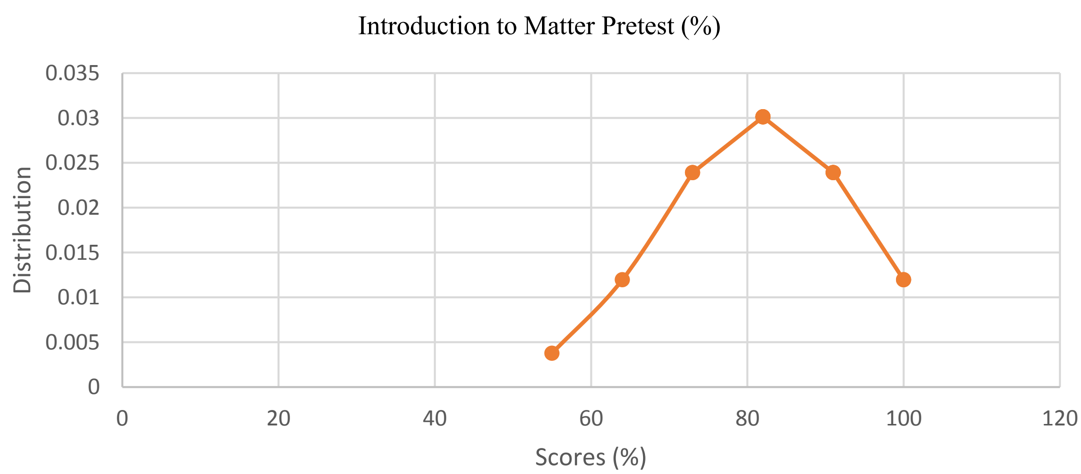


Figure 68. Eight-grade Criterion-referenced Introduction to Matter Pretest

The descriptive data analysis results for the eight-grade criterion-referenced Introduction to Matter posttest has been presented in Table 68. According to the data analysis, most of the non-normally distributed (*Figure 69*) sample (SD= 20.56883378) scores fell to the left of the center (Mdn=60, skewness = 0.421483375) with a skinny-tailed distribution (Kurtosis= -0.900916604).

Table 68

Eight-grade Criterion-referenced Introduction to Matter Posttest

	Introduction to Matter posttest %
Mean	66.92307692
Standard Error	5.704768067
Median	60
Mode	60
Standard Deviation	20.56883378
Sample Variance	423.0769231
Kurtosis	-0.900916604
Skewness	0.421483375
Range	60
Minimum	40
Maximum	100
Sum	870
Count	13
Largest (1)	100
Smallest (1)	40
Confidence Level (95.0%)	12.42962185

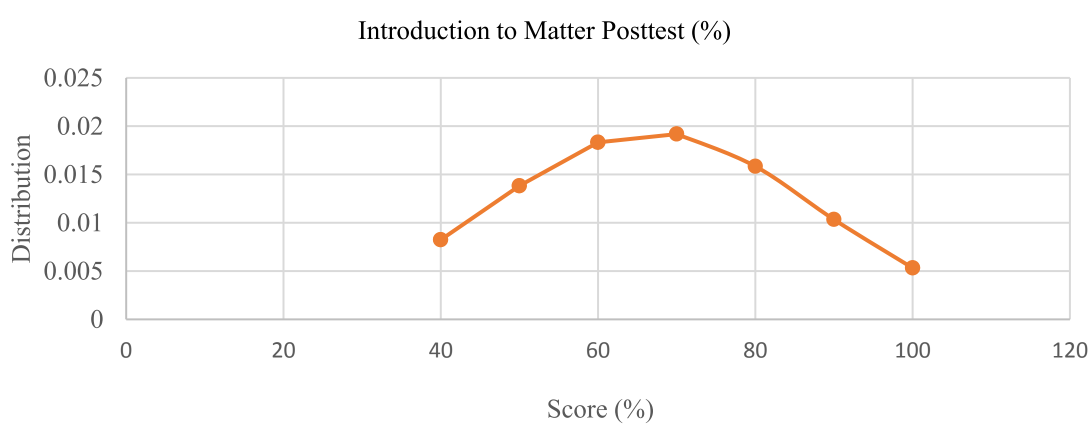


Figure 69. Eight-grade Criterion-referenced Introduction to Matter Posttest

As shown in Figure 70 below, a comparative analysis of the results of criterion-referenced Introduction to Matter, pretest, and posttest showed that 69 percent (nine out of 13) of the participants demonstrated measurable loss in points. Further analysis showed that 23 percent (three out of 13) of the participants demonstrated no change or negligible change in testing results, as can be seen in *Figure 70*. Participant JLB8M34 showed an increase of 25 percentage points, as can be seen in *Figure 70*.

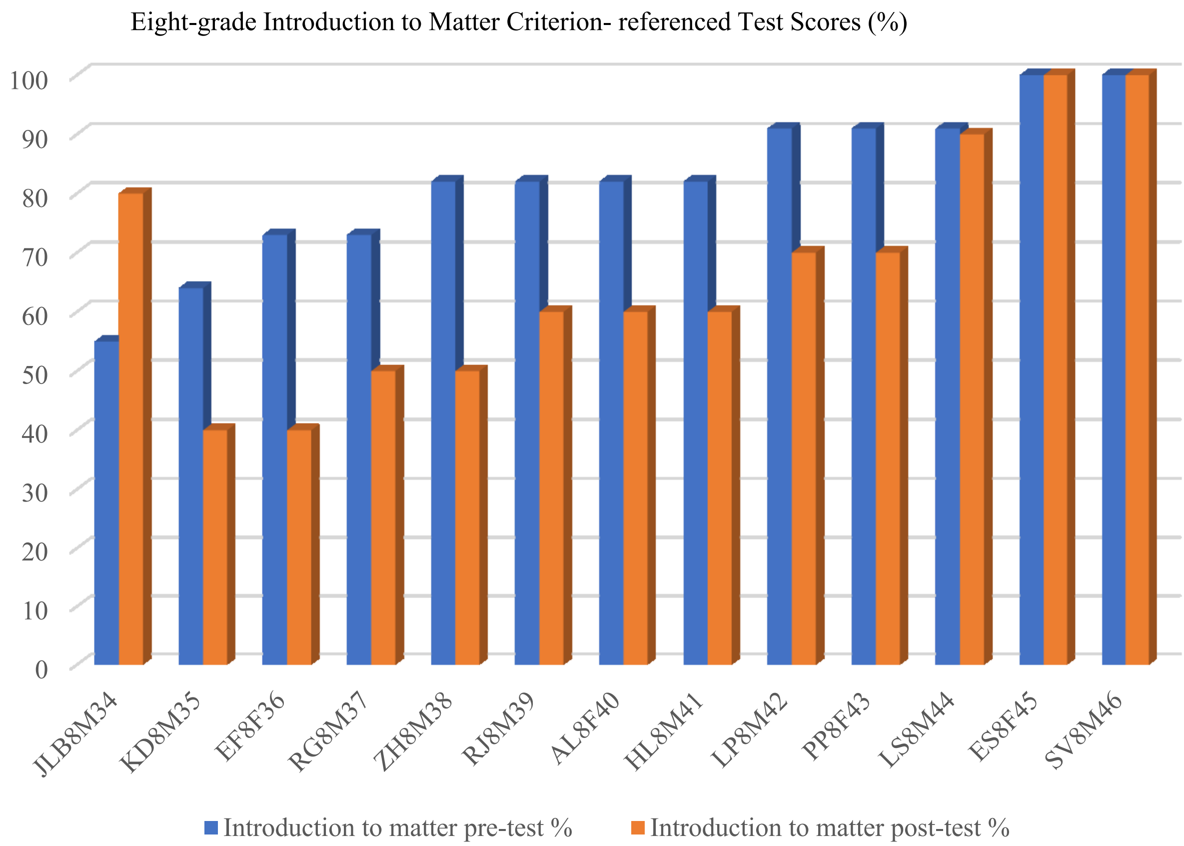


Figure 70. Eight-grade Introduction to Matter Criterion-referenced Test Scores(%)

Wilcoxon Sign Rank test results for the eight-grade criterion-referenced Introduction to Matter pretest and posttests have been presented in Table 69. The small sample size (N=11), meant that the W-value needed to be used for the evaluation of the hypothesis. The test results for two subjects with the same scores in both pretest and posttest were discarded and caused a reduction in sample size. The results of the Wilcoxon Signed-Rank test (Table 69) for Introduction to Matter pretest and posttest indicated that the results were not considered significant at $p < 0.05$.

Table 69

Wilcoxon Signed-Rank Test for Introduction to Matter Pretest and Posttest

W-value	9
Mean Difference	49.64
Sum of positive ranks	57
Sum of negative ranks	9
Mean (*W*)	33
Standard Deviation (*W*)	11.25
Sample Size (*N*)	11

The value of W is 9. The critical value for W at $N = 11$ ($p < .05$) is 7.
The result is *not* significant at $p < .05$.

A comparative analysis was conducted between the results of the eight-grade Introduction to Matter pretest and posttests using the Spearman Rho non-parametric test (Table 70) showed that the association between the two variables (r= 0.71454) was considered statistically significant.

Table 70

Eight-grade Spearman Rho Test for Introduction to Matter Pretest and Posttest

X Ranks Mean	7
X Ranks Standard Deviation	3.81
Y Ranks Mean	7
Y Ranks Standard Deviation	3.85

Combined
Covariance = 125.75 / 12 = 10.48
R = 10.48 / (3.81 * 3.85) = 0.715
$r_s = 0.71454$, p (2-tailed) = 0.00606.
By normal standards, the association between the two variables would be considered statistically significant.

The eighth-grade criterion-referenced Phases of Matter pretest and posttest results have been presented in Table 71. The data has been presented in both the actual raw score as well as the percentage of the total number of points represented.

Table 71

Eight-grade Criterion-referenced Phases of Matter Pretest and Posttest

Participant Code	Phases of Matter pretest	Phases of Matter pretest split-half reliability	Phases of Matter pretest Split-half reliability (%)	Phases of Matter posttest	Phases of Matter posttest split-half reliability	Phases of Matter posttest Split-half reliability (%)
JLB8M34	9		90	10	10	100
KD8M35	9	9	90	7		70
EF8F36	9		90	10	10	100
RG8M37	8	8	80	10		100
ZH8M38	8		80	9	90	90
RJ8M39	8		80	10		100
AL8F40	8	8	80	10	10	100
HL8M41	9	9	90	7		70
LP8M42	8	8	80	10	10	100
PP8F43	8		80	10		100
LS8M44	8	8	80	8	8	80
ES8F45	10		100	8		80
SV8M46	7	7	70	10	10	100

The descriptive data analysis results for the eight-grade criterion-referenced Phases of Matter pretest has been presented in Table 72. According to the data analysis, most of the non-normally distributed (*Figure 71*) sample (SD= 7.67948) scores fell to the left of the center (Mdn=80, skewness = 0.4555) with a skinny-tailed distribution (Kurtosis= 0.51741).

Table 72

Eight-grade Criterion-referenced Phases Of Matter Pretest

	Eight-grade Phases of Matter Pretest (%)
Mean	83.8462
Standard Error	2.1299
Median	80
Mode	80
Standard Deviation	7.67948
Sample Variance	58.9744
Kurtosis	0.51741
Skewness	0.4555
Range	30
Minimum	70
Maximum	100
Sum	1090
Count	13
Largest (1)	100
Smallest (1)	70
Confidence Level (95.0%)	4.64066

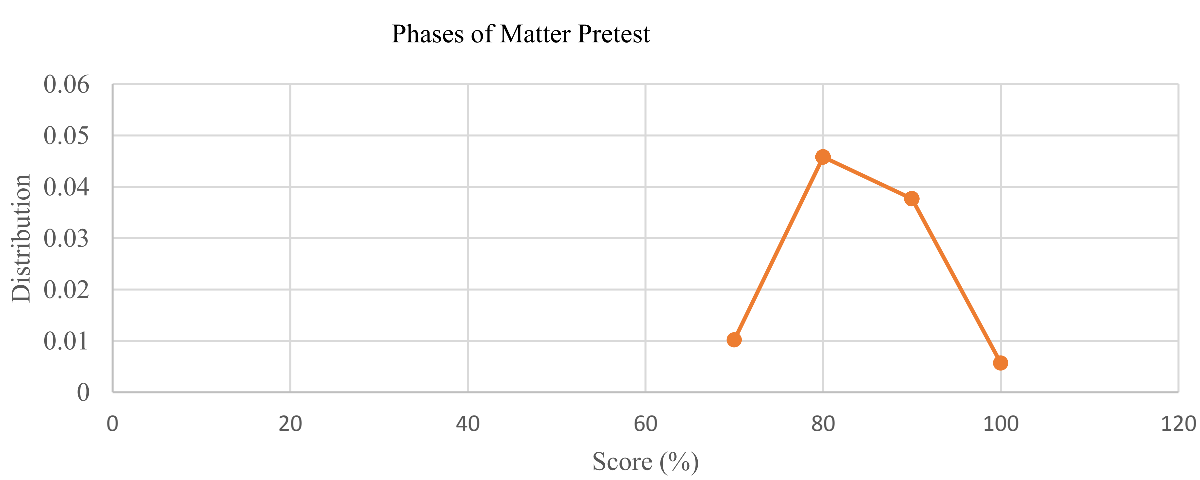


Figure 71. Eight-grade Criterion-referenced Phases Of Matter Pretest

The descriptive data analysis results for the eight-grade criterion-referenced Phases of Matter pretest has been presented in Table 73. According to the data analysis, most of the non-normally distributed (*Figure 72*) sample (SD= 12.1423) scores fell to the right of the center (Mdn=100, skewness = -1.002) with a skinny-tailed distribution (Kurtosis= -0.7121).

Table 73

Eight-grade Criterion-referenced Phases Of Matter Posttest

Eight-grade Phases of Matter Posttest (%)	
Mean	91.5385
Standard Error	3.36767
Median	100
Mode	100
Standard Deviation	12.1423
Sample Variance	147.436
Kurtosis	-0.7121
Skewness	-1.002
Range	30
Minimum	70
Maximum	100
Sum	1190
Count	13
Largest (1)	100
Smallest (1)	70
Confidence Level (95.0%)	7.33753

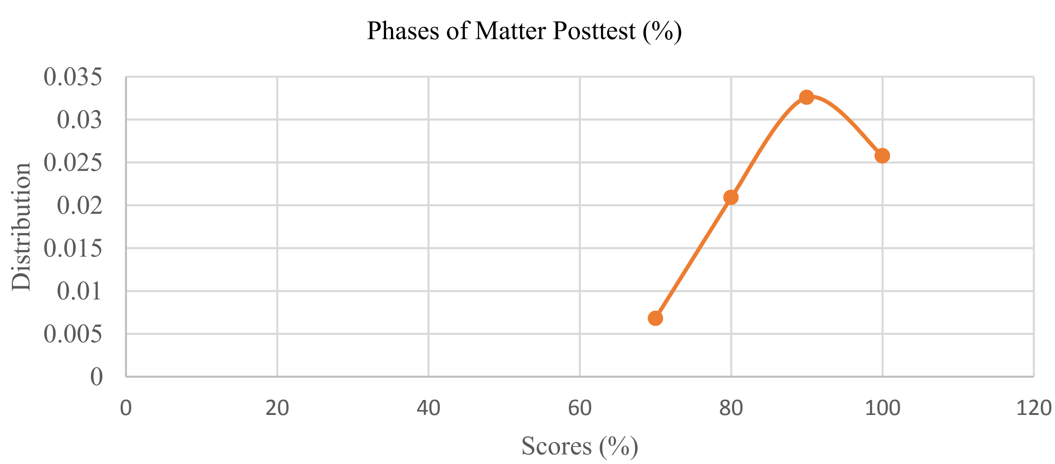


Figure 72. Eight-grade Criterion-referenced Phases Of Matter Posttest

A comparative analysis of the results of criterion-referenced Phases of Matter pretest and posttest showed that sixty-two percent (eight out of 13) of the participants demonstrated the measurable gain in points, as shown in *Figure 73* below. Further analysis showed that thirty-one percent (four out of 13) of the participants demonstrated no change in testing results, as can be seen in *Figure 73* below. Participant KD8M35 showed a decrease of ten percentage points, as can be seen in *Figure 73*.

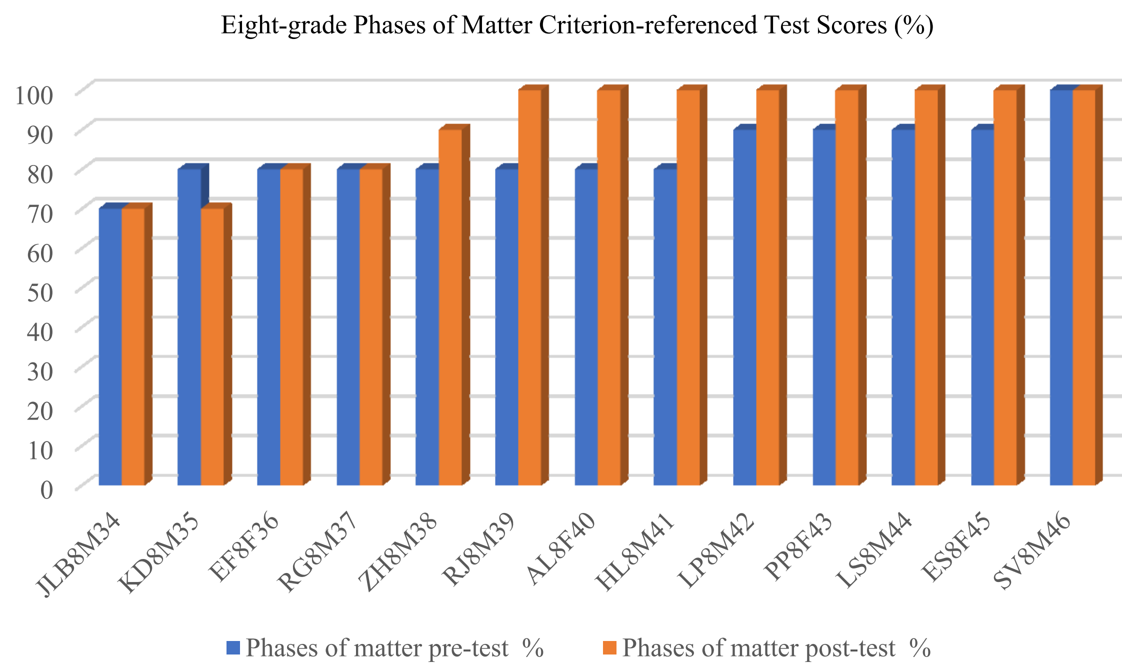


Figure 73. Eight-grade Phases of Matter Criterion-referenced Test Scores (%)

Wilcoxon Sign Rank test results for the eight-grade criterion-referenced Phases of Matter pretest and posttests have been presented in Table 74. The small sample size (N=9), meant that the W-value needed to be used to evaluate the hypothesis. The test results for four subjects with the same scores in both pretest and posttest were discarded and caused a reduction in sample size. Because the sample size (N=9) is not large enough for the normal distribution of the Wilcoxonon W statistic, it is not possible to calculate an exact p-value. The results of the Wilcoxon Signed-Rank test (Table 74) for Introduction to Phases of Matter pretest and posttest indicated that the results were not considered significant at $p < 0.05$.

Table 74

Eight-grade Wilcoxon Signed-Rank Test for Introduction to Phases of Matter Pretest and Posttest

W-value	3.5
Mean Difference	20
Sum of positive ranks	3.5
Sum of negative ranks	41.5
Sample Size (*N*)	9

Note: *N* (9) is not large enough for the distribution of the Wilcoxon *W* statistic to form a normal distribution. Therefore, it is not possible to calculate accurate *p*-value.
The value of *W* is 3.5. The critical value for *W* at $N = 9$ ($p < .05$) is 3. The result is *not* significant at $p < .05$

A comparative analysis between the results of the eight-grade Introduction to Phases of Matter pretest and posttests using the Spearman Rho non-parametric test (Table 75) showed that the association between the two variables (r= 0.67402) was considered statistically significant.

Table 75

Eight-grade Spearman Rho Test for Introduction to Phases of Matter Pretest and Posttest

X Ranks Mean	7
X Ranks Standard Deviation	3.52
Y Ranks Mean	7
Y Ranks Standard Deviation	3.40

Combined
Covariance = 97 / 12 = 8.08
R = 8.08 / (3.52 * 3.4) = 0.674
r_s = 0.67402, p (2-tailed) = 0.01153.
By normal standards, the association between the two variables would be considered statistically significant.

The eight-grade Wilcoxon Signed-Rank Test for the criterion-referenced tests showed that the difference between the diagnostic pretests and benchmark posttest was statistically significant at $p < .05$. Furthermore, testing results using the Spearman Rho showed that by normal standards, the association between the implementation of PBL and test scores was considered statistically significant. The Wilcoxon Signed-Rank Test for the Introduction to Matter pretest and posttest showed that the results were not statistically significant at $p < .05$. However, testing results using the Spearman Rho showed that by normal standards, the association between the implementation of PBL and test scores was considered statistically significant. The Wilcoxon Signed-Rank Test for the Phases of Matter pretest and posttest showed that the results were not statistically significant at $p < .05$. Due to the small sample size, it was not possible to accurately calculate the *p*-value that may have impacted the results. However, testing results using the Spearman Rho showed that by normal standards, the association between the implementation of PBL and test scores was considered statistically significant.

The eighth-grade Design and Build a chair, Design and Build a Density Calculating Model, Changes in Matter, and the Periodic Table of Elements project results have been presented in Table 76. The data was presented as the actual raw score as well as the percentage of the total number of points represented. *Figure 74* below showed parts of student's investigation into the Law of Conservation of Mass as part of the Changes in Matter project. Students designed their experiments (projects) based on the concept that matter could change state as related to the Law of Conservation of Mass.

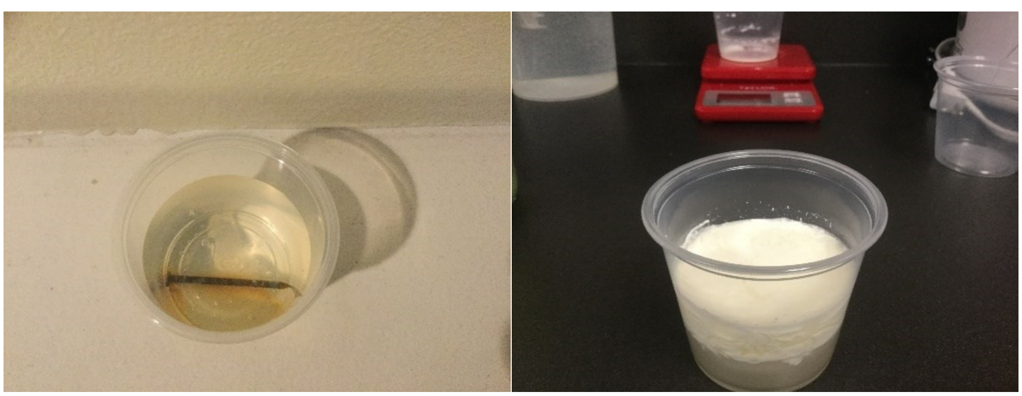


Figure 74. Investigating Law of Conservation of Mass in an Open System

Figure 75 below shows a team of students who completed a chair that was able to hold 240 pounds of weight. The students were expected to create an armchair out of cardboard that could hold the weight of a campus Assistant Director (240 pounds). They were not allowed to use staples, glue, or tape.

Figure 75. Chair Project

Figure 76 below showed an example of one of the devices built by students to calculate density according to the Archimedes Principle. Students were expected to design a device capable of measuring mass and volume to calculate density without the use of modern laboratory equipment.

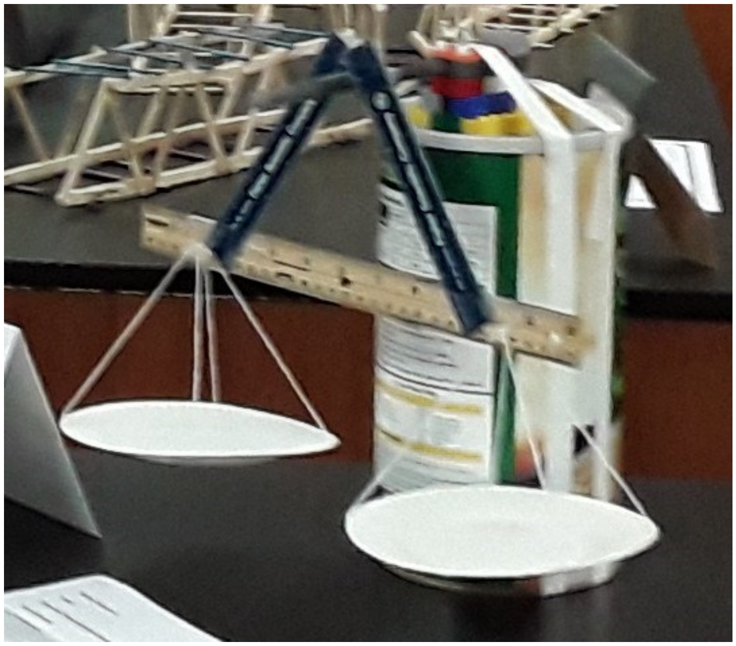


Figure 76. Destiny Calculating Device

Figure 77 shows an example of the periodic table project. Students were required to create a periodic table with a minimum of 40 elements according to the rules of the modern Periodic Table of Elements. Students could choose a create their table based on any topic. Students also completed this project at the control site. *Figure 78* showed an example of the project completed at the control site.

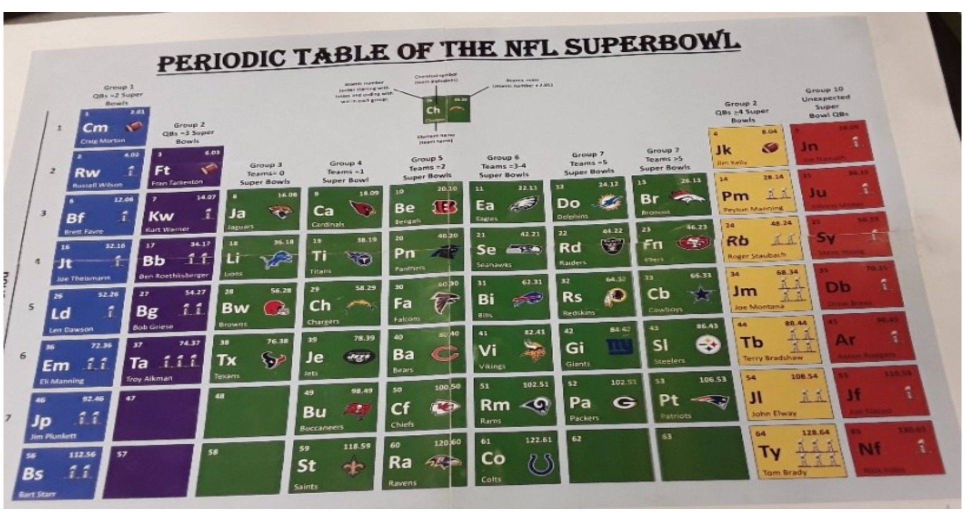


Figure 77. Student-Created Periodic Table of Elements

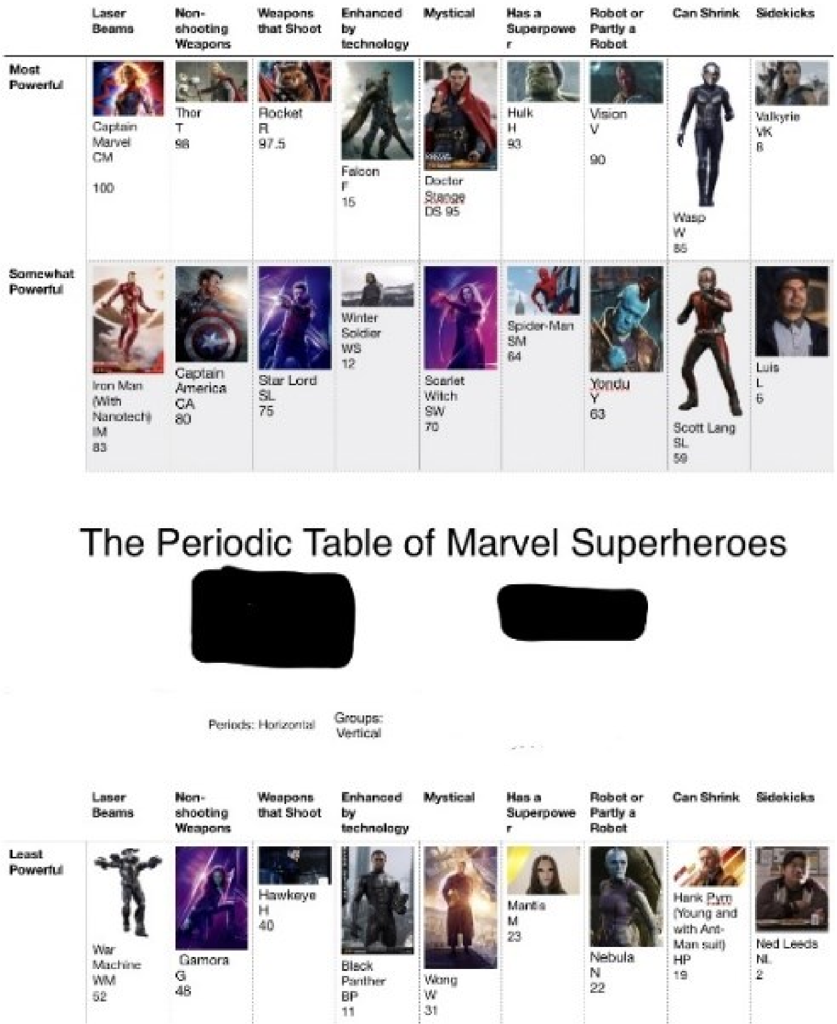


Figure 78. Student-Created Periodic Tabel of Elements (Control Site)

Participant ES8F45 was unable to complete and present the design and build a chair and design and build a density calculating the model.

Table 76

Eight-grade PBL Project Scores

Participant Code	Design and Build a Chair (%)	Design and Build a Density Calculating Model (%)	Changes in Matter (%)	Periodic Table of Elements (%)
JLB8M34	100	92	70	100
KD8M35	100	83	80	80
EF8F36	100	0	86	0
RG8M37	100	100	50	100
ZH8M38	100	67	60	55
RJ8M39	100	100	86	100
AL8F40	85	83	86	75
HL8M41	100	83	40	88
LP8M42	85	0	60	69
PP8F43	100	24	86	93
LS8M44	100	50	0	99
ES8F45	NA	NA	86	72
SV8M46	100	67	54	100

The descriptive data analysis results for the eight grade Changes in Matter project has been presented in Table 77. According to the data analysis, most of the non-normally distributed (*Figure 79)* sample (SD= 25.3327) scores fell to the right of the center (Mdn=70, skewness = -1.4759) with a skinny-tailed distribution (Kurtosis= 2.51953).

Table 77

Eight-grade Changes In Matter Project

	Changes in Matter Project (%)
Mean	64.9231
Standard Error	7.02602
Median	70
Mode	86
Standard Deviation	25.3327
Sample Variance	641.744
Kurtosis	2.51953
Skewness	-1.4759
Range	86
Minimum	0
Maximum	86
Sum	844
Count	13
Largest (1)	86
Smallest (1)	0
Confidence Level (95.0%)	15.3084

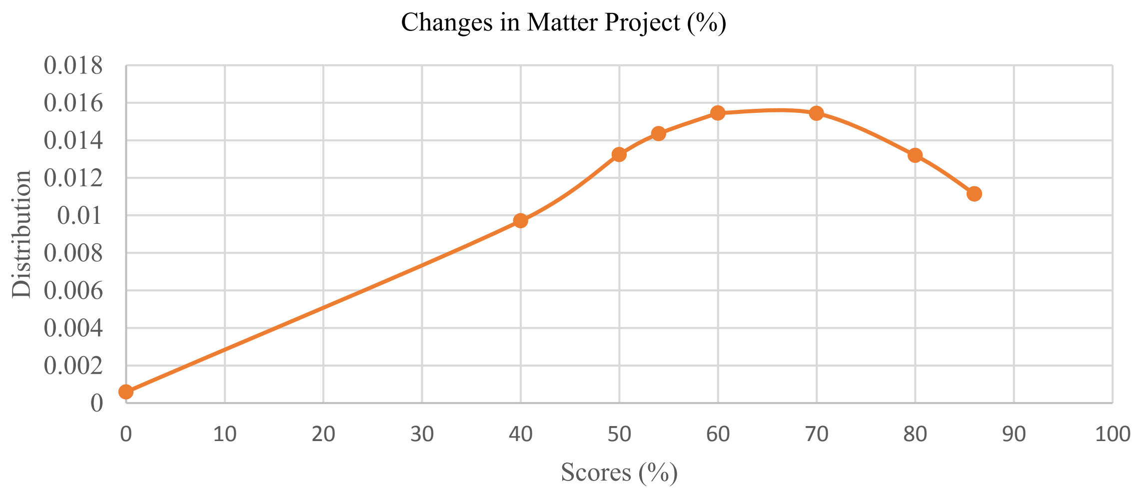


Figure 79. Eight-grade Changes in Matter Project

The descriptive data analysis results for the eight-grade Design and Build a Chair project has been presented in Table 78. According to the data analysis, most of the non-normally distributed (*Figure 80*) sample (SD= 5.8387421) scores fell to the right of the center (Mdn=100, skewness = -2.055237) with a skinny-tailed distribution (Kurtosis= 2.64).

Table 78

Eight-grade Desing and Build a Chair

	Design and Build a Chair (%)
Mean	97.5
Standard Error	1.6854997
Median	100
Mode	100
Standard Deviation	5.8387421
Sample Variance	34.090909
Kurtosis	2.64
Skewness	-2.055237
Range	15
Minimum	85
Maximum	100
Sum	1170
Count	12
Largest (1)	100
Smallest (1)	85
Confidence Level (95.0%)	3.7097597

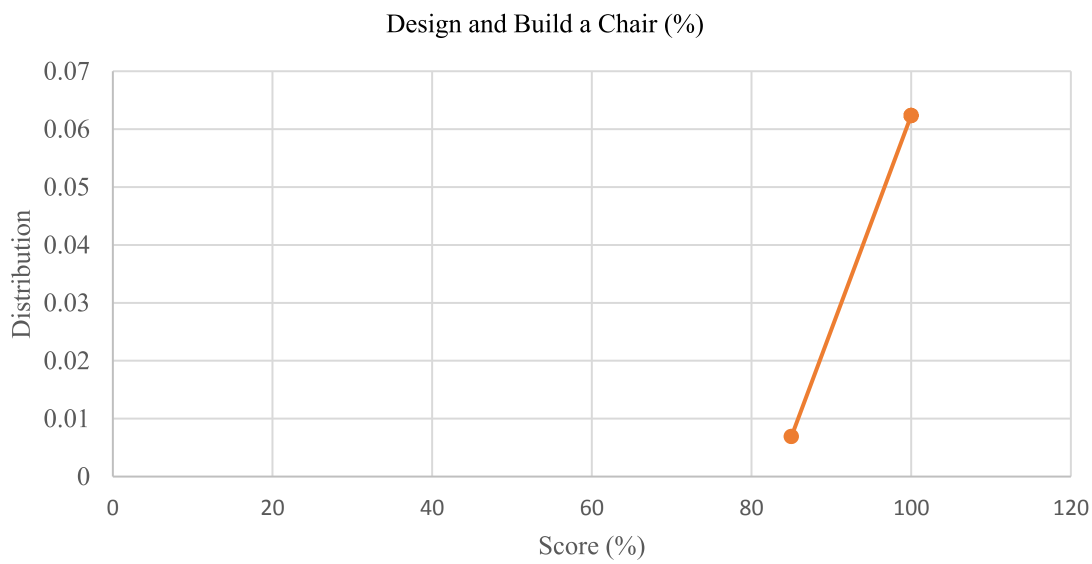


Figure 80. Eight-grade Design and Build a chair project

The descriptive data analysis results for the eight-grade Design and Build a Density Calculating Model project has been presented in Table 79. According to the data analysis, most of the non-normally distributed (*Figure 81*) sample (SD= 38.76325249) scores fell to the right of the center (Mdn=67, skewness -0.62313964) with a skinny-tailed distribution (Kurtosis= -1.27374851).

Table 79

Eight-grade Desing and Build a Density Calculating Model Project

	Design and Build a Density Calculating Model (%)
Mean	57.61538462
Standard Error	10.75099188
Median	67
Mode	0
Standard Deviation	38.76325249
Sample Variance	1502.589744
Kurtosis	-1.27374851
Skewness	-0.62313964
Range	100
Minimum	0
Maximum	100
Sum	749
Count	13
Largest (1)	100
Smallest (1)	0
Confidence Level (95.0%)	23.42439904

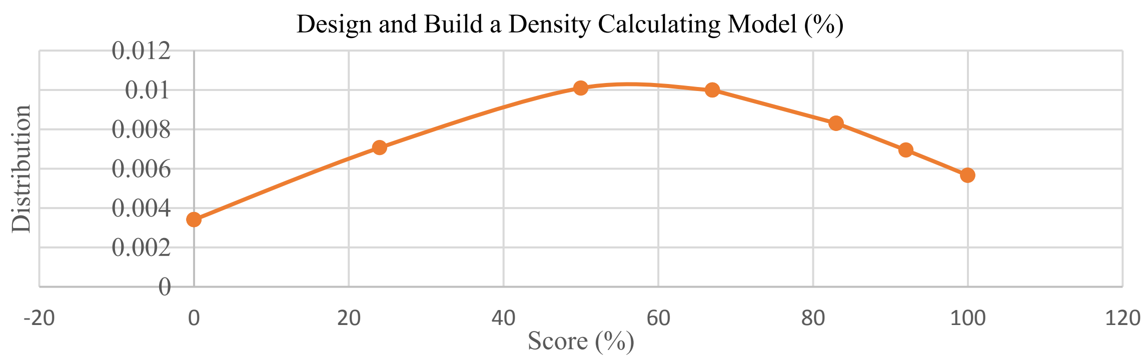


Figure 81. Eight-grade Desing and Build a Density Calculating Model Project

The descriptive data analysis results for the eight grade Periodic Table of Elements project has been presented in Table 80. According to the data analysis, most of the non-normally distributed (*Figure 82*) sample (SD= 28.022) scores fell to the right of the center (Mdn=88, skewness = -2.0967) with a fat-tailed distribution (Kurtosis= 5.20713).

Table 80

Eight-grade Periodic Table of Elements Project

	Periodic Table of Elements (%)
Mean	79.3077
Standard Error	7.7719
Median	88
Mode	100
Standard Deviation	28.022
Sample Variance	785.231
Kurtosis	5.20713
Skewness	-2.0967
Range	100
Minimum	0
Maximum	100
Sum	1031
Count	13
Largest (1)	100
Smallest (1)	0
Confidence Level (95.0%)	16.9335

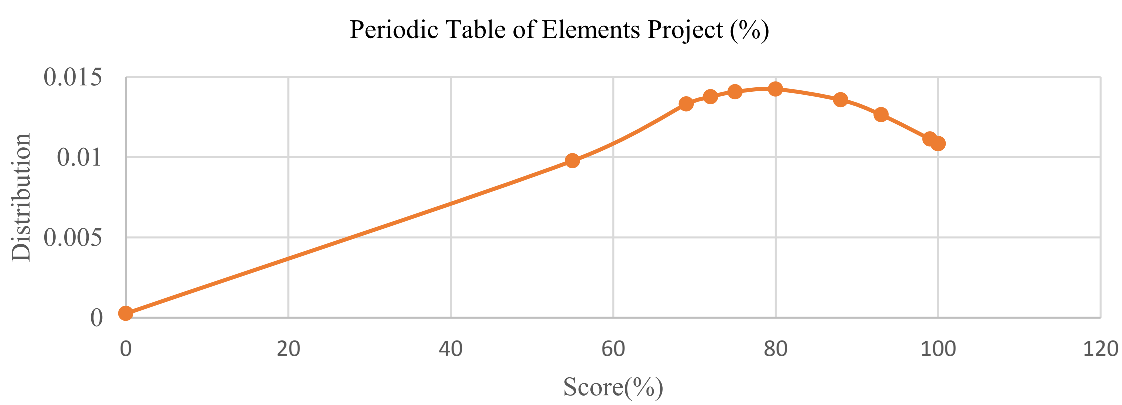


Figure 82. Eight-grade Periodic Table of Elements Project

A comparative analysis of the seventh-grade project scores showed that the most frequent score earned by students was 100 percent, as can be seen in *Figure 83* below.

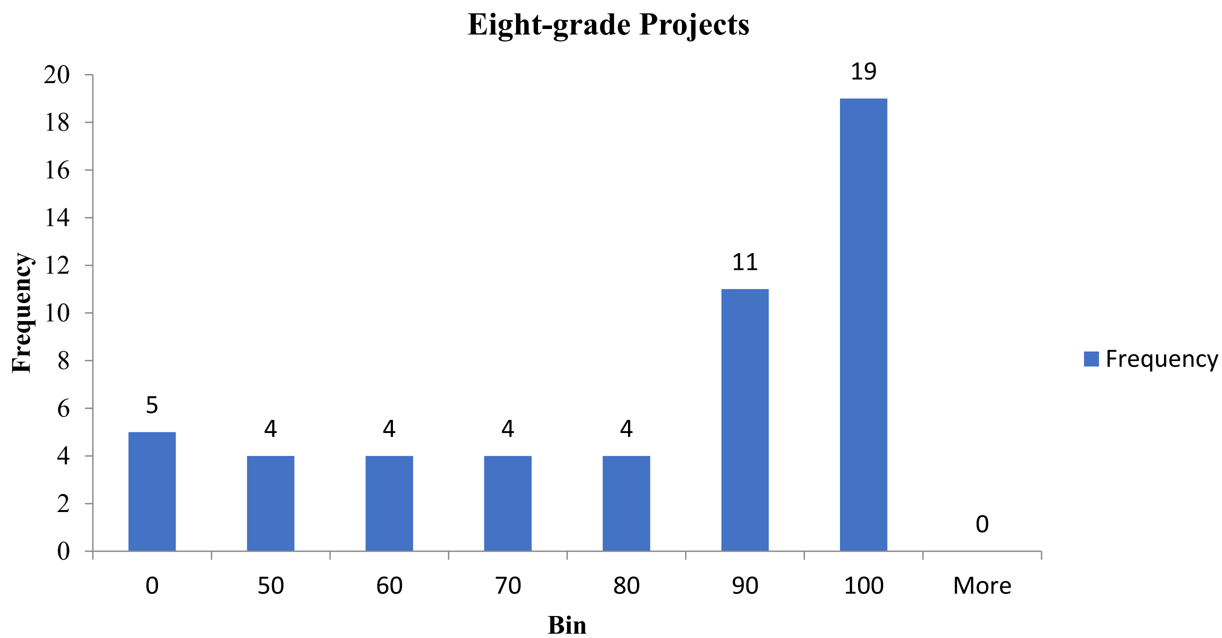


Figure 83. Eight-grade Projects Histogram

Standardized Science CTP4 Testing

The CTP4 Standardized Science Test scores for participants in grades six, seventh, and eight have been presented in Table 81. Students participate in the CTP4 Standardized Science for the first time as sixth-graders. Therefore, only one year of CTP4 Standardized Science Test scores were available for the sixth-grade student participants. In the same token, only two years of CTP4 Standardized Science Test scores were available for the seventh-grade students. Table 81 presents three years of data for eighth-grade students. Participants MA7F17, ZH8M38, HL8M41, PP8F43 were not students at the experimental school site during the academic year 2016-2017. Therefore, the only scores available are from the academic year 2018-2019.

Participant EF8F36 did not participate in the CTP4 Standardized Science Test in the academic year 2017-2018.

Table 81

CTP4 Scores

Participant Code Sixth Grade	CTP4 2018-2019	Participant Code Seventh Grade	CTP4 2017-2018	CTP4 2018-2019	Participant Code Eight Grade	CTP4 2016-2017	CTP4 2017-2018	CTP4 2018-2019	CTP4 Control Site 2018-2019	
NA6F1	682	MA7F17	NA	720	JLB8M34	858	882	900	687	764
NA6M2	611	AG7F18	559	567	KD8M35	641	639	718	855	820
KC6M3	710	JG7M19	633	595	EF8F36	733	NA	804	790	718
RD6M4	742	CH7M20	589	768	RG8M37	704	720	804	611	820
SK6M5	669	DK7F21	522	576	ZH8M38	NA	679	718	837	601
HP6M6	760	IN7F22	463	557	RJ8M39	679	639	611	740	629
NP6M7	644	IT7F23	473	731	AL8F40	539	669	718	855	
MR6M8	695	KA7M24	780	743	HL8M41	NA	547	601	876	
AS6F9	695	SB7F25	644	720	LP8M42	704	709	804	629	
IS6F10	682	BC7M26	671	689	PP8F43	NA	797	990	620	
AT6F11	682	VG7F27	633	679	LS8M44	663	689	648	764	
SV6F12	599	AJ7F28	531	634	ES8F45	581	689	740	820	
SA6F13	549	AM7M29	828	743	SV8M46	733	567	707	990	
AH6M14	725	MN7F30	599	731					764	
AN6F15		DS7F31	656						990	
ST6F16		TS7M32	669						764	
		RT7M33	599						601	
									837	
									837	
									790	
									804	
									764	
									790	
									752	
									677	
									667	
									620	
									709	
									687	
									696	
									752	
									648	
									740	
									876	

The descriptive data analysis results for the sixth-grade CTP standardized testing scores for 2018-2019 has been presented in Table 82. According to the data analysis, most of the non-normally distributed (*Figure 84)* sample (SD=70.02448976) scores fell to the right of the center (Mdn=682, skewness -0.946342804) with a skinny-tailed distribution (Kurtosis= 0.370054442).

Table 82

Sixth-grade CTP Scores 2018-2019

Sixth Grade CTP Scores 2018-2019	
Mean	668.6875
Standard Error	17.50612244
Median	682
Mode	682
Standard Deviation	70.02448976
Sample Variance	4903.429167
Kurtosis	0.370054442
Skewness	-0.946342804
Range	248
Minimum	512
Maximum	760
Sum	10699
Count	16
Largest (1)	760
Smallest (1)	512
Confidence Level (95.0%)	37.31341672

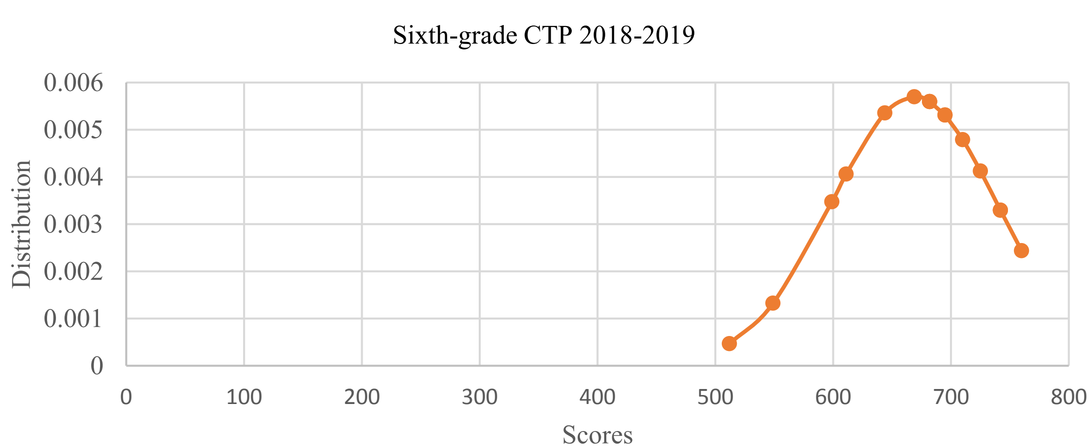


Figure 84. Sixth-grade CTP Scores 2018-2019

The descriptive data analysis results for the seventh-grade CTP4 standardized testing (2017-2018) have been presented in Table 83. According to the data analysis, most of the non-normally distributed (*Figure 85*) sample (SD= 98.35579546) scores fell to the left of the center (Mdn=616, skewness = 0.510511708) with a skinny-tailed distribution (Kurtosis= 0.424606066).

Table 83

Seventh-grade CTP4 2017-2018

Seventh-grade CTP4 2017-2018	
Mean	615.5625
Standard Error	24.58894886
Median	616
Mode	599
Standard Deviation	98.35579546
Sample Variance	9673.8625
Kurtosis	0.424606066
Skewness	0.510511708
Range	365
Minimum	463
Maximum	828
Sum	9849
Count	16
Largest (1)	828
Smallest (1)	463
Confidence Level (95.0%)	52.41010388

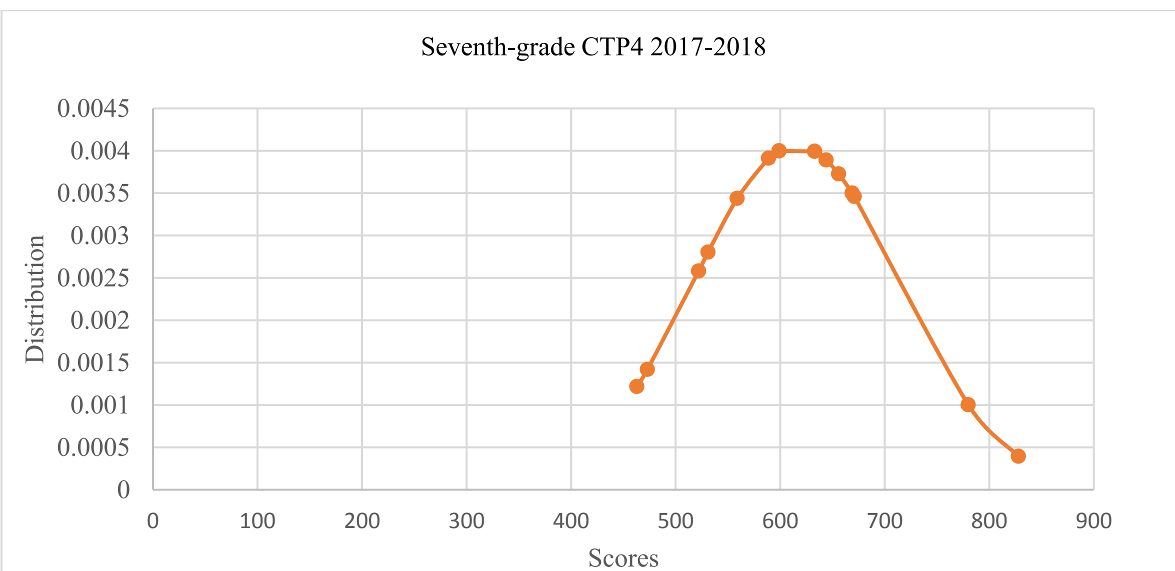


Figure 85. Seventh-grade CTP4 2017-2018

The descriptive data analysis results for the seventh-grade CTP4 standardized testing (2018-2019) have been presented in Table 84. According to the data analysis, most of the non-normally distributed (*Figure 86*) sample (SD= 70.41656515) scores fell to the right of the center (Mdn=720, skewness = -0.786428365) with a skinny-tailed distribution (Kurtosis= -0.854711346).

Table 84

Seventh-grade CTP 2018-2019

Seventh-grade CTP Scores 2018-2019	
Mean	683.3529412
Standard Error	17.07852564
Median	720
Mode	720
Standard Deviation	70.41656515
Sample Variance	4958.492647
Kurtosis	-0.854711346
Skewness	-0.786428365
Range	211
Minimum	557
Maximum	768
Sum	11617
Count	17
Largest (1)	768
Smallest (1)	557
Confidence Level (95.0%)	36.20485701

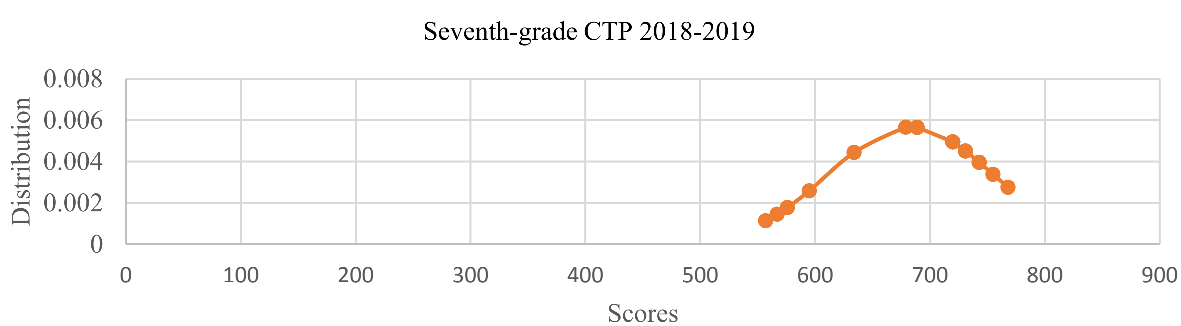


Figure 86. Seventh-grade CTP 2018-2019

The descriptive data analysis results for the eight grade CTP4 standardized testing (2016-2017) scaled scores have been presented in Table 85. According to the data analysis, most of the non-normally distributed (*Figure 87*) sample (SD= 88.08108638) scores fell to the left of the center (Mdn= 691.5, skewness = 0.283285699) with a skinny-tailed distribution (Kurtosis= 1.061266969).

Table 85

Eight-grade Grade CTP4 2016-2017

	Eight-grade 2016-2017
Mean	683.5
Standard Error	27.85368517
Median	691.5
Mode	704
Standard Deviation	88.08108638
Sample Variance	7758.277778
Kurtosis	1.061266969
Skewness	0.283285699
Range	319
Minimum	539
Maximum	858
Sum	6835
Count	10
Largest (1)	858
Smallest (1)	539
Confidence Level (95.0%)	63.00941343

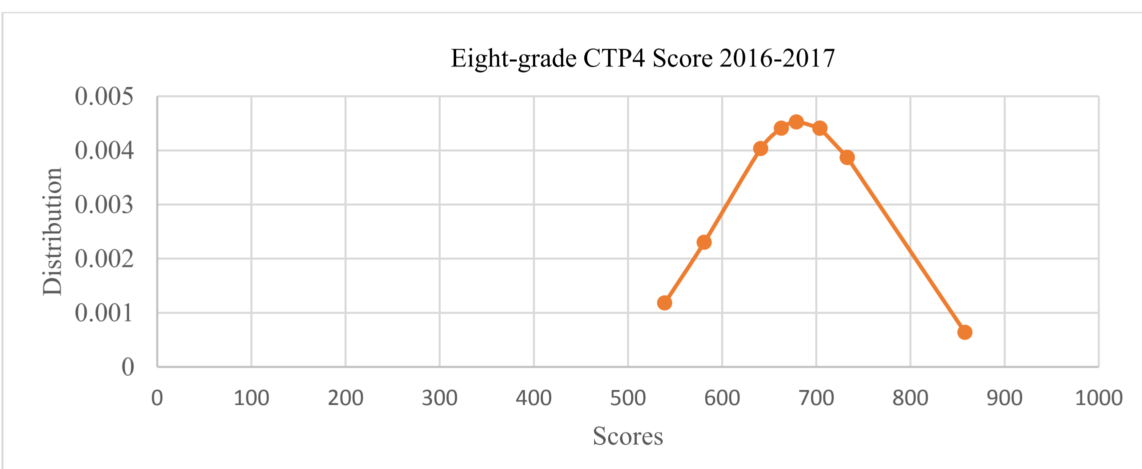


Figure 87. Eight-grade CTP4 2016-2017

The descriptive data analysis results for the eight grade CTP4 standardized testing (2017-2018) have been presented in Table 86. According to the data analysis, most of the non-normally distributed (*Figure 88*) sample (SD= 90.79197001) scores fell to the left of the center (Mdn=684, skewness = 0.656081458) with a skinny-tailed distribution (Kurtosis= 1.118912054).

Table 86

Eight-grade CTP4 Standardized Testing (2017-2018)

	Eight-grade CTP4 2017-2018
Mean	685.5
Standard Error	26.20938416
Median	684
Mode	639
Standard Deviation	90.79197001
Sample Variance	8243.181818
Kurtosis	1.118912054
Skewness	0.656081458
Range	335
Minimum	547
Maximum	882
Sum	8226
Count	12
Largest (1)	882
Smallest (1)	547
Confidence Level (95.0%)	57.6864656

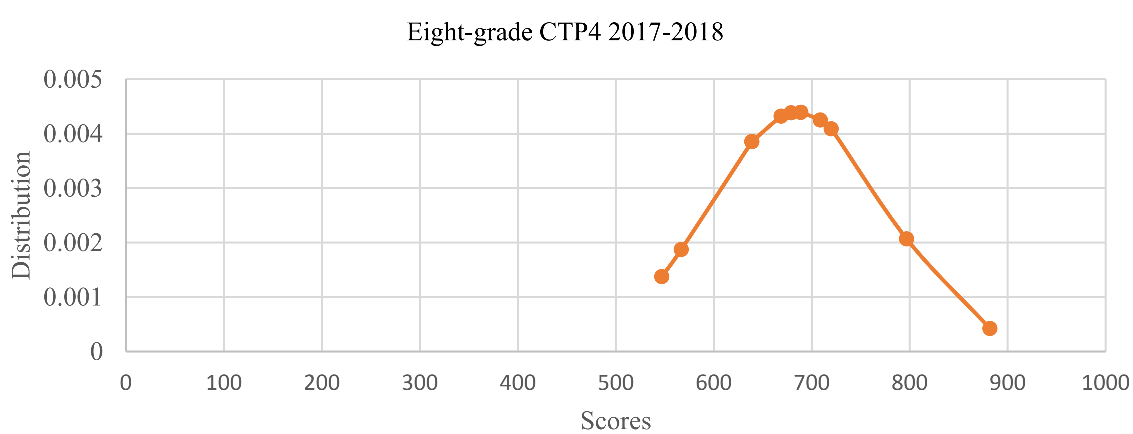


Figure 88. Eight-grade CTP4 standardized testing (2017-2018)

The descriptive data analysis results for the eight grade CTP4 standardized testing (2018-2019) have been presented in Table 87. According to the data analysis, most of the non-normally distributed (*Figure 89*) sample (SD= 110.2202341) scores fell to the left of the center (Mdn=718, skewness = 0.735537473) with a skinny-tailed distribution (Kurtosis= 0.547340939).

Table 87

Eight-grade CTP 2018-2019

Eight-grade CTP Scores 2018-2019	
Mean	751
Standard Error	30.56959274
Median	718
Mode	718
Standard Deviation	110.2202341
Sample Variance	12148.5
Kurtosis	0.547340939
Skewness	0.735537473
Range	389
Minimum	601
Maximum	990
Sum	9763
Count	13
Largest (1)	990
Smallest (1)	601
Confidence Level (95.0%)	66.60542085

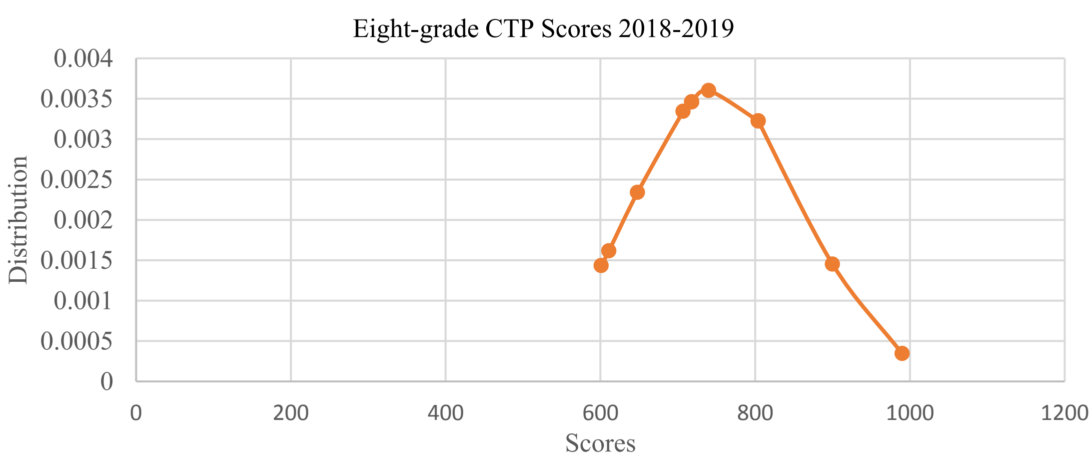


Figure 89. Eight-grade CTP 2018-2019

The descriptive data analysis results for the control site eight grade CTP4 standardized testing (2018-2019) have been presented in Table 88. According to the data analysis, most of the non-normally distributed (*Figure 90*) sample (SD= 98.3696554) scores fell to the left of the center (Mdn=764, skewness = 0.337406173) with a skinny-tailed distribution (Kurtosis= -0.06689845).

Table 88

Control Site Eight -grade CTP 2018--2019

Control Site Eight-grade 2018- 2019	
Mean	754.775
Standard Error	15.55360818
Median	764
Mode	764
Standard Deviation	98.3696554
Sample Variance	9676.589103
Kurtosis	-0.06689845
Skewness	0.337406173
Range	389
Minimum	601
Maximum	990
Sum	30191
Count	40
Confidence Level (95.0%)	31.46014205

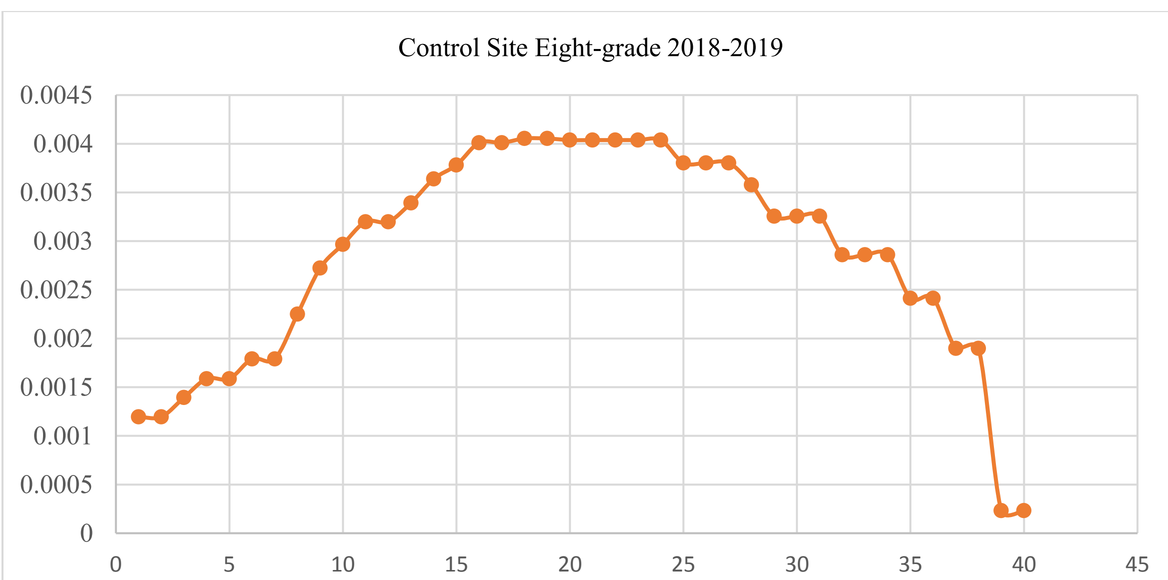


Figure 90. Control Site Eight-grade CTP 2018-2019

Findings of Qualitative Research

The qualitative portion of this study was conducted using an ethnographic methodology to explore how the implementation of technology-integrated project-based learning could impact a middle school science classroom culture. This study was approached with the assumption that multiple educational theories such as constructivism, situated learning, the theory of change, and the theory of learning and awareness impact of the implementation of technology-integrated project-based learning (PBL) in a middle school science classroom.

This study allowed the researcher to collect information from a culture-sharing group using ethnographic methods and showed how the study findings tie back to the study questions. The researcher analyzed and triangulated the data collected from formal and informal classroom observations, structured student and staff surveys, teacher interview, lesson plans and rubrics, classroom artifacts, project presentations, the researcher field journal, interactive student science journals, photographs, and videos taken during the study to uncover codes and themes described in this section. The data collected based on the participants' actions and words provided valuable insight into interactions within the science classroom culture, as well as a unique opportunity for implementation of science lessons and assessments within the project-based learning instructional design framework. The member check gave the researcher a unique opportunity to confirm and discuss the results of the study with the participants.

Fieldwork collection Process

The researcher collected extensive data through observations of the participants' actions and words, the use of field notes, photographs and videos, lesson plans and rubrics, projects, interactive science journals, student artifacts, student surveys, staff surveys, and participant teacher interviews.

Observations of the science classroom. A total of 14 daily and weekly formal observations of the sixth through eighth-grade science classrooms were conducted to collect descriptive data on participant behavior and attitudes using the classroom observations protocol (Appendix R). Additional informal daily as well as weekly field notes and observations about students' progress, problems, explanatory, and reflective notes on the physical setting of the classroom, the participants, activities and interactions, conversations, student attitude and demeanor, and even the researcher's behavior were documented in the researcher's diary as soon as possible following the classroom observation. The confidentiality of the participants was ensured by using pseudonyms, group data reporting, and the use of coded information to be sure that the data collected could not be linked to individual participants.

Formal administrative observation and evaluations. During the study, the school site administrators conducted three formal observations of the researcher's classroom to ensure compliance with the PBL lesson plans with state and school site teaching standards. Classroom formal observations were scheduled using the organization's commonly accessible Google Calendar. Before each observation, the researcher sent an invitation to the administrators via the Google Calendar. Before each observation, the administrators were provided with copies of the formal lesson plan, the Classroom Formal Observation Rubric (Appendix L), and the Lesson Plan Evaluation Rubric (Appendix K) to assist the school site administrators with the evaluation process. The observations were scheduled to allow the administrators to observe all the different aspects of project-based learning from the introduction of the topic to the presentation of the project. Following the formal observation, a formal meeting was scheduled via Google Calendar to discuss the formal observation with the administrator.

Photographs of classroom activities were collected as part of classroom observations to document activities relevant to project-based learning, collaboration, scientific content understudy, and project presentations. Because all students received regular science instruction using PBL, the researcher attempted to collect and used detailed data only from students who voluntarily consented to be participants in the study (Maxwell, 2013). Photographs of the control classroom were taken to show only student artifacts and classroom settings.

C**ontrol Classroom Observation.** The researcher conducted three formal observations in the eighth-grade control classroom using the Classroom Observation Protocol (Appendix R) to collect data. The data collected included information about the lesson and activity being observed, the classroom's physical setting, students' attitudes and demeanors, student conversations, and classroom activities and interactions. During each visit, the researcher was strictly an observer and did not participate in the classroom activities.

Control the classroom's physical setting. The control classroom setting was very different from the experimental classroom. The control classroom was on a campus with access to more substantial space. Therefore, the control classroom (*Figure 91*) was more extensive and had a separate dedicated laboratory.

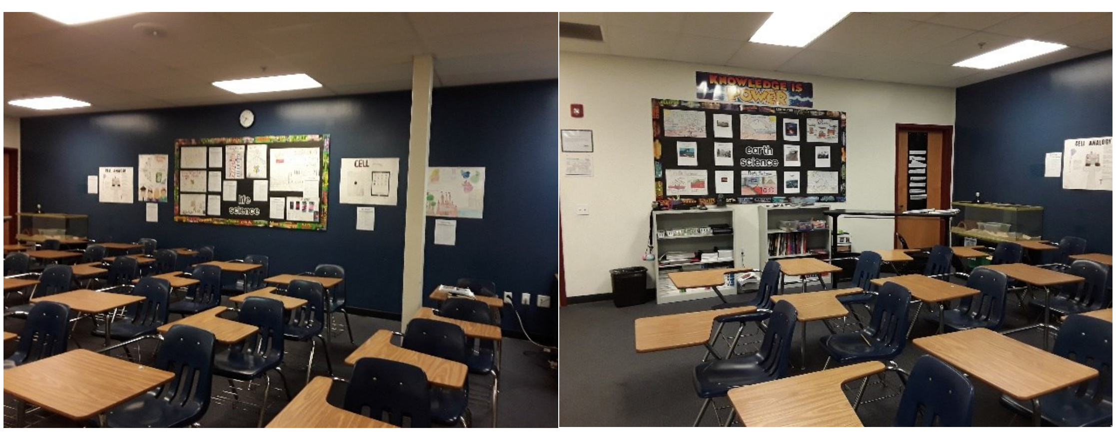


Figure 91. Control Classroom

Lessons and activities. The experimental group and the control group studied the same materials through the course of this study. Both groups used the same curriculum (Thornton et al., 2013) and had similar access to technology, along with administrative support. However, due to restrictions of time and distance, the two groups were only able to participate in the Periodic Table of Elements unit simultaneously. Students received similar instructions about the Periodic Table of elements. Both groups received basic instruction about the structure and historical significance of the Periodic Table of Elements. The project documentation used in the control classroom was different from the documentation received by the experimental group. The experimental group also received different instructions and expectations for the presentation of the final project than the control group (Appendices V and V1). The experimental group received a benchmark lesson to provide context and background for the history and basic structure of the Periodic table. However, the experimental group was expected to gather additional information through extensive research. As can be seen in *Figure 92*, the experimental group was not provided with any other documentation or handouts other than what was available in the student textbook.

The control teacher selected and provided the researcher with anonymous student artifacts collected in the control classroom. When collecting field notes in the control classroom, all notes and observations were recorded using pseudonyms, group data reporting, and use of coded information to be sure that the data collected could not be linked to individual participants. The control classroom teacher removed all student identification information from work submitted to the researcher.

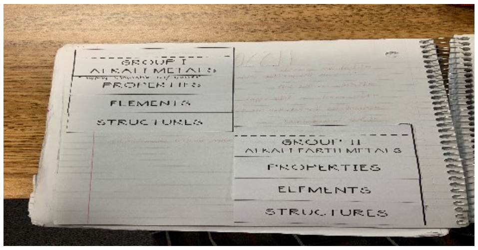
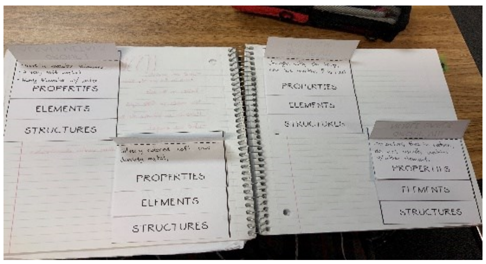
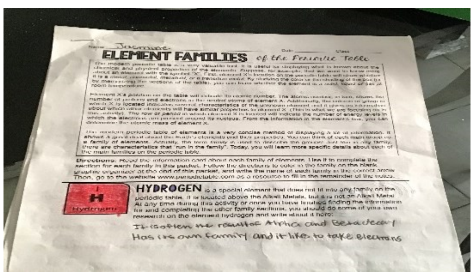
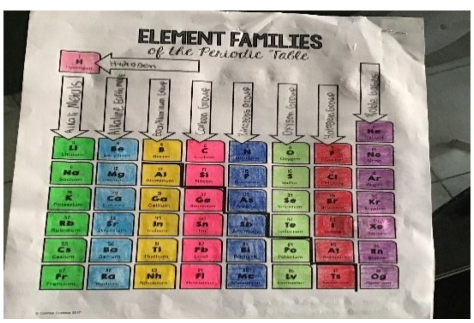
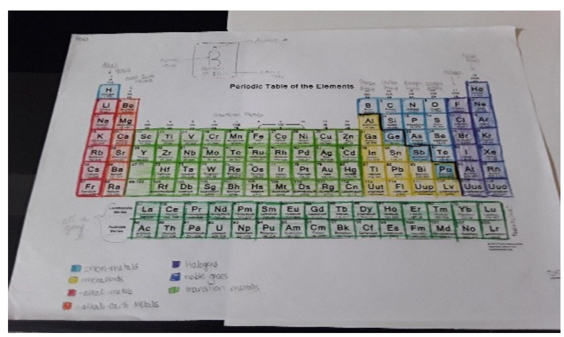
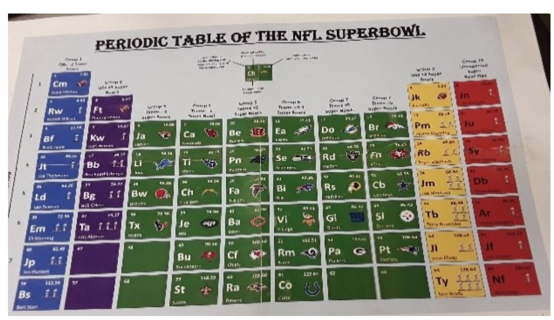
Control Group	**Experimental Group**
	**Not Applicable**
	**Not Applicable**
	**Not Applicable**
	
	

Figure 92. Experimental vs. Control Group (Periodic Table of Elements Project)

Participating in a teacher interview. A single follow-up face-to-face semi-structured interview (Appendix W) was conducted with the control classroom teacher at the end of the study to gain insight into similarities and differences between how PBL could be used to enhance learning in relationship to other research-based instructional strategies. A written copy of the interview questions was provided to the participating teacher during the interview. The researcher kept a written record of the participating teacher's responses to each question throughout the interview process. Additional conversations emerged during the interview because of the professional relationship between the researcher and the participating teacher. Therefore, the participating teacher's written responses to the interview questions reflected the original questions as well as subsequent conversations that helped to inform the purpose of the study.

Lesson plans and assessment. To ensure that the grade-level science standards, as well as school site curriculum goals, were met the researcher selected the topic of the study based on California middle school science standards (California Department of Education, 1998), New Generation of Science Standards (2013) and lesson pacing guidelines provided by the currently used science curriculum (Thornton, Buckley, Miller, Padilla, & Wysession, 2013). The sixth-grade curriculum consisted of an introduction to Earth Science. The topics covered in the sixth-grade curriculum included the basic structure of the earth, plate tectonics, earthquakes, volcanoes, weathering, and erosion as well as the earth's resources.

The seventh-grade curriculum consisted of an introduction to life Science. The topics covered in the seventh-grade curriculum included the essential characteristics of living things, the cell and its structures, genetics, and the science of heredity, DNA, microbial life, plants, animals, and an introduction to the human body.

The eighth-grade curriculum consisted of an introduction to Physical Science. The topics covered in the eighth-grade curriculum included the basic structure of different Phases of Matter, atoms, molecules, and the Periodic Table of Elements, bonding and chemical reactions, acids and bases, forces, and motion (Thornton et al., 2013).

The researcher planned and developed lesson plans that contained literature-based criteria for PBL based on the principals of PBL. Before the introduction of a new topic of study, the researcher assessed students' prior knowledge by using criterion-referenced diagnostic pretests and chapter tests (Version B) provided by the currently used science curriculum. The topics for each grade level were introduced using a concept map (Appendix M). The concept maps created at the beginning of each unit were displayed through the end of the unit or the completion of a chapter as the means of documenting whole class progress (Ozdemir, 2006; Rye et al., 2013). The concept maps were used for formative assessment of students' progress throughout the life of the unit or a chapter.

As part of the whole class instruction, the teacher provided additional information through a benchmark lesson. After the benchmark lesson, students were presented with the needed documentation and instructions to begin working on their projects. As part of regular classroom practices, students were placed in small groups who worked together towards finding the answer for a common driving question in a project using the principles of PBL integrated with the currently used science curriculum. Students were provided with guidelines and an organizer packet to follow over the project period (Appendix Y). Students were also provided with the assessment rubrics and needed technology training before the start of each project. Students' projects were assessed using formative assessment rubrics (Appendix S) designed to monitor progress and summative assessment rubric (Appendix T) designed to evaluate the final project presentation (Thornton et al., 2013).

Students submitted their plan (design) for the project (Appendix O) before the start of the project. As part of their plan, students submitted a timeline for project completion (Appendix Y), presentation of the final product, and individual student self-evaluation (Appendix P). The researcher provided students with guidance as needed and a checklist to assist the students with the process of formulating a driving question (Appendix N) that their investigations would answer. Problems designed by students were developmentally appropriate, utilized student personal knowledge and experiences, considered student skills and resources, and supported classroom curriculum goals. Students designed and tested their projects or prototypes and maintained detailed documentation of their design process using their Interactive Science Folders and Journals (Appendix U).

Formative and summative rubrics (Appendix S &T) were used to measure students' success at completing their projects effectively with their team members and as individuals. At the completion of project, criterion-referenced tests (diagnostic unit pretest, chapter tests, and benchmark summative unit posttest) available as part of the teacher resources that accompany the existing curriculum (Thornton et al., 2013) were administered by the researcher as part of the classroom assessment practices to measure comprehension of materials and ensure content knowledge proficiency. The tests included multiple-choice, fill-in-blank, true, or false, short answer, essay questions. The researcher administered the tests as part of the classroom assessment practices.

The formative assessment rubric (Appendix S) provided students with feedback while the project (investigation) was still in progress to allow students to make necessary changes and corrections as they moved toward completion of the projects or investigations and achievement of learning goals. A rubric-based summative assessment (Appendix T) (Thornton et al., 2013) was also conducted to evaluate students based on items such as meeting project milestones on time, quality of the final product, teacher observations of students' work in the classroom, team reports, individual reports. In preparation for project presentations, the students worked collaboratively with the teacher to review and evaluate the whole project, select materials to share, find creative ways to share their knowledge and make a purposeful transition between the conclusion of the project and the topic of study in the current as well as the next project (Ozdemir, 2006).

Each student was involved in representing what was learned while working in their level of core competencies through the production of artifacts and products. The completed products of the projects consisting of group and individual written reports, a poster, and model presentation demonstrating a scientific principle were evaluated at a culminating event where students shared what they had learned with others.

Interactive science journals. Throughout the investigational process, students were responsible for maintaining their detailed and chronological individual and collaborative group notes using their Interactive Science Folders and Journals. Students designed and tested their project and maintained detailed documentation of their design process using their Interactive Science Folders and Journals (Appendix U).

Students maintained their detailed and chronological individual and collaborative group notes using their Interactive Science folder and Journals throughout the life of the study. Student folders and journals were assessed using the Interactive Science Folder and Journal evaluation rubric (Appendix U). Students were evaluated on the quality and type of data recorded during the life of the project. Students documented the concept map (Appendix M) that was created during the topic introduction in their science journals. As part of each class period, students updated their notes and concept map to show daily progress. At the end of a project, students reflected on their collaborative efforts (Appendix Q) by describing the general process followed by the group to achieve their learning goals, state their contributions to the team effort, and suggestions for future improvements. Student reflections provided the researcher with insight into how the groups were functioning and any necessary future changes that needed to be made (Frank & Barzilai, 2004).

Student artifacts. The researcher collected artifacts demonstrating the implementation and use of PBL and technology integration into the currently used science curriculum. Additional, artifacts such as quizzes, examination results, and formal and informal student products such as Interactive Science folder and Journals, research papers, and project background reports were collected based on their relevance to the learning activities, demonstrating student engagement in the classroom learning activities. Other artifacts collected included class handouts, weekly lesson plans, and pictures of students engaged in PBL activities. When collecting student artifacts, all identifying information, including the student name, was removed to make sure that the data collected could not be traced back to any participant in the study.

Fieldwork Coding Process

The raw data collected was sorted and manually organized. A codebook was developed, including a list of data collected along with the description of each type of data collected and the numerical values assigned by the researcher. The researcher examined the data collected, including the field notes, student artifacts, and photographs taken during the study while writing memos from an emic perspective to develop organizational themes by grouping similar codes using a conventional axial coding method that allowed for the elimination of redundancy and overlap of codes. Photographs were also tagged and coded similarly. Axial coding allowed for an understanding of contextual relationships between themes (Creswell, 2013).

The data was then coded using Microsoft Excel 2018 spreadsheets as well as Microsoft Word 2018 to clarify the text from the qualitative data collected during the study (*Figure 93*). The field notes, observations, Interactive Science Journals, open-ended survey questions, teacher interviews as well as photographs underwent a process that allowed for examination and coding of data based on common characteristics, thus helping the researcher to answer the study's guiding questions. The ethnographic fieldwork analysis and the subsequent coding process lead to the identification of 11 themes that helped explain the classroom culture as a culture-sharing group. The seven themes that emerged from the analysis of the student surveys were: (a) life and social skills; (b) collaboration and teamwork; (c) learning and understanding; (d) leadership and responsibility; (e) communication; (f) academic skills; and (g) real-world experience. The four themes that emerged from the analysis of the staff surveys and the teacher interview were: (a) benefits of collaboration and teamwork; (b) challenges of collaboration and teamwork; (c)

Project-based learning; and (d) use and role of technology in the classroom.

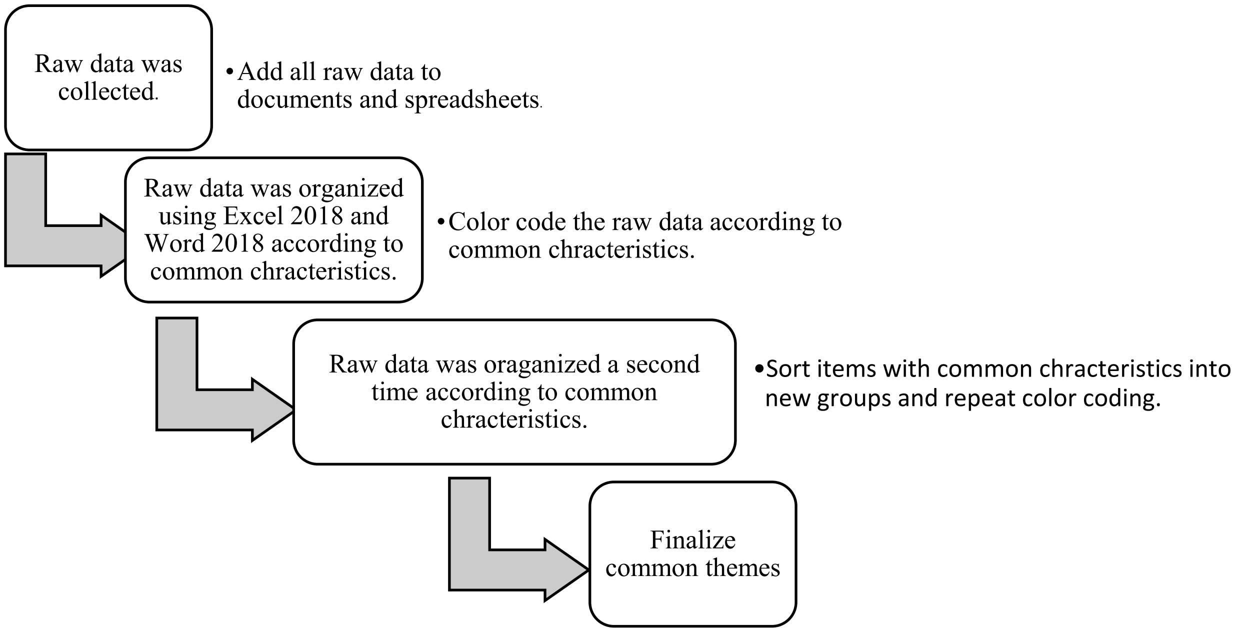


Figure 93. Fieldwork Coding Process

Student Surveys. The data collected from the open-ended questions found in the students' Pre-study and Post-study surveys were organized into Tables using Microsoft Excel 2018 software for further analysis. The researcher listed all responses, identified common themes, grouped the data according to common themes, and created graphics to assist in data analysis. The themes that emerged from the analysis of the students' Pre-study and Post-study surveys were: (a) life and social skills; (b) collaboration and teamwork; (c) learning and understanding; (d) leadership and responsibility; (e) communication; (f) academic skills; and (g) real-world experience.

Life and social skills. Life and social skills emerged as one of the themes in the students' survey. In their response's students listed time management; development of social skills by working together; dealing with different personalities; cooperating within a team;

meeting deadlines; organizational skills; research and presentation skills; creativity and problem-solving as meaningful life and social skills learned through project-based learning.

Collaboration and teamwork. An additional theme that emerged from the analysis of the student surveys was collaboration and teamwork. In their response's students stated some of the benefits of collaborative teamwork, such as the ability to discuss and exchange thoughts and ideas. Participants also believed that work became more natural and more interesting because they could work together as a team, so "more work could be done, which made the project easier and more fun." Work also became less stressful because "everybody took part in the project; that way, there was no huge amount of workload." Survey data showed that students liked working in groups because "groups were supportive," which helped them to "feel as if they had an extra commitment to the group to finish on time." Many also enjoyed talking to the other teams regarding their projects because they thought that "when working in groups, students could learn a lot and gain a lot of new perspectives on the topics that their classmates were learning." Students believed that lack of cooperation, someone not doing a part, arguments, talking, and being distracted were the main challenges when working in groups.

Learning and understanding. Analysis of the open-ended student survey questions led to the emergence of learning and understanding as one of the themes in the study. In their response's students stated that one of the benefits of working collaboratively in groups was that they could "further expand their knowledge by hearing other's ideas and seeing things from different viewpoints." Students believed that working collaboratively, they could learn more by brainstorming different ideas and help each other to understand the concepts. Therefore, the student thought that they did not "need to rely on the teacher for getting a question answered." Student responses suggested that the social support received while working in groups helped them to learn while making work fun. Additionally, many felt that the research the teams did as part of developing their projects allowed them to "learn the information better by finding the information using more senses."

One student participant did not believe that "working on a project was not an effective way of learning science." However, the student qualified this answer by saying that working on a project helped with a more in-depth understanding. Many of the student responses showed that they felt that project-based learning was an effective way of learning science because "you can see what you are learning in action, not by the teacher standing in front of a classroom and talking." Student responses indicated that they liked the hands-on aspects of project-based learning because "kids are a little immature and like to play with weird things and make weird stuff. It is more fun." As one student stated, "you do not have to sit and learn, you can build things, innovate and discover new things as you learn more about the topic. Because I must research the topic and then make a model, I remember the topic better."

Leadership and responsibility. Leadership and responsibility emerged as one of the themes in this study. In their comment's students stated that they believed that one of the benefits of working in teams was that they could "expand their leadership skills" by "working hard," "being trustworthy," and taking responsibility for the team's success. Students also believed that communication skills were essential to the team's success. As stated by one of the participants, "when working in groups, you learn to work together in unity. You learn to take responsibility and be a leader. You learn to better communicate with other group members."

Academic skills. Academic skills were one of the themes for this study. The student responses given on the survey showed that they believe that "one of the skills the teacher wants us to learn by doing a project is to understand the concept and become an independent learner fully." Student data showed that students preferred "doing projects" to show progress on academic skills such as critical thinking, problem-solving, and writing, and reflection. One student indicated that projects rather than the test would be a better way to assess students on the acquisition of academic skills because being assessed through a project rather than a test because "for projects you have to show that you understand while in the test you have to memorize the vocabulary and functions."

Real-world experience. One of the themes for this study dealt with the real-world connections of each project. In their comment's students stated that PBL was an effective way of teaching because students were able to experience many aspects of real-life such as working with other people, time management, organizational skills, research skills, presentation skills, coping with deadlines and responsibilities. Many stated that they believed PBL allowed them to 'experience science in the real world" and see "how the topic of the lesson reflects in real life." One student stated that in their opinion, PBL was "an effective way to learn science because it replicated what it was like to be a scientist working in a science lab rather than simply taking on a project."

Staff Survey. The themes that emerged from the analysis of the staff surveys were: (a) benefits of collaboration and teamwork; (b) challenges of collaboration and teamwork; (c) Project-based learning; and (d) use and role of technology in the classroom.

Benefits of collaboration and teamwork. The analysis of the responses given by the administrative and teaching staff who participated in this study indicated that they saw many benefits for the use of collaboration and teamwork in the classroom, such as the development of leadership skills, social and life skills. One of the participants said that working in groups allowed the students to generate "ideas in a "hive mind," thus "developing cooperative skills" and the ability to communicate effectively by “listening to others thoughts and ideas and hearing how others process information.” Participants also felt that working in groups was useful for teaching students how to work effectively with others while “practicing with real-world situations.” Furthermore, the participants believed that “collaborative learning ensured participation and a higher level of learning” because “students could discuss, explain, and reflect on their understanding.”

Challenges of collaboration and teamwork. The analysis of the responses given by the administrative and teaching staff who participated in this study indicated that they saw many challenges for the use of collaboration and teamwork in the classroom. Many teachers believed that it would be difficult to grade the projects since “some students may not be as dedicated to getting a good grade as others.” The teachers were concerned that “students may not understand what needs to be done and 'divide up' tasks without understanding the tasks.” The teachers were also concerned with the issues of classroom management. Many teachers believed that “ensuring students were on task, ensuring equitable distribution of labor, and managing personality conflicts” would be challenging. Additionally, teachers who dealt with students who were in the process of learning English as a second language were concerned that these students would be “passive learners and hesitant to participate in groups” due to issues created by lack of command of the English language.

Project-based learning. The staff participants were asked to give their definition of project-based learning. The administrators stated that they believed PBL to be” when students learn by choosing to investigate a problem with real-life applications presented by the teacher to show that they have learned in the lesson in place of a test.” The teachers defined PBL as” “when students learn by investigating an assigned problem with real-life applications in place of a test to help them learn the lesson or show that they have learned the lesson."

Use and role of technology in the classroom. The administrative and teaching staff had different ideas about the use and role of technology in the classroom. The participating administrators believed that the use of technology-integrated project-based learning as presented by this study to be beneficial to the students by providing them "with the tools necessary for future success." The administrators believed that it was essential to use technology in the classroom. However, their concern was that the use of technology could interfere with the "completion of the curriculum and having the students learn all the necessary academic skills." Administrators also indicated that they believed that "teacher buy-in" and knowledge of teaching methods needed was their most significant constraints when thinking about the implementation of project-based learning.

The participating teacher's views ranged from "technology can sometimes be a distraction more than it is engaging" to "technology opens new avenues with projects and levels of understanding that are different from traditional methods." Some teachers stated that they use technology almost daily to help students make real-world connections. These teachers believed that there was a "place and value for the use of technology mixed with traditional methods in today's classroom, and there should be a balance of both in a student-driven classroom." In consideration of college and career readiness, one teacher stated that "students learn better how to use technology in a guided manner and have more opportunities to learn how to access a wide range of information." On the other hand, some teachers "preferred non-technology-based projects, or projects using "tried and true" methods like PowerPoint. Sometimes the amount of effort to implement the project does not merit the results." These teachers believed that giving students access to technology means that they “want to multi-task and get distracted with games, making it difficult to monitor everyone's attention and engagement."

Additionally, teachers were concerned that students become “dependent on looking to the internet for answers so that they do not have to think their way through a process. They believe that Google has all the answers and that all the answers on Google are correct. They do not bother to assess the validity of the information they found.” Although they agreed that the skills needed for effective use of technology could be taught, they stated that they lacked resources and time to learn the “technology before putting it hands of students.”

Teacher Interview. The teacher interview responses were analyzed according to the themes of the study. The teacher interview themes were learning and understanding, leadership and responsibility, real-world experience, benefits of collaboration and teamwork, challenges of collaboration and teamwork, project-based learning, and the use and the role of technology in the classroom.

Learning and understanding. CCT’s felt that PBL was “a great technique to learn more about and implement in my classroom.” However, CCT also felt that there was a place “for traditional teaching methods alongside PBL that help students develop important skills.” CCT believed that a balance of traditional methods alongside PBL could create a beneficial curriculum model. According to CCT, during a lecture, students may learn how to focus and engage in the discussion, as well as learn how to take notes and draw diagrams efficiently. This opinion was based on CCT’s belief that the ability to listen to information and take useful notes has helped CCT become a successful adult. However, CCT stated that the benefits of PBL could significantly enhance some of the less engaging methods of teaching, such as a lecture. CCT said that PBL was an effective method of teaching because students were able to integrate concepts into real-world applications that were more likely to engage them in the material. Engagement could lead to higher retention. CCT did not wholly feel comfortable using PBL exclusively due to a lack of training and knowledge. CCT agreed that gaining more understanding of the process, and seeing other teachers using the strategy effectively could lead to a change of opinion.

Leadership and responsibility. When asked about allowing students to design their projects, CCT stated that "I think that this would be a great method for students who have already gotten accustomed to PBL, so they understand the process. Without prior experience, I could imagine that students would have a hard time with task management and time constraints. They might also have a difficult time delegating responsibility effectively so that everyone is fully involved."

Real-world experience. When discussing the application of PBL to the real-life, CCT stated that "the advantages of implementing PBL in middle school is the level of engagement and retention that can be attained by allowing students to work through real-world problems to understand the content. Students also use more higher-level thinking as they work through PBL than they would with just lecture alone."

Benefits of collaboration and teamwork. According to CCT, "the benefits of inquiry-based learning is the level of independent learning and personal engagement of the students. They have ownership of the topics they learn, which can be a powerful motivator for students as well as allowing for a higher level of differentiation for a variety of learning styles and levels."

Challenges of collaboration and teamwork. CCT felt that PBL helped "to focus students on particular topics, whereas inquiry-based learning seemed to have a less defined roadmap. Inquiry-based learning can be extremely intimidating to teachers who may not have complete knowledge of the concepts they want to cover. It can also make grading and curriculum develop more of a challenge since the students drive the direction of the curriculum to a more significant extent."

Project-based learning. The control classroom teacher (CCT) defined PBL as "an assignment that requires students to work in groups or independently to complete a task which expands on a concept learned in class. Typically, the amount of effort involved is above the level expected on a normal class activity. Projects also have a higher point value than a normal assignment due to the additional effort that is expected. They usually have a longer time to complete their work as well." CCT felt that PBL allowed for "some independent learning but in a more controlled way since the students are given a specific problem to solve or scenario to develop, giving teachers a little more control and direction of the curriculum. It also still allows for differentiation since the students will develop solutions at the level of their ability."

Use and role of technology in the classroom. CCT used technology as part of her curriculum and instruction. Students had access to a personal iPad. However, they were only allowed to use them if they were involved in a teacher-directed activity. According to CCT, "a rubric and guidelines for teacher-selected projects would be given to the students at the beginning of the project so the students would know what to expect and how they will be assessed." While the students worked independently, the CCT supervised and guided students as needed. At the end of the project, students would be expected to turn in a "product of some kind or present their product to the class."

Validity Issues

Validity referred to the ability of a method to measure what the researcher believed it should be measuring (Maxwell, 2013). To establish internal validity researcher addressed how well the research instruments measured what they were expected to measure through evaluation of formative and summative criterion-referenced tests used for this study to make sure all the relevant areas of the topic studied were represented in the tests. A comparison was made between materials taught and what was tested. The similarity between these areas indicated very high content validity. The criterion-referenced tests were provided by the publishers of the textbook (Thornton et al., 2013) and as such, contained high item validity and sampling validity. The item validity was used to verify that all elements of test B (pretest) and test A (post-test) covered the topics studied in the classroom. The sampling validity was used to make sure that the questions used tested the full breadth of the content taught.

Internal validity allowed the researcher to say with a degree of certainty that no other variables other than the independent variables were responsible for the change in the dependent variables (Maxwell, 2013). Threats to internal validity included unclear test directions that could have caused the participants to misinterpret the question and thus provide an incorrect or an incomplete answer. Additionally, confusing, and ambiguous test terms, as well as vocabulary and acronyms that were too difficult for test-takers to understand, could have made it difficult for the test takers to answers the questions on the test. Untaught items included in the achievement tests and failure on the part of the students or proctors to follow standardized test administration procedures might have influenced the test results.

To control the threats to internal validity, the researcher used multiple validation strategies. Intensive long-term involvement (ethnography) led to repeated observations. The continued presence of the researcher as a participant-observer (ethnographer) helped rule out distortions and premature conclusions. Triangulation of detailed and varied data such as detailed note-taking as well as an accurate transcription of specific events was used to help the researcher develop a complete account of the events studied. A member check was employed to overcome researcher bias and misinterpretation of the participants' comments and actions. To further overcome researcher bias, the data was collected but not examined or analyzed until after the study data collection phase had been completed. The data collected was extensively searched for discrepant evidence and the sources of the discrepant data to identify and communicate the diversity of activities and perspectives in the setting, and the population studied (Maxwell, 2013; Oliver-Hoyo & Allen, 2006).

To control bias, the researcher compared the data collected in the experimental classroom using PBL with the data collected in the control classroom using traditional research-based instructional strategies. To avoid bias in the data collected, the researcher used an intercoder agreement of 80% between multiple coders of data sets based on the code names, coding of the same passages the same way, and the agreement on the themes of the study. Additionally, the researcher triangulated control classroom data with other sources of data collected and checked for alternative explanations.

External validity addresses how well the findings from a research study could be applied to additional participant's circumstances such as people in different settings, different ages, or from alternate lifestyles (Maxwell, 2013). External Validity measured whether interferences gained from this test or study could be held for participants in an alternative situation such as those involving different age groups, socioeconomic groups, and people of diverse cultural backgrounds. Threats to external validity, such as funding or frequency of intervention, could determine if the results of the study can be generalized across types of students, organizations, and schools. Treatment variations created by external variables such as funding or frequency of intervention, outcomes of the study, and settings created by the availability of resources were among other threats to external validity. External validity could be increased through participant sampling choice. A more significant sample size with multiple demographics and ethnicities, socioeconomic status, as well as international participants, could have increased external validity.

CTP4 test used by the researcher's organization measured advanced skills in keeping with the advanced curriculum used by the organization. Because the study school selected has no features that make it different from other small private school organizations with a traditional science curriculum offered in grades six, seven, and eight, the researcher found no reason to study teachers in other private school settings. Students participated in surveys anonymously to ensure that students were responding honestly, thereby eliminating any power the researcher might have had over them as their science teacher. Data collector characteristics and data collector bias were controlled because the researcher was also the data collector. Educational Records Bureau (ERB) scored the Standardized Science Achievement tests, thus helping to eliminate validity issues caused by collector bias and teacher fatigue (Creswell, 2013).

Summary

The researcher conducted a Quasi-experimental (Nested design) ethnographic study to explore if the implementation of technology-integrated PBL in a middle school science classroom could enhance existing science curriculum while adhering to the curriculum standards and lesson pacing guidelines would lead to changes in students' attitude and aptitude resulting in an improved overall academic achievement for science. Additionally, this study attempted to determine if administrative support could serve to change the attitude of teachers with basic knowledge of technology toward the implementation of technology-integrated PBL in their classrooms to improve students' levels of academic achievement.

The purpose of this study was achieved through analysis of data collected from structured student and staff surveys, Science Standardized Testing (CTP4), observations, field notes, lesson plans, rubrics, interactive science journals, and student artifacts. The data collected was analyzed quantitatively as well as qualitatively.

The quantitative data analysis was conducted using both descriptive statistical tests as well as inferential statistical tests. Due to a small sample size, the data collected from students and staff structured surveys, Science Standardized Test (CTP4), and criterion-referenced tests were analyzed using non-parametric inferential statistical tests, including Spearman's Rank Correlation (Spearman Rho), Wilcoxon Signed Rank test. The level of significance of 0.05 was set for each statistical analysis test used. The data analyzed quantitively using the Excel 2018 Data Analysis Tool Pack and Real Statistics Resouce Pack for Excel 2018 (Zaiontz, 2019).

The data generated by Likert-style survey could only say one score was higher than another, but could not provide the distance between the two points (ordinal data). The student survey results showed that students' rating of their favorites academic subjects, as stated in the Pre-study and Post-study surveys (Table 11) decreased 15.2% for mathematics, increased 2.5% for Spanish, decreased 7.9% for Literature, increased 2.2% for Art, increased 0.8% increase for science and decreased 3.4% for Language arts during the life of the study. An overall comparative analysis of the students' Pre-study and Post-study surveys did not show significant levels of change despite the shifting of the students' opinions from one category to another.

A comparative analysis of teachers' and the administrators' surveys (table 17) showed that 99.99% of administrators responding to the survey either strongly agreed or agreed that they would like to see teachers use more complex tasks in the classroom whereas only 49.99% of teachers agreed with them. Both groups responded the same way when asked about their level of motivation for the implementation of technology-integrated PBL in the classroom. There was an apparent disconnect between the views of the staff and students regarding the use of digital devices in the classroom. As shown in table 18, an average of 30.9% of students either strongly agreed or agreed that they learned more when they used their digital devices as opposed to 18.74 of teachers and administers who agreed with them.

The descriptive statistical data analysis conducted for the ordinal data collected from the criterion-referenced diagnostic (pretest) and benchmark (posttest) for grades six, seven, and eight showed that the data collected was non-parametric. Therefore, further data analysis to determine the significance of the data collected was done using inferential statistical tests Wilcoxon Signed-Rank Test and Spearman Rho.

The sixth-grade Wilcoxon Signed-Rank Test for the criterion-referenced tests showed that the difference between the pretests and posttest was statistically significant at $p < .05$. However, testing results using the Spearman Rho showed that by normal standards, the association between the implementation of PBL and test scores was not considered statistically significant. A comparative analysis of the sixth-grade project scores showed that the most frequent score earned by students was 100 percent, as can be seen in *Figure 46*.

The seventh-grade Wilcoxon Signed-Rank Test for the criterion-referenced tests showed that the difference between the pretests and posttest was statistically significant at $p < .05$. Furthermore, testing results using the Spearman Rho showed that by normal standards, the association between the implementation of PBL and test scores was considered statistically significant. A comparative analysis of the sixth-grade project scores showed that the most frequent score earned by students was 100 percent, as can be seen in *Figure 64*.

The seventh-grade Wilcoxon Signed-Rank Test for the criterion-referenced tests showed that the difference between the pretests and posttest was statistically significant at $p < .05$. Furthermore, testing results using the Spearman Rho showed that by normal standards, the association between the implementation of PBL and test scores was considered statistically significant. A comparative analysis of the sixth-grade project scores showed that the most frequent score earned by students was 100 percent, as can be seen in *Figure 64*.

The eight-grade Wilcoxon Signed-Rank Test for the criterion-referenced tests showed that the difference between the diagnostic pretests and benchmark posttest was statistically significant at $p < .05$. Furthermore, testing results using the Spearman Rho showed that by normal standards, the association between the implementation of PBL and test scores was considered statistically significant. The Wilcoxon Signed-Rank Test for the Introduction to Matter pretest and posttest showed that the results were not statistically significant at $p < .05$. However, testing results using the Spearman Rho showed that by normal standards, the association between the implementation of PBL and test scores was considered statistically significant. The Wilcoxon Signed-Rank Test for the Phases of Matter pretest and posttest showed that the results were not statistically significant at $p < .05$. Due to the small sample size, it was not possible to accurately calculate the *p*-value that may have impacted the results. However, testing results using the Spearman Rho showed that by normal standards, the association between the implementation of PBL and test scores was considered statistically significant. A comparative analysis of the sixth-grade project scores showed that the most frequent score earned by students was 100 percent, as can be seen in *Figure 83*

The qualitative portion of this study was conducted using an ethnographic methodology to explore how the implementation of technology-integrated project-based learning could impact a middle school science classroom culture with the assumption that multiple educational theories such as constructivism, situated learning, the theory of change and the theory of learning and awareness impact of the implementation of technology-integrated project-based learning (PBL) in a middle school science classroom. The researcher utilized triangulation and member checks to analyze and confirm the results of the study based on the data collected.

A total of 14 formal observations were conducted in the experimental classroom during the life of the study. Additional informal daily as well as weekly field notes and observations about students' progress, problems, explanatory, and reflective notes on the physical setting of the classroom, the participants, activities and interactions, conversations, student attitude and demeanor, and even the researcher's behavior were documented in the researcher's diary. The experimental site administrators also conducted formal observations of the experimental site classroom to ensure compliance with the PBL lesson plans with state and school site teaching standards.

The researcher planned and developed lesson plans that contained literature-based criteria for PBL based on the principals of PBL. Before the introduction of a new topic of study, the researcher assessed students' prior knowledge by using criterion-referenced diagnostic pretests and chapter tests provided by the currently used science curriculum. The topics for each grade level were introduced using a concept map created at the beginning of each unit. Additional information was provided through a benchmark lesson. Students were placed in small groups who worked together towards finding the answer for a common driving question in a project using the principles of PBL integrated with the currently used science curriculum. Students were provided with guidelines and an organizer packet to follow over the project period (Appendix Y), including the assessment rubrics.

Students submitted their plan (design) for the project (Appendix O) before the start of the project. The researcher provided students with guidance as needed and a checklist to assist the students with the process of formulating a driving question (Appendix N) that their investigations would answer. Students designed and tested their projects or prototypes and maintained detailed documentation of their design process using their Interactive Science folder and Journals. At the completion of the project, criterion-referenced tests (diagnostic unit pretest, chapter tests, and benchmark summative unit posttest) available as part of the teacher resources that accompany the existing curriculum (Thornton et al., 2013) were administered by the researcher to measure comprehension of materials and ensure content knowledge proficiency. The formative assessment rubric (Appendix S) provided students with feedback while the project (investigation) was still in progress to allow students to make necessary changes and corrections as they moved toward completion of the projects or investigations and achievement of learning goals. A rubric-based summative assessment (Appendix T) (Thornton et al., 2013) was also conducted to evaluate students. In preparation for project presentations, the students worked collaboratively with the teacher to review and evaluate the whole project, select materials to share, find creative ways to share their knowledge and make a purposeful transition between the conclusion of the project and the topic of study in the current as well as the next project (Ozdemir, 2006). The completed products of the projects consisting of group and individual written reports, a poster, and model presentation demonstrating a scientific principle were evaluated at a culminating event where students shared what they had learned with others. Students were responsible for maintaining their detailed and chronological individual and collaborative group notes using their Interactive Science folder and Journals. Student reflections provided the researcher with insight into how the groups were functioning and any necessary future changes that needed to be made (Frank & Barzilai, 2004).

The experimental group and the control group studied the same materials through the course of this study. Both groups used the same curriculum (Thornton et al., 2013) and had similar access to technology, along with administrative support. Students received similar instructions about the Periodic Table of elements. The control classroom teacher selected and provided the researcher with anonymous student artifacts collected in the control classroom. When collecting field notes in the control classroom, all notes and observations were recorded using pseudonyms, group data reporting, and use of coded information to be sure that the data collected could not be linked to individual participants. The control classroom teacher removed all student identification information from work submitted to the researcher. The researcher conducted three formal observations of the control classroom to collect data about the lesson and activity being observed, the classroom's physical setting, students' attitudes and demeanors, student conversations, and classroom activities and interactions. The confidentiality of the participants was ensured by using pseudonyms, group data reporting, and the use of coded information to be sure that the data collected could not be linked to individual participants. The researcher interviewed the control classroom teacher to gain insight into similarities and differences between how PBL could be used to enhance learning in relationship to other research-based instructional strategies.

Academic artifacts were collected to document activities relevant to project-based learning, collaboration, scientific content understudy, and project presentations. The raw data collected was sorted and organized to develop a codebook. The data collected was examined from an emic perspective to develop themes using axial coding (Creswell, 2013). Using

Microsoft Excel 2018 spreadsheets as well as Microsoft Word 2018, 11 themes were identified that helped explain the classroom culture as a culture-sharing group. The seven themes that emerged from the analysis of the student surveys were: (a) life and social skills; (b) collaboration and teamwork; (c) learning and understanding; (d) leadership and responsibility; (e) communication; (f) academic skills; and (g) real-world experience. The four themes that emerged from the analysis of the staff surveys and the teacher interview were: (a) benefits of collaboration and teamwork; (b) challenges of collaboration and teamwork; (c) Project-based learning; and (d) use and role of technology in the classroom.

Students listed time management; development of social skills by working together; dealing with different personalities; cooperating within a team; meeting deadlines; organizational skills; research and presentation skills; creativity and problem-solving as meaningful life and social skills learned through project-based learning. Participants stated that work became more natural and more attractive because they could work together as a team, so "more work could be done, which made the project easier and more fun." Learning and understanding emerged as one of the themes in the study. Many students felt that project-based learning was an effective way of learning science because "you can see what you are learning in action, not by the teacher standing in front of a classroom and talking." Students believed that one of the benefits of working in teams was that they could "expand their leadership skills" by "working hard," "being trustworthy," and taking responsibility for the team's success. Data showed that students preferred "doing projects" to show progress on academic skills such as critical thinking, problem-solving, and writing, and reflection. Furthermore, students believed PBL allowed them to 'experience science in the real world" and see "how the topic of the lesson reflects in real life."

Administrators and teachers who participated in this study saw the use of collaboration and teamwork in the classroom, such as the development of leadership skills, social and life skills as the benefits for the use of collaboration and teamwork in the classroom. One of the participants stated that working in groups allowed the students to generate “ideas in a "hive mind,” thus “developing cooperative skills” and the ability to communicate effectively by “listening to others thoughts and ideas and hearing how others process information.” The administrators and teachers who participated in this study saw difficulties in grading projects, lack of maturity and understanding, lack of full knowledge of the English language, and classroom management as challenges for the use of collaboration and teamwork in the classroom.

When asked about their understanding of what the PBL process, students believed that PBL was “when students learn by investigating an interesting problem presented by the teacher” (question 47), additionally, students believed that PBL was “when students learn by investigating a problem with real-life applications” (question 48). The administrators stated that they believed PBL to be” when students learn by choosing to investigate a problem with real-life applications presented by the teacher to show that they have learned in the lesson in place of a test.” The teachers defined PBL as” “when students learn by investigating an assigned problem with real-life applications in place of a test to help them learn the lesson or show that they have learned the lesson.”

The researcher established consistency of analysis through a comparative analysis of the formative and summative criterion-referenced tests for the content taught verses content tested to ensure a high content validity in addition to the use of split-half reliability, scorer/rater reliability and parallel reliability analysis of CTP testing scores. The comparison of the test grades for the criterion-referenced tests established the level of split-half reliability and the scorer reliability at 100% (Sprinthall, 2012). Multiple validation strategies such as intensive long-term involvement (ethnography), triangulation, and member check were used to overcome the threats to internal validity. An intercoder agreement of 80% was used to overcome bias in the interpretation of data collected. A more significant sample size with multiple demographics and ethnicities, socioeconomic status, as well as international participants, could have increased external validity. CTP4 test used by the researcher's organization measured advanced skills in keeping with the advanced curriculum used by the organization. Because the study school selected has no features that make it different from other small private school organizations with a traditional science curriculum offered in grades six, seven, and eight, the researcher found no reason to study teachers in other private school settings. Students participated in surveys anonymously to ensure that students were responding honestly, thereby eliminating any power the researcher might have had over them as their science teacher. Data collector characteristics and data collector bias were controlled because the researcher was also the data collector. Educational Records Bureau (ERB) scored the Standardized Science Achievement tests, thus helping to eliminate validity issues caused by collector bias and teacher fatigue (Creswell, 2013).

CHAPTER 5: DISCUSSION

This chapter included a discussion of the study's significant findings as related to the literature on the use of project-based learning in the classroom. This chapter also included a review of the connections between the study's findings and the theoretical foundations for this study based on constructivism, situated learning theory, the theory of change, and the theory of learning and awareness. The study conclusions about implications for practice and recommendations for further research provide valuable contributions to the recognition of a middle school science classroom culture and how it affected the learning of science. This study was valuable as an unconventional approach to collecting active learning education research data to inform educational efforts for the implementation of best practices in the classroom and effective methods of monitoring the progress of science education.

Discussion

Through this study, the researcher attempted to build upon currently available research by looking at the impact of the addition of technology-integrated PBL to the existing science curriculum and instruction. Additionally, the researcher examined the effect of teacher's attitude and administrative support for the application of technology-integrated PBL in middle school science classrooms on the students' attitude and aptitude, and their levels of academic achievement on the standardized science test (CTP4).

According to Blumenfeld et al. (1991), the PBL served as a comprehensive approach to classroom teaching and learning that designed to engage students in the investigation of authentic problems to bring relevance and meaning to educational experiences. As the center of PBL, engagement, accented with the use of creativity, could lead to collaboration, teamwork, motivation, relevance, and establishment of relationships among students as they work on authentic projects.

Active learning strategies such as PBL that allow students to make connections between content taught in the classroom and their real-life experiences help schools prepare students for college and career readiness ("21st Century Skills for Students and Teachers," 2010). As schools' transition to the Next Generation of Science Standards, it becomes more important to assess student progress using authentic assessment based on the artifacts produced by students rather than simple recall of information for a test (Nextgenscience.org, 2013). However, despite the evidence from the literature that shows the need for educators to find ways to increase academic achievement, engage students, and prepare them for the real world, support the use active learning strategies such as PBL in the classroom has been very slow for many reasons (Cole, 2008). The practice of the PBL generates a shift away from traditional educational practices. Therefore, many teachers and administrators struggle to accept that learning strategies such as PBL that fall outside of the traditional classroom model could meet the demands of standards-based testing and accountability (Boud & Feletti, 1997).

Theoretical Foundation

The data collected based on the words and actions of the participants was interpreted as befitting the theoretical foundations of this study. These theories that supported this study were selected because of their support for the PBL learning experience as relevant, engaging, rigorous, and authentic. Like the constructivism (Krajcik et al., 1999; Moursund, 2003), PBL provided the participants with the opportunity to have real-world experiences (*Figure 94*). Using a technology-integrated PBL methodology used in this study, the researcher made decisions and based actions on beliefs that were consistent with constructivism. However, the researcher did not suggest how learners should construct knowledge (Kemp, 2014). The students' comments and data collected throughout the study showed that participants were given a voice and choice to learn and construct knowledge in a way that made sense to them rather than as mandated by the teacher.

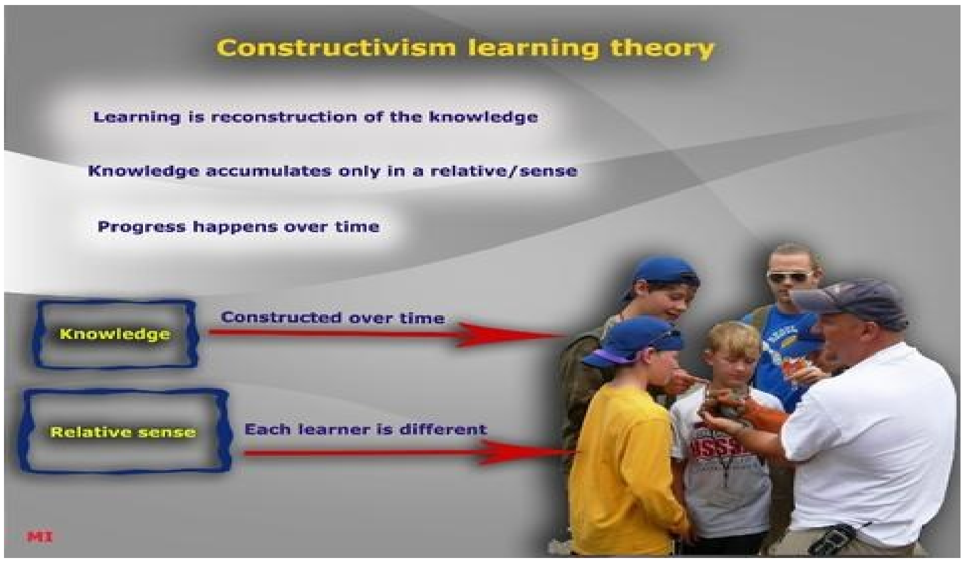


Figure 94. Constructivist Learning Theory

In a manner like the situated learning theory (Korthagen, 2009) Implementation of PBL provided the opportunity for students to learn through reflection and application of the concepts learned to other situations (*Figure 95*). The data collected showed that by being part of a community of learners' students were intrinsically motivated to learn and understand scientific concepts and develop social skills through carrying out a project in a supportive learning environment (Goldstein & Bevins, 2016; Moursund, 2003).

Figure 95. Situated Learning Theory

Similar to the theory of learning and awareness (*Figure 96*), utilization of PBL in the science classroom allowed the students to observe various facets of experiments simultaneously in a part-whole relationship where they reached a more in-depth understanding through careful reflection on the objectives of the experiment (Marton & Booth, 1997; Marton et al., 2004).

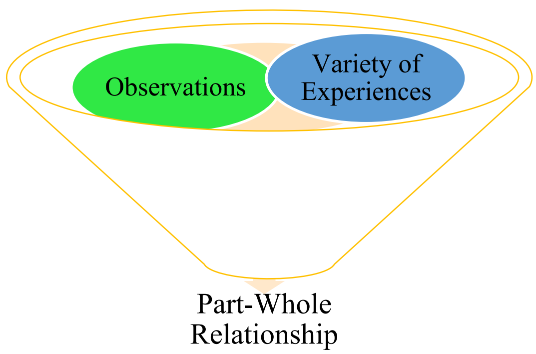


Figure 96. Theory of Learning and Awareness

The theory of change (Carole Weiss) states that PBL could help organizations study the relationship between all steps of teacher training and development ("What is theory of change," n.d.) by defining goals and desired outcomes and then mapping pathways backward in chronological order to make informed decisions about strategies for change and reflectively evaluate the organization's plan for teacher training and development (Fullan, 2006) (*Figure 97*).

The data collected in this study could help to form the foundations for changes to the teacher training and development programs within the researcher's organization.

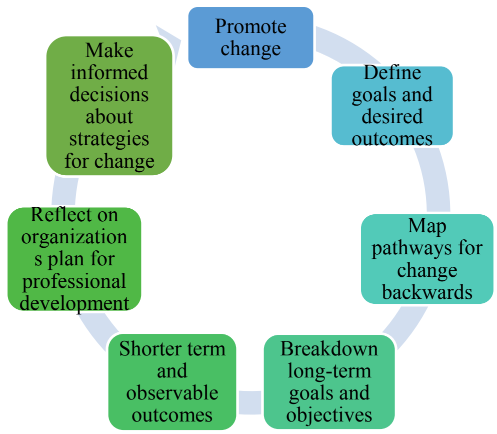


Figure 97. Theory of Change

Acknowledgment of Limitations

Due to the use of non-random, convenience sample for this study it was not possible to use a probability sampling technique that would have allowed for generalizations from the student samples used in this study to all students in grades six, seven and eight. The study population came from a single for-profit private school organization with three schools; therefore, it may not be possible to replicate the results of this study in all school populations. The study's findings may have been influenced by many variables that were outside of the researcher's control that could have changed the outcome of the students' achievement in science such as small class sizes, the level of technological expertise of the individual teachers and students, the degree of scientific knowledge and ability, availability of technical infrastructure, student aptitude and attitude toward science and school and students' level of English language proficiency.

Discussion of Themes

The analysis of data gathered from the classroom observations, use of field notes, photographs and videos, lesson plans and rubrics, projects, interactive science journals, student artifacts, student surveys, staff surveys, and participant teacher interview led to the 11 themes that emerged and helped to answer the research questions for this mixed-method study of a middle school science classroom culture. The 11 themes included (a) life and social skills; (b) collaboration and teamwork; (c) learning and understanding; (d) leadership and responsibility; (e) communication; (f) academic skills; and (g) real-world experience; (h) benefits of collaboration and teamwork; (I) challenges of collaboration and teamwork; (j) Project-based learning; and (k) use and role of technology in the classroom.

Life and social skills. Life and social skills emerged as one of the themes in the study data generated by the students as well as the staff surveys. The data showed the study participants saw time management, development of social skills by working together, dealing with different personalities, cooperating within a team, meeting deadlines, organizational skills, research and presentation skills, creativity, and problem-solving were meaningful life and social skills learned through project-based learning.

Collaboration, teamwork, and communication. The analysis of the study data leads to the recognition of collaboration and teamwork as one of the major themes in the study. Student data showed that some of the benefits of collaborative teamwork included the ability to discuss and exchange thoughts and ideas. Participants believed that the work became more natural and exciting because they could work together as a team. Working together made the work less stressful because everybody took part in the project and shared the workload. Survey data showed that students liked working in groups because of the supportive environment created when students worked together towards a common goal. The data indicated that the staff believed that collaboration and teamwork in the classroom led to the development of leadership skills, social, and life skills. The participants believed that collaborative work allowed the students to develop cooperative and practical communication skills, thus ensuring a higher level of learning. The staff data also showed that the level of independent learning and personal engagement of the students increased due to the sense of ownership experienced by students participating in project-based learning. Along with many benefits, the study participants believed that lack of cooperation and poor communication skills as the main challenges when working in groups. Teachers believed that it would be difficult to grade the projects and managing the equitable distribution of labor, personality conflicts, and levels of English proficiency.

Learning and understanding. Analysis of the study data led to the emergence of learning and understanding as one of the themes in the study. Student participants believed that working collaboratively in groups could help students expand their knowledge through research and cooperative learning rather than only relying on the teacher. In contrast to the student participants, the teachers believed that it was necessary to still use traditional teacher-centered methods alongside student-centered cooperative learning methods such as PBL to help students learn how to focus and engage in the discussion, listen to information, and take useful notes. Participating teachers agreed that PBL was an effective method of teaching. However, they did not wholly feel comfortable using PBL exclusively due to a lack of training and knowledge.

Leadership and responsibility. Student participants stated that they believed that working in teams helped them to develop their leadership and communication skills were essential to the team's success. In contrast, teacher participants felt that without prior experience, students would have difficulty managing time and sharing the workload equally.

Academic skills. The student participants' data showed that students preferred to show progress on academic skills such as critical thinking, problem-solving, and writing, and reflection. Student data showed students preferred projects over traditional tests to assess the acquisition of academic skills because students preferred demonstrating their understanding rather than memorizing information for a traditional test.

Read-world experience. Students believed that PBL was an effective way of teaching. They were able to experience many aspects of real-life such as working with other people, time management, organizational skills, research skills, presentation skills, coping with deadlines, and responsibilities. Teachers also believed that the implementation of PBL in middle school would allow students to work through real-world problems using higher-level thinking skills.

Project-based learning. *PBL* is defined as a teaching strategy where students develop knowledge and skills over time through investigation of an authentic, engaging, and complicated question, problem, or challenge (https://www.bie.org/object/document/pbl_essential_elements_checklist). In contrast, the administrators believed PBL to be" when students learn by choosing to investigate a problem with real-life applications presented by the teacher to show that they have learned in the lesson in place of a test." The teachers defined PBL as" "when students learn by investigating an assigned problem with real-life applications in place of a test to help them learn the lesson or show that they have learned the lesson." The control classroom teacher (CCT) defined PBL as "an assignment that requires students to work in groups or independently to complete a task which expands on a concept learned in class.

Use and the role of technology in the classroom. The administrative and teaching staff had different ideas about the use and role of technology in the classroom. The participating administrators felt that the use of technology-integrated project-based learning as presented by this study to be beneficial to the students, however, their concern was that without teacher buy-in, the use of technology while implementing project-based learning could interfere with the completion of the curriculum and learning of all the necessary academic skills. The participating teachers had varied views. Whereas some teachers believed that technology could sometimes be a distraction more than a benefit, others felt that the use of technology could help students make real-world connections.

Research question one. Research question one asked, "How could technology-integrated PBL be implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines?" The data generated through the researcher developed lesson plans and rubrics, interactive science journals, student artifacts, criterion-referenced tests, CTP4, observations, field notes, and reflections demonstrated how technology-integrated PBL was implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines. The grade-level science standards, school site curriculum goals, and California middle school science standards (California Department of Education, 1998), New Generation of Science Standards (2013) and lesson pacing guidelines provided by the currently used science curriculum (Thornton, Buckley, Miller, Padilla, & Wysession, 2013) were met through the selection of the study topics by the researcher (Katz & Chard, 2000).

Utilization of criterion-based diagnostic tests and chapter pretests provided by the currently used science curriculum (Thornton et al., 2013) helped the researcher to assess the student's prior knowledge and establish a starting point for instruction. The use of concept maps (Rye, Landenberger, & Warner, 2013) (Appendix M) helped to introduce new topics as well as engage and focus learners. Students were given a voice by being allowed to contribute their experiences and understanding of the topic to the concept map.

Benchmark lessons provided the researcher with the opportunity to provide students with additional background knowledge, scientific skills, and context before the start of the project. PBL projects allowed the students to work together towards finding the answer to a standard driving question in a project using the principles of PBL integrated with the science curriculum. PBL projects encouraged students to work and speak with others in the school community who were experts on the topic of study to help them with their investigations and project planning.

By going beyond the confines of the classroom and working with scientists within the community of learners, students not only learned to communicate but also came to appreciate the connection between the materials studied in the classroom and the real-world. PBL allowed students to work at their level of core competencies through the production of artifacts and products individually and collaboratively for the project (investigation) to develop a better understanding of the concept studied and how scientists use it.

Through providing students with clear instructions and assessment guidelines, the researcher assisted the students in taking responsibility for team's project thus allowing the researcher to transition into the role of an advisor or facilitator and guide, reminding students of upcoming deadlines and expectations while holding students accountable for their learning process (McCright, 2012). Clear guidelines and expectations (Appendices N, T, U, & Y) helped the researcher to be able to measure students' success at completing their projects effectively with their team members and as individuals. Student awareness of the evaluation process (Appendix T) and its focus on progress rather than a final product, helped students to become responsible for their learning and reduced students' level of stress and anxiety (Jacques, Bissey, & Martin, 2016).

Students learned critical thinking, problem-solving, and science skills when they designed their project prototypes and maintained detailed documentation of their design process using their Interactive Science Folders and Journals (Appendix U) (Chesbro, 2006, Doppelt, 2009). Students learned real-life skills such as time management by thinking about and creating a project timeline. Problems designed by students helped them to reflect on their knowledge, experiences, skills, and resources as they learned new information (Blumenfeld, Fishman, Krajcik, et al., 1999, Krajcik, 2003; Marton & Booth, 1997; Marx, & Solloway, 2000; Moursund,2003). The sharing of the completed products at a culminating event helped the students to develop presentations and public speaking skills.

The criterion-referenced tests (chapter tests and benchmark summative unit posttest) available as part of the teacher resources that accompany the existing curriculum (Thornton et al., 2013) used along with the assessment of the final PBL product presentations allowed the researcher to measure comprehension of materials and ensure content knowledge proficiency. By working with students to review and evaluate the whole project, select materials to share, the researcher helped the students to make a purposeful transition between the conclusion of the project and the topic of study in the current as well as the next project (Ozdemir, 2006).

The comparison of the data for the CTP4 standardized science achievement test during the 2018-2019 academic year with the data from 2016-2017 and 2017-2018 CTP4 in the same content area demonstrated that the implementation of PBL had led to an increase in the students' performance levels on the standardized tests. Study results revealed that through the one-year PBL implementation, CTP4 science scores for seventh-grade students increased significantly (67.79 points) during the life of the study (Pre-study Mean=615.5625, Post-study Mean=683.359412). The eighth-grade student scores increased two points in the two testing cycles before the study (2016-2017 Mean = 683.5, 2017-2018 Mean= 685.5). However, the eighth-grade scores increased significantly (65.5 points) through the life of the study (Pre-study Mean= 685.5, Post-study Mean=751). Mean CTP4 scores for the entire group of eighth-grade students at the experimental site (M=747.318) was marginally lower than the mean at the control site (M= 754.775). The fact that the mean value of the experimental site was lower than the control site might suggest that PBL may not have played some role in the CTP4 score increases.

Both sites used the same curriculum and participated in the Standardized Science Test CTP4 that measured academic achievement. Perhaps the overall increase in the eight-grade CTP4 science scores at the experimental site as compared to the scores of the same group in the previous years may have been due to the emphasis on the development of science skills in the PBL projects. As the PBL projects continued throughout the year, the teacher, and students in the PBL group became better in conducting projects. Science skills were taught throughout the year and were incorporated in the PBL projects leading to the strengthening of skills and content knowledge tested in CTP4 Standardized Science testing. Variables such as teacher willingness to implement technology-integrated PBL in the classroom and administrative support for the implementation of technology-integrated PBL in the classroom may have affected science growth more than other variables.

Through making observations, using classroom observations protocol (Appendix R), and collecting data from the online student surveys (Appendix D), the researcher (ethnographer) was able to examine and document the participants' behavior and attitudes. The ethnographic qualitative data documented in the researcher diary about student's progress, problems, activities, interactions, conversations, attitude, and demeanor along with the student artifacts collected demonstrated that the implementation of technology-integrated PBL into the science curriculum led to the student engagement in classroom activities (Baysura et al., 2016; Creswell, 2013, Doppelt, 2009; Remmen & Froyland, 2014).

The researcher (ethnographer) conducted observations of the control classroom using the Classroom Observation Protocol (Appendix R). The follow-up interview with the control classroom teacher (CCT) examined the similarities and differences between the experimental and control groups to gain insight into the impact of the use of project-based learning and other research-based instructional strategies in a science classroom. Based on the researchers' observations and the interview with the control classroom teacher, the control classroom used elements of inquiry-based learning. However, the control classroom was very much a traditional classroom. The topics of study at the control site were introduced using a short activity to engage the students (like inquiry-based learning) before teaching the material. The significant concepts were taught using a PowerPoint presentation while students took guided notes using teacher provided worksheets. Depending on the topic, the project would be introduced in the middle of the chapter or at the end of the chapter. Most of the projects were completed in groups picked by the control classroom teacher to get groups with mixed abilities.

A rubric and guidelines were provided to the students at the beginning of the project so they would know what to expect and how they will be assessed. The students could work independently while the control classroom teacher supervised and provided guidance to groups as needed. At the end of the project, students turned in a product or presented their product to the class. As shown by the data generated, technology-integrated PBL could be implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines.

Research question two. Research question two asked, "How could the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom lead to changes in students' attitude and aptitude resulting in an improved overall academic achievement for science?" The data generated by the student surveys, field notes, student interactive journals, criterion-references test data, and CTP4 testing data led to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science.

As a teaching strategy, technology-integrated project-based learning provided an opportunity for students to actively explore real-world challenges and develop a deeper understanding of the concepts taught in the classroom. In the student survey (Appendix D), 30.9% of students responded that they learned more when they could use personal digital devices in the classroom in contrast to 18.74% of teachers and administrators who believed the same thing. Today's tweens have lived their entire lives in a world surrounded by technology. They do not recall a time without the internet because, as far as they can remember, it has always been there. The appropriate use of technology-integrated curriculum in the classroom must assume, therefore, play a significant role in our schools' educational framework (Katz & Chard, 2000).

The use of technology in conjunction with laboratory experiments and observation allowed the students to develop an improved understanding of scientific concepts learned in the classroom and the real-world. As a complement to the scientific skills developed in the classroom, the use of technology helped the students better identify and state problems, develop and implement solutions. Additionally, students learned to connect with other areas of knowledge, such as mathematics, social science, and engineering (*Science Teaching Reconsidered: A Handbook,* 1997). Students benefitted from participating in PBL projects through the development of life and social skills that enable humans to speak appropriately, make good choices, and behave appropriately according to various situations. Possessing excellent social skills is essential for students' academic success. Project-based learning may play an essential role in reinforcing positive life and social skills that tweens may have picked up through their daily interactions with adult role models.

Addition of technological tools and skills to PBL lesson plans created by the researcher (Appendix I) potentially allowed students to personalize their learning. A combination of PBL and technology provided students with an opportunity to transfer knowledge learned from one area to another in a collaborative learning environment by focusing on solving a problem or accomplishing a task (Hmelo-Silver, 2004; Laboy-Rush, 2009). By creating their digital projects, students not only enhanced their understanding of new materials but also connected concepts learned with authentic real-life examples (Groff, 2013; Kwek, 2011; Klopfer et al., 2009; U.S. Department of Education, 2017). Students explored and applied their knowledge in the ways that worked best for them, leading to changes in students' attitude, aptitude, and improvement of overall academic achievement for science.

Access to digital workspaces in an active learning environment potentially provided real-world opportunities for tweens to participate in teamwork, collaborate and communicate with others, create artifacts, develop leadership, critical thinking, and problem-solving skills in real-time. The development of active life and social skills can, in turn, facilitate success in school.

Research shows that working in groups creates several challenges. When teams work well, team members feel valued and motivated to do the best they can do. However, when teams do not work well, team members do not feel valued and motivated because of issues such as poor communication, difficulty resolving conflicts, lack of participation, lack of creativity, and ineffective leadership. Students participating in a PBL project could have an opportunity to experience the challenges of teamwork and learn how to overcome them in a situation that may closely mimic real-life as they work towards college and career readiness (Beaty-O'Ferrall, Green, & Hanna, 2010; Brame & Biel, 2015; Bruffee, 1998).

By using personal iPads, students could access and use multiple apps to create digital artifacts as part of their project presentations. A comparison of the student artifacts collected from the experimental and control sites demonstrated that both sites utilized the same curriculum and active teaching strategies. Therefore, the researcher did a follow-up interview (Appendix W) with the control classroom teacher at the end of the study to focus on gaining insight into similarities and differences between how technology was used to enhance projects and learning. Based on the researcher's observations and the interview with the control classroom teacher, technology was used minimally to enhance learning in the control classroom. Students used their iPads to do research and used a few apps such as Pages and Keynote for taking notes and creating presentations as well as the onboard camera to take pictures or make movies on iMovie as opposed to how technology was used in the experimental classroom to engage students. As shown by the data generated, the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom led to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science.

Research question three. Research question three asked, "What would be the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement?" The data collected generated by the staff survey, teacher interview, formal administrative observations, and evaluations demonstrated the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement.

The researcher maintained an open and continuous line of communication with the school site administrators to ensure the continual support of the organizational gatekeepers and school site administrators. To complete this study, the researcher received adequate planning time, physical classroom resources, time for teacher collaboration, classroom observations, and lesson plan evaluations to ensure that PBL lesson plans developed by the researcher met the standards and aligned with other school initiatives (Poulos, 2016). Additionally, the researcher received access to students' standardized testing data as well as technology support the help students with the use of their iPads and other technological tools in the classroom (Moeller & Reitzes, 2011).

The school site Director and the Assistant director observed the researcher's classroom formally (three times) using Classroom Formal Observation Rubric (Appendix L) to ensure that the compliance of the PBL lesson plans with state and school site teaching standards. Using the Lesson Plan Evaluation Rubric (Appendix K), the school site administrators evaluated the researcher's weekly lesson plans.

Following the completion of the study, the administrators provided the researcher with an opportunity to present the content of the study, its application in the classroom environment, assessment methods, and the study results during an all-staff in-service meeting. Following the presentation 12 teachers and three administrators to participated in a voluntary and anonymous online survey about their opinions on achievement, attitudes toward science, collaborative workgroups, learning styles, use of technology in the classroom and PBL in the class as a whole (Frank & Barzilai, 2004, Blair, Czaja, & Blair, Harrigan, 2014, 2014, McCright, 2012).

The administrative evaluation of the implementation of technology-integrated PBL in a science class was very positive. The administrators were able to observe the implementation of the lesson plans as well as project presentations. When administrators were asked if they would be interested in learning more about how they could implement technology-integrated PBL in their classrooms using the existing curriculum, 100% of the administrators stated that they would be interested in learning in contrast to 83.33% of teachers who answered the same question. The data generated by this study showed that administrative support could impact teachers' attitudes toward the implementation of technology-integrated PBL to improve students' levels of academic achievement.

Implications for Practice

The implementation of the technology-integrated PBL has been previously studied (Blumenfeld et al., 1991; Eady & Lockyer, 2013; Gollub, Bertenthal, Labov, & Curtis, 2002; Groff, 2013; Krajcik & Czerniak, 2014). The review of the literature showed a few PBL studies

(Discovery Education, 2017; Fox, 2016; Lattimer & Riordan, 2011; NYC Department of Education, 2009) that targeted achievement in the middle grades. However, research was not evident in the implementation of technology integrated PBL using existing classroom curriculum while adhering to science standards and lesson pacing guidelines; thus, providing the opportunity and the need to conduct this study.

This study was designed to examine the relationship between administrative support for teacher-led educational innovation in a private school and students' achievement scores on standardized achievement tests in an interrelated planning process to determine the feasibility of the successful use of technology-integrated PBL in science considering the importance placed on supporting middle school students for learning science at the middle school. Furthermore, the study's design considered and attempted to mitigate all the challenges involved in the implementation of technology-integrated PBL.

The results of this study showed that despite the many benefits to the implementation of technology-integrated PBL, there were also many challenges. When tweens become involved in choosing and planning a project as part of a technology-integrated PBL, they become more motivated to learn (Katz, 1994). However, teachers find it difficult to trust their students with the task of choosing a topic of study within the confines of the PBL curriculum (Andrews, 2014). Some educators believe that students do not know what would be essential to learn when working on projects. Others cite the level of work and planning involved for the teachers and suggest that they may not be able to cover the amount of material covered in a traditional classroom (Boud, D. & Feletti, 1997). Teachers feel that allowing students time to investigate a problem means that they could no longer follow the lesson pacing guidelines (Stepanek, 1999). The designing of assessments that could accurately measure student understanding of content learned through a PBL project was frequently cited as one of the challenges teachers face for implementation of technology-integrated PBL (Curtis, 2002). Other challenges listed in the literature included the lack of time, resources, lack of administrative support, and organizational knowledge about PBL (Harrigan, 2014; Laboy-Rush, 2007; Thomas, 2000).

However, the results of this study also show that many challenges cited by the critics of implementation of PBL in the classroom could be overcome depending on the level of teachers' willingness to learn and implement PBL along with administrative support for the implementation. The results of this research support the findings of Falik, Eylon, and Rosenfeld (2008) that showed despite the high positive impact technology-integrated PBL implementation could have for students, teachers require training and support to overcome their misconceptions and reluctance for implementing technology-integrated PBL in their classroom successfully. This study also confirmed that the students participating in PBL treatments showed significant increases in their Science Standardized Testing Scores on CTP4 during the testing cycle following the implementation of the technology-integrated PBL (2018-2019) as compared to the previous two testing cycles (2016-2017 and 2017-2018). The methodology designed by the researcher and used for this study could be useful for the future development of teacher training models and strategies for dealing with issues such as classroom management and assessment when implementing active learning strategies such as PBL in science classrooms at the middle school level and beyond (Fallik et al., 2008).

Recommendations for Further Research

The study's delimitations, limitations, and assumptions offer opportunities for further research: 1) due to the non-probability nature of sampling, external validity was limited to study participants; 2) the study was delimited to one school in a private school organization in Orange County, California; 3) the study was delimited to three grade levels and two middle school; 4) the study was delimited to the outcome measures of academic achievement in science based on the CTP4 standardized test; 5) it was assumed that the existing data used had been accurately measured the criteria, and 6) it was assumed that the participating PBL school followed the curricula accordingly. To enhance the generalization of the results, the researcher recommends the: 1) replication of the study in other schools within the private school organization; 2) replication of the study in other grade levels; 3) replication of the study in other academic achievement subjects; 4) replication of the study in the other academic achievement environments.

Despite the production of useful results from this study, given the nature of applied field research, the results of additional studies using a similar research design, treatment, methods, and participants could be compared to this study's results to determine replicability. Slight variations of elements such as incorporating participants from urban schools or using PBL in other content areas would redefine parameters of the findings, perhaps strengthening generalizability to other populations and content areas.

Longitudinal, demographics, and growth data gathered for this project could provide the bases for numerous studies. For example, this study examined growth in science process skills and achievement; a similar study could be replicated focusing on thinking skills using other academic concepts such as mathematics or literature. Other demographics (i.e., gender, ethnicity, English Language Learner status, gifted and talented selection, or special education identification, could be analyzed under the same parameters of this study. Those same data could also be examined through the lens of thinking skills growth. One appealing approach would be to explore the growth of science process skills in students formally identified as gifted in science across treatment groups and years of implementation. Data could be collected for students in the areas of general intellectual ability, specific academic aptitude in math and science, and creativity. Analyses of any one of these demographics or a combination of them could shed light on teaching strategies for the gifted. One could even examine the impact of PBL on the percentage of students who are formally identified in science, or general intellectual ability as compared to students who did not receive PBL instruction.

Another interesting potential study stemming from this variable focuses on the experimental group only. A qualitative study focusing on students' motivation, self-efficacy, or even self-esteem would prove interesting. How did they feel about themselves knowing that they were bright? Conversely, the students experienced long periods with their teacher, potentially developing productive, personal relationships, and engaging in PBL. They had time to complete work, which impacted the amount of homework. What impact did those conditions have on their view of self, school, or learning?

It is furthermore suggested that a study be done on the impact of teacher fidelity of treatment on student growth. Observations were completed on participating teachers according to tenets of PBL instruction in science. Interrater reliability could be determined between the school administrator and the outside observer. If reliability were high, then a study could be conducted correlating student growth via comparison of qualitative observation data and pretests and posttests on individual units with teacher implementation of PBL.

Another interesting approach would be a comparison of the project growth outcomes with state accountability data. For example, one might look at the percentage of PBL students who scored high in science on the CTP4 assessments. Comparisons could be made over longitudinal growth, perhaps indicating the effect of PBL learning in science on CTP4 assessments over time.

Conclusions

The researcher had hypothesized that:

$\mathbf{H_1}$: The data collected would demonstrate how technology-integrated PBL could be implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines.

$\mathbf{H_2}$: The data collected would demonstrate how the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom could lead to changes in students' attitude and aptitude, resulting in an improved overall academic achievement for science.

$\mathbf{H_3}$: The data collected would demonstrate the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement.

Analysis of the study data supported the study's hypotheses. Despite the study's limitations, the overall findings support the use of PBL in science instruction since students in PBL treatment groups experienced significantly more growth in Science Standardized Testing Scores (CTP4) and process skills. Moreover, significant growth suggested that sustained implementation is desirable. PBL is an effective instructional method in science process skills for this population.

Given that parents, educators, scientists, and government officials have been concerned about student ability to deal with the changes brought on by the recent innovations in science and technology (Michaels, Shouse, & Schweingruber, 2008) and the role science plays in our lives, it is essential that young people understanding essential scientific skills such as critical thinking and problem-solving supported by PBL that would enable them to improve the quality of their lives, pursue scientific careers or become scientifically literate citizens in a global society (Krajcik, Czerniak, & Berger, 1999).

Summary

This chapter included a discussion of this study's significant findings relative to the literature on the use of project-based learning in the classroom and the connection between the study's findings and the theoretical foundations for this study based on constructivism, situated learning theory, the theory of change, and the theory of learning and awareness.

The study conclusions provided valuable contributions to the understanding of how the culture in a middle school science classroom culture affected the learning of science. This study's unconventional approach to collecting educational research data helped to inform efforts for effective means of monitoring the progress of science education.

In conducting this study, the researcher tried to build on existing research on the impact of the addition of technology-integrated PBL to the existing science curriculum and instruction. Additionally, the researcher looked at the effect of teacher's attitude and administrative support for the use of technology-integrated PBL in middle school science classrooms on the students' attitude and aptitude, and their levels of academic achievement on the standardized science test (CTP4).

Educational methods designed to engage students in relevant and authentic problem-solving help students to take ownership of their education by bringing meaning to instructional practices (Blumenfeld et al., 1991). Learning strategies such as PBL allow students to connect content taught to real-life experiences as they prepare for college and career readiness ("21st Century Skills for Students and Teachers," 2010). Even though the evidence from research shows the need for educators to find ways to increase academic achievement, engage students, and prepare them for the real world, support the use of active learning strategies such as PBL in the classroom has been very slow for many reasons (Cole, 2008). Therefore, many teachers and administrators have difficulty accepting learning strategies such as PBL that could meet the demands for school accountability (Boud & Feletti, 1997).

The experimental data were interpreted as befitting the theoretical foundations of this study that were selected because of their support for the PBL learning experience as relevant, engaging, rigorous, and authentic. Like constructivism (Ackermann, n.d.; Krajcik et al., 1999; Moursund, 2003), PBL allowed students to have real-world experiences (Figure 94). As in the situated learning theory (Korthagen, 2009), students learned through reflection and application of the concepts learned to other situations (Figure 95). Like the theory of learning and awareness (Figure 96), students observed various facets of experience simultaneously in a part-whole relationship, thus learning through reflection for an in-depth understanding of the object of learning (Marton & Booth, 1997; Marton et al., 2004). Like the theory of change (Carole Weiss), organizations involved in PBL could make informed decisions about establishing teacher professional development and training by mapping backward starting at the desired outcome (Fullan, 2006; "What is theory of change," n.d.).

The non-random convenience sampling from a single for-profit school may have generalized form this study population to other populations more difficult. Many variables outside of the researcher's control such as small class sizes, the level of the technological expertise of the individual teachers and students, the degree of scientific knowledge and ability, availability of technical infrastructure, student aptitude and attitude toward science and school and students' level of English language proficiency could have changed the outcome of the study.

Eleven themes emerged from the data analysis and helped to answer the research questions for this mixed-method study of a middle school science classroom culture. The themes included (a) life and social skills; (b) collaboration and teamwork; (c) learning and understanding; (d) leadership and responsibility; (e) communication; (f) academic skills; and (g) real-world experience; (h) benefits of collaboration and teamwork; (I) challenges of collaboration and teamwork; (j) Project-based learning; and (k) use and role of technology in the classroom.

Research question one asked, "How could technology-integrated PBL be implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines?" Question one was answered by the data generated through the researcher developed lesson plans and rubrics, interactive science journals, student artifacts, criterion-referenced tests, CTP4, observations, field notes, and reflections demonstrated how technology-integrated PBL was implemented in a middle school science classroom as an augmentation to the existing curriculum while adhering to the curriculum standards and lesson pacing guidelines. The grade-level science standards (California Department of Education, 1998; New Generation of Science Standards, 2013) and lesson pacing guidelines provided by the currently used science curriculum (Thornton, Buckley, Miller, Padilla, & Wysession, 2013) were met through the selection of the study topics by the researcher (Katz & Chard, 2000). The utilization of criterion-based tests provided by the currently used science curriculum (Thornton et al., 2013) helped the researcher to assess the student's knowledge before and after the implementation of PBL. Utilization of concept maps (Rye, Landenberger, & Warner, 2013) (Appendix M) helped to engage and focus learners by allowing them to contribute their experiences and understanding of the topic to the concept map. Benchmark lessons provided the students with background knowledge, scientific skills, and context before the start of the project. PBL projects allowed the students to seek from experts in the school community as they worked together towards finding the answer for a common driving question with a real-world scientific connection.

The use of provided instructions and assessment guidelines, helped the students to take responsibility for the team's project, thus allowing the researcher to transition into the role of an advisor or facilitator and guide (McCright, 2012). Additionally, students' experienced reduced levels of anxiety and stress due to their awareness of the evaluation process (Jacques, Bissey, & Martin, 2016).

By participating in a PBL project, students learned critical thinking, problem-solving, science processing skill, presentation skills, and real-life skills when they designed their project prototypes and maintained detailed documentation of their design process using their Interactive Science Folders and Journals (Appendix U) (Blumenfeld, Fishman, Krajcik, et al., 1999; Chesbro, 2006, Doppelt, 2009; Krajcik, 2003; Marton & Booth, 1997; Marx, & Solloway, 2000; Moursund,2003). The comparison of the data for the CTP4 standardized science achievement test during the 2018-2019 academic year with the data from ' 2016-2017 and 2017-2018 CTP4 in the same content area demonstrated that the implementation of PBL had led to an increase in the students' performance levels on the standardized tests. Study results revealed that through the one-year PBL implementation, CTP4 science scores for seventh-grade students increased significantly (67.79 points) during the life of the study (Pre-study Mean=615.5625, Post-study Mean=683.359412). The eighth-grade student scores increased 2 points in the two testing cycles before the study (2016-2017 Mean = 683.5, 2017-2018 Mean= 685.5). However, the eighth-grade scores improved significantly (65.5 points) through the life of the study (Pre-study Mean= 685.5, Post-study Mean=751). Mean CTP4 scores for the entire group of eighth-grade students at the experimental site (M=747.318) was marginally lower than the mean at the control site (M= 754.775). The fact that the mean value of the experimental site was lower than the control site might suggest that PBL may not have played some role in the CTP4 score increases.

Since both sites used the same curriculum and participated in the Standardized Science Test (CTP4) that measured academic achievement, the overall increase in the eight-grade CTP4 science scores at experimental site as compared to the scores of the same group in the previous years may have been due to the emphasis on the development of science skills in the PBL projects. Variables such as teacher willingness to implement technology-integrated PBL in the classroom and administrative support for the implementation of technology-integrated PBL in the classroom may have affected science growth more than other variables.

Through making observations and collecting data from the surveys, the researcher (ethnographer) was able to examine and document the participants' behavior and attitudes. The ethnographic qualitative data recorded in the researcher diary along with the student artifacts collected demonstrated that the implementation of technology-integrated PBL into the science curriculum led to the student engagement in classroom activities (Baysura et al., 2016; Creswell, 2013, Doppelt, 2009; Remmen & Froyland, 2014). The researcher (ethnographer) conducted observations of the control classroom using the Classroom Observation Protocol (Appendix R). The students at the control site did not experience any changes in their classroom instructional routine while using the currently available curriculum, as well as technology. Depending on the topic, the project would be introduced in the middle of the chapter or at the end of the chapter. At the end of the project, students will turn in a product or presented their product to the class. Despite the use of projects to enhance learning, the control classroom was very much a traditional classroom.

Research question two asked, “How could the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom lead to changes in students’ attitude and aptitude resulting in an improved overall academic achievement for science?” Question two was answered using data generated by the student surveys, field notes, student interactive journals, criterion-references test data, and CTP4 testing data led to changes in students’ attitude and aptitude, resulting in an improved overall academic achievement for science. As an instructional strategy, technology-integrated PBL could allow students to explore real-world challenges and develop a better understanding of the concepts taught in the classroom. In the student survey (Appendix D), 30.9% of students responded that they learned more when they could use personal digital devices at school in contrast to 18.74% of teachers and administrators who believed the same thing.

Technology has surrounded tweens their entire lives. The appropriate use of a technology-integrated curriculum (Katz & Chard, 2000), in conjunction with laboratory experiments and observation, could benefit students' understanding of scientific concepts (Science Teaching Reconsidered: A Handbook, 1997). Furthermore, the development of life and social skills may help students with their academic success. Addition of technological tools and skills to PBL lesson plans could allow students to personalize their learning by transferring knowledge learned from one area to another in a collaborative learning environment (Hmelo-Silver, 2004; Laboy-Rush, 2009) leading to changes in students' attitude, aptitude, and, improvement of overall academic achievement for science.

Research question three asked, "What would be the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement?" Question three was answered using the data collected generated by the staff survey, teacher interview, formal administrative observations, and evaluations demonstrated the impact of administrative support on the teachers' attitude toward the implementation of technology-integrated PBL to improve students' levels of academic achievement. An open line of communication with the school site administrators was essential to ensure the continual support of the organizational gatekeepers and school site administrators. The administration provided the researcher with adequate planning time, physical classroom resources, time for teacher collaboration, classroom observations, lesson plan evaluations, technological tools, and access to students' standardized testing data (Moeller & Reitzes, 2011; Poulos, 2016). The school site Director and the Assistant director observed the researcher's classroom formally (3 times) using Classroom Formal Observation Rubric (Appendix L) and evaluated the researcher's weekly lesson plans (Appendix K) to ensure that the compliance of the PBL lesson plans with state and school site teaching standards.

Following the completion of the study, the researcher could present the research, its application in the classroom environment, assessment methods, and the study results during an all-staff in-service meeting. Following the presentation 12 teachers and three administrators to participated in a voluntary and anonymous online survey about their opinions on achievement, attitudes toward science, collaborative workgroups, learning styles, use of technology in the classroom and PBL in the class as a whole (Frank & Barzilai, 2004, Blair, Czaja, & Blair, Harrigan, 2014, 2014, McCright, 2012).

100% of the administrators and s 83.33% of teachers who participated in the survey stated that they would be interested in learning more about how they could implement technology-integrated PBL in their classrooms using the existing curriculum. The use of technology-integrated PBL as an instructional strategy did target achievement in the middle grades had been previously examined (Blumenfeld et al., 1991; Discovery Education, 2017; Eady & Lockyer, 2013; Fox, 2016; Gollub, Bertenthal, Labov, & Curtis, 2002; Groff, 2013; Krajcik & Czerniak, 2014; Lattimer & Riordan, 2011; NYC Department of Education, 2009) However, research was not evident in the implementation of technology integrated PBL using existing classroom curriculum while adhering to science standards and lesson pacing guidelines thus, the need to conduct this study.

This study examined the relationship between administrative support for teacher-led educational innovation in a private school and students' achievement scores on standardized achievement tests in an interrelated planning process to determine the feasibility of the successful use of technology-integrated PBL in science while attempting to mitigate all the challenges involved in the implementation of technology-integrated PBL. The results of this study showed that despite the many benefits to the implementation of technology-integrated PBL, there were also many challenges. If trusted by their teacher's tweens could become more motivated to learn by choosing a topic of study within the confines of the PBL curriculum (Andrews, 2014; Boud, D. & Feletti, 1997; Katz, 1994). Other challenges listed by teachers include worrying that they may not be able to follow the lesson pacing guidelines (Stepanek, 1999), designing adequate assessments of projects conducted using technology-integrated PBL (Curtis, 2002), lack of time, resources, lack of administrative support, and managerial knowledge about PBL (Harrigan, 2014, Laboy-Rush, 2007, Thomas, 2000).

The results of this study also showed that many of the challenges cited could be overcome depending on the level of teachers' willingness to learn and implement PBL along with administrative support for the application. The results of this research support the findings of Falik, Eylon, and Rosenfeld (2008) that showed despite the high positive impact technology-integrated PBL implementation could have for students, teachers require training and support to overcome their misconceptions and reluctance for implementing technology-integrated PBL in their classroom successfully. This study also confirmed that the students participating in PBL treatments showed significant increases in their Science Standardized Testing Scores on CTP4 during the testing cycle following the implementation of the technology-integrated PBL (2018-2019) as compared to the previous two testing cycles (2016-2017 and 2017-2018).

The methodology designed and used for this study could be useful for the future development of teacher training models and strategies for dealing with issues such as classroom management and assessment when implementing active learning strategies such as PBL in science classrooms at the middle school level and beyond (Fallik et al., 2008).

The study's delimitations, limitations, and assumptions offer opportunities for further research. To enhance the generalization of the results, the researcher recommends the: 1) replication of the study in other schools within the private school organization; 2) replication of the research in different grade levels; 3) replication of the study in other academic achievement subjects; 4) replication of the study in the other educational achievement environments. The results of additional studies using a similar research design, treatment, methods, and participants could be compared to this study's results to determine replicability. Slight variations of elements such as incorporating participants from urban schools or using PBL in other content areas would redefine parameters of the findings, perhaps strengthening generalizability to other populations and content areas. Longitudinal, demographics, and growth data gathered for this project could also provide the bases for numerous studies.

Analysis of the study data supported the study's hypotheses. Despite the study's limitations, the overall findings support the use of PBL in science instruction since students in PBL treatment groups experienced significantly more growth in Science Standardized Testing Scores (CTP4) and process skills. Moreover, a significant increase for these students suggested that sustained implementation is desirable. PBL is an effective instructional method in science process skills for this population.

References

21st Century Skills for Students and Teachers. (2010). Retrieved from http://www.ksbe.edu/_assets/spi/pdfs/21_century_skills_full.pdf

Akpan, J. A. (2001). Issues Associated with Inserting Computer Simulations into Biology Instruction: A Review of the Literature. Retrieved from https://wolfweb.unr.edu/homepage/crowther/ejse/akpan.html

Aloisi, C., Major, L. E., Coe, R., & Higgins, S. (2014). What Makes Great Teaching? Review of the Underpinning Research. Retrieved from https://www.suttontrust.com/research-paper/great-teaching/

American Chemical Society. (2012). *ACS Guidelines and Recommendations for the Teaching of High School Chemistry* [Guidelines]. Retrieved from https://www.acs.org/content/dam/acsorg/education/policies/recommendations-for-the-teaching-of-high-school-chemistry.pdf

American Psychological Association. (2002). *Developing Adolescents*. Retrieved from https://www.apa.org/pi/families/resources/develop.pdf

Anderman, E. M., Sinatra, G. M., & Gray, D. L. (2012). The challenges of teaching and learning about science in the twenty-first century: exploring the abilities and constraints of adolescent learners. *Studies in Science Education*, *48*(1), 89-117. https://doi.org/https://doi.org/10.1080/03057267.2012.655038

Andrews, P. G. (Ed.). (2014). *Curriculum and Instruction, Selections from Research to Guide Practice in Middle-Grade Education*. Westerville, Ohio: Association for Middle-Level Education.

Apedoe, X. S., Ellefson, M. R., & Schunn, C. D. (2012). Learning together while designing: Does group size make a difference? *Journal of Science Education and Technology*, *21*(1), 83-94. https://doi.org/1007/s10956-011-9284-5

Arain, M., Haque, M., Johal, L., Mathur, P., Nel, W., Rais, A., Sharma, S. (2013). Maturation of the adolescent brain. *Ne. Psychiatric Disease and Treatment*, *9*, 449-461. https://doi.org/10.2147/NDT.S39776

Assess Teaching and Learning. (2016). Retrieved from https://www.cmu.edu/teaching/assessment/index.html

Aviles, N., & Grayson, K. (2017). Backward Planning – How Assessment Impacts Teaching and Learning. Retrieved from https://www.idra.org/resource-center/backward-planning-assessment-impacts-teaching-learning/

Bada, D., & Olusegun, S. (2015, Nov. - Dec). Constructivism Learning Theory: A paradigm for teaching and learning. *IOSR Journal of Research & Method in Education*, 5(6), 66-70. Retrieved from https://pdfs.semanticscholar.org/1c75/083a05630a663371136310a30060a2afe4b1.pdf?_ga=2.184578733.563872428.1550562252-72244570.1550562252

Barnhardt, S., Kevorkian, J., & Delett, J. (1998). *Portfolio Assessment in The Foreign Language Classroom* [White Paper]. Retrieved from Eric: https://files.eric.ed.gov/fulltext/ED448602.pdf

Baysura, O. D., Altun, S., & Yucel-Toy, B. (2016). Perception of teacher candidates regarding PBL. *Eurasian Journal of Educational Research*, 6215-36. Retrieved from http://ezproxy.cui.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1097975&site=ehost-live

Beaty-O'Ferrall, M. E., Green, A., & Hanna, F. (2010, March). Classroom management strategies for difficult students: Promoting change through relationships. *Middle School Journal*, *41*(4), 4-11. Retrieved from https://files.eric.ed.gov/fulltext/EJ887746.pdf

Blair, J., Czaja, R. F., & Blair, E. A. (2014). *Designing Surveys: A Guide to Decisions and Procedures* (Third ed.). Thousand Oaks, California: Sage.

Blair, N. (2012, January/February). Technology integration for the new 21st-century learner. *Principal*, 8-11. Retrieved from https://www.NAESP.org/sites/default/files/Blair_JF12.pdf

Blakemore, S. (2012). The adolescent brain. Retrieved from https://www.edge.org/conversation/sarah_jayne_blakemore-the-adolescent-brain

Blakemore, S., Choudhury, S., & Charman, T. (2007, January). Social cognitive development during adolescence. *Social Cognitive and Affective Neuroscience*, *1*(3), 165-174. https://doi.org/10.1093/scan/nsl024

Blumenfeld, P. C., Marx, R. W., Krajcik, J. S., Guzdial, M., Palincsar, A., & Soloway, E. (1991). Motivating PBL: Sustaining the doing, supporting the learning. *Educational Psychologist*, *26*(3 & 4), 369-398. Retrieved from http://ezproxy.cui.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=6370955&site=ehost-live

Blumenfeld, P., Fishman, B., Krajcik, J., Marx, R., & Solloway, E. (2000). Creating usable innovations in systemic reform: Scaling-up technology embedded project-based science in urban schools. *Educational Psychologist*, *35*(3), 149-164.

Boss, S. (2015). *Real-World Projects: How do I design relevant and engaging learning experiences?* Alexandria, Va.: ASCD.

Boss, S., & Krauss, J. (2007). *Reinventing PBL: Your Field Guide to Real-World Projects in the Digital Age*. Eugene, OR: ISTE.

Boud, D., & Feletti, G. (1997). *The Challenge of Problem-Based Learning* (second ed.). London, NJ: Kogan Page Limited.

Boyd-Dimock, V., & McGree, K. M. (1995). Leading change from the classroom: Teachers as leaders. Retrieved from http://www.sedl.org/change/issues/issues44.html

Brame, C., & Biel, R. (2015). Group work: Using cooperative learning groups effectively. Retrieved from https://wp0.vanderbilt.edu/cft/guides-sub-pages/setting-up-and-facilitating-group-work-using-cooperative-learning-groups-effectively/

Brookhart, S. M. (2017). *How to Give Effective Feedback to Your Students* (2nd ed.). Alexandria, Va.: ASCD.

Bruffee, K. A. (1998). *Collaborative Learning: Higher Education, Interdependence, and the Authority of Knowledge* (second ed.). Baltimore, Maryland: John Hopkins University Press.

Building a School Culture that Supports Teacher Leadership. (2015). Retrieved from www.doe.mass.edu/edeval/leadership/BuildingSchoolCulture.pdf

Burgess, J., & Bates, D. (2009). *Other Duties as Assigned*. Alexandria, Va.: ASCD.

California Department of Education. (1998). http://www.cde.ca.gov/be/st/ss/documents/sciencestnd.pdf

California Department of Education. (2016). *2016 Science Framework for California Public Schools Kindergarten through Grade 12: Instructional Strategies for CA NGSS Teaching and Learning in the Twenty-first-century* [Educational Standards]. Retrieved from

California Department of Education: https://www.cde.ca.gov/ci/sc/cf/documents/scifwch11prepub.doc

Cambridge Dictionary. (2018). In. Retrieved from http://dictionary.cambridge.org/us/dictionary/english

Casey, B. J., Jones, R. M., & Hare, T. A. (2008). The Adolescent Brain. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2475802/

Center on Education Policy. (2019). Retrieved from https://www.cep-dc.org

Chanlin, L. (2008). Technology integration applied to project- based learning in science. *Innovations in Education and Teaching International*, *45*(1), 55–65. https://doi.org/10.1080/14703290701757450

Chen, C. (2011). Transforming online professional development: The design and implementation of the PBL management system (PBLMs) for in-service teachers. *British Journal of Educational Technology*, *42*(1), E5-E8. http://dx.doi.org/10.1111/j.1467-8535.2010.01143.x

Cheng, R. W., Lam, S., & Chan, J. C. (2008). When high achievers and low achievers work in the same group: The roles of group heterogeneity and processes in PBL. *British Journal of Educational Psychology*, *78*, 205-221.

Chesbro, R. (2006). Using Interactive Notebooks for Inquiry-Based Science. Retrieved from http://www.nsta.org/publications/news/story.aspx?id=51882

Clayton-Pederson, A. R., & O'Neal, N. (2018). Curricula Designed to Meet twenty-first-century Expectations. Retrieved from https://www.educause.edu/research-and-publications/books/educating-net-generation/curricula-designed-meet-twenty-first-century-expectations

Cole, R. W. (Ed.). (2008). *Educating Everybody's Children: Diverse Teaching Strategies for Diverse Learners* (2nd ed.). Alexandria, Va.: ASCD.

Collins Dictionary. (). In. Retrieved from https://www.collinsdictionary.com/dictionary/english/cross-curricular

Collins, W. A. (Ed.). (1984). *Development During Middle Childhood: The Years from Six to Twelve.* https://doi.org/10.17226/56

Creswell, J. W. (2013). *Qualitative Inquiry and Research Design; Choosing Among Five Approaches* (Third ed.). Thousand Oaks, California: SAGE.

Current challenges in basic science education [program and meeting document]. (2010). Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000191425

Curtis, D. (2002, September). The Power of Projects. *Educational Leadership*, 50-53. Retrieved from http://ezproxy.cui.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ653553&site=ehost-live

Davis, M. (2012). How Collaborative Learning Leads to Student Success. Retrieved from https://www.edutopia.org/stw-collaborative-learning-college-prep

Delisle, R. (1997). *How to Use Problem-Based Learning in the Classroom*. Alexandria, Virginia: ASCD.

Department of Education and Training (Melbourne). (2017). *High Impact Teaching Strategies* [Training Document]. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=17&ved=2ahUKEwi__sKc9MXgAhXJhFQKHXAfD0kQFjAQegQIAhAC&url=http%3A%2F%2Fwww.

education.vic.gov.au%2FDocuments%2Fschool%2Fteachers%2Fsupport%2Fhighimpactteachstrat.docx&usg=AOvVaw071y3_cQcNqTDd57yDRdNZ

Design Your Own Periodic Table. (2018). [Blog post]. Retrieved from https://lhsblogs.typepad.com/files/design-your-own-periodic-table-project.pdf

Dewey, J. (1938). *Experience and Education*. New York, NY: Simon & Schuster.

Discovery Education. (2017). *Meeting the Students in the Middle: A framework for transforming middle-level education* [White Paper]. Retrieved from www.discoveryeducation.com

Donnelly, R. Fitzmaurice, M. (2005) Collaborative Project-based Learning and Problem-based Learning in Higher Education: A Consideration of Tutor and Student Role in Learner-Focused Strategies. In G. O'Neill, S. Moore & B. McMullin (eds) Emerging Issues in the Practice of University Learning and Teaching (pp.87-98). Dublin, AISHE/HEA.

Dooly, M., & Sadler, R. W. (*20*16). Becoming little scientists: Technologically-enhanced project-based language learning. *Language Learning and Technology*, 20(1), 54-78. https://doi.org/http://hdl.handle.net/10125/44446

Doppelt, Y. (2009). Assessing creative thinking in design-based learning. *International Journal of Technology and Design Education*, *19*, 55-65. http://dx.doi.org/10.1007/s10798-006-9008-y

Dumontheil, I. (2014, October). Development of abstract thinking during childhood and adolescence: The role of the rostrolateral prefrontal cortex. *Developmental Cognitive Neuroscience*, *10*, 57-76. https://doi.org/https://doi.org/10.1016/j.dcn.2014.07.009

Dweck, C. S. (2016). *Mindset: The New Psychology of Success* (Updated ed.). New York, NY: Ballantine Books.

Dweck, C. S., Walton, G. M., & Cohen, G. L. (2014). *Academic Tenacity Mindsets and Skills that Promote Long-Term Learning* [White Paper]. Retrieved from Stanford.edu: https://ed.stanford.edu/sites/default/files/manual/dweck-walton-cohen-2014.pdf

Eady, M. J., & Lockyer, L. (2013). *Tools for Learning: technology and teaching strategies; Learning to Teach in the Primary School*. Retrieved from https://www.researchgate.net/publication/329505008_Tools_for_learning_Technology_and_teaching_strategies

Education Theory/Constructivism and Social Constructivism - UCD - CTAG. (2019). Retrieved August 25, 2019, from http://www.ucdoer.ie/index.php/Education_Theory/Constructivism_and_Social_Constructivism

Educational Records Bureau. (2019). Retrieved from https://www.erblearn.org/

Educational Testing Service. (2003). *Linking Classroom Assessment with Student Learning*. Retrieved from https://www.ets.org/Media/Tests/TOEFL_Institutional_Testing_Program/ELLM2002.pdf

Effective Practices in Closing Achievement Gaps. (2019). Retrieved from http://www.nea.org/home/20609.htm

Eliot, L. (2009, September 8). Girl Brain, Boy Brain? Retrieved August 25, 2019, from https://www.scientificamerican.com/article/girl-brain-boy-brain/

Fallik, O., Eylon, B., & Rosenfeld, S. (2008, October 23). Motivating Teachers to Enact Free-Choice PBL in Science and Technology (PBLSAT) Effects of a Professional Development Model. *Springer Science + Business Media*. http://dx.doi.org/10.1007/s10972-008-9113-8

Families and Youth. (2019). Retrieved from https://www.aacap.org/AACAP/Families_and_Youth/Home.aspx?hkey=4e918a42-7a64-4c60-bf12-9c9ef6e48164

Fernandes, S., Mesquita, D., Flores, M. A., & Lima, R. M. (2014). Engaging students in learning: Findings from a study of project-led education. *European Journal of Engineering Education*, *39*(1), 55-67. http://dx.doi.org/10.1080/03043797.2013.833170

Finn, C. E., & Ravitch, D. (1995). *Education reform 1994 -1995* [Report]. Retrieved from ERIC: https://files.eric.ed.gov/fulltext/ED409651.pdf

Fisher, D., Frey, N., & Pumpian, I. (2012). *How to Create a Culture of Achievement in Your School and Classroom*. Alexandria, Va.: ASCD.

Fox, J. E. (2016). *The Effects of Project-Based Learning in the Middle School Science Classroom* (Doctoral dissertation, Montana State University). Retrieved from http://www.montana.edu/msse/FoxJ_MS.pdf

Frank, M., & Barzilai, A. (2004, February). Integrating alternative assessments in a PBL course for pre-service science and technology teachers. *Assessment & Evaluation in Higher Education, 29*(1), 41-60. http://dx.doi.org/04/010041-21

Friesen, S., & Scott, D. (2013). Inquiry-Based Learning: A Review of the Research Literature. Retrieved from http://galileo.org/focus-on-inquiry-lit-review.pdf

Full Option Science System. (2018). *Science Notebooks in Middle School* [Gray Literature]. Retrieved from https://www.fossweb.com/delegate/ssi-wdf-ucm-webContent?dDocName=D1423685

Fullan, M. (2002, May). The Change Leader. *Educational Leadership*, *59*(8), 16-21. Retrieved from www.ascd.org/publications/educational-leadership/may02/vol59/num08/The-Change-Leader.aspx

Fullan, M. (2006). *Change theory: A force for school improvement* [White Paper]. Retrieved from Center for Strategic Education: http://michaelfullan.ca/wp-content/uploads/2016/06/13396072630.pdf

Fuster, J. M. (2002, December 1). Frontal lobe and cognitive development. *Journal of Neurocytology, 31*, 373–385. Retrieved from http://www.its.caltech.edu/~squartz/fuster.pdf

Galvan, M. E., & Coronado, J. M. (2014, Fall). Problem-based and PBL: Promoting Differentiated Instruction. *National Teacher Education Journal*, *7*(4), 39-42. Retrieved from http://ezproxy.cui.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=110268119&site=ehost-live

Gardner-Webb University. (2018). How Administrators Can Empower Teachers. Retrieved from https://www.teachhub.com/working-together-administrators-role-empowering-teachers

Gbollie, C., & Keamu, H. P. (*2017*, March 20). Student Academic Performance: The Role of Motivation, Strategies, and Perceived Factors Hindering Liberian Junior and Senior High School Students Learning. *Education Research International*, 2017. https://doi.org/10.1155/2017/1789084

Gerlach, D. L. (2008). *Project-Based Learning as a Facilitator of Self- Regulation in Middle School Curriculum* (Unpublished doctoral dissertation). University of Pittsburgh, Pittsburgh, Pennsylvania. Retrieved from http://d-scholarship.pitt.edu/7836/

Glowa, L., & Goodell, J. (2016). *Student-Centered Learning: Functional Requirements for Integrated Systems to Optimize Learning* [EXECUTIVE SUMMARY]. Retrieved from International Association for K–12 Online Learning (iNACOL): https://www.inacol.org/wp-content/uploads/2016/05/iNACOL_FunctionalRequirementsForIntegratedSystems_ExecutiveSummary.pdf

Goldstein, O., & Bevins, S. (2016, Feb 6). A PBL approach to teaching physics for pre-service elementary school teacher education students. *Cogent Education*, *3*(1). https://doi.org/https://doi.org/10.1080/2331186X.2016.1200833

Gollub, J. P., Bertenthal, M. W., Labov, J. B., & Curtis, P. C. (2002). *Learning and Understanding: Improving Advanced Study of Mathematics and Science in U.S. High Schools*. https://doi.org/10.17226/10129

Goos, M., Galbraith, P., Renshaw, P., & Geiger, V. (2000). Reshaping Teacher and Student Roles in Technology-Enriched Classrooms. *Mathematics Education Research Journal*, *12*(3), 303-320. Retrieved from https://espace.library.uq.edu.au/data/UQ_139748/UQ139748_OA.pdf?Expires=1550564162&Signature=a2ITyAKBwMOpDeN51C7en0izD2WvhYmTnp1It6IQFSg7WluF1EfJCBjrmr~xHDRs9wdq7SlgyULY0aSg7jii-OM7bSw14RkrTdC6B927i6vEyBp9~WoI4Q7NkcD7afqe1ZVLurXnlCFa5r4sB9uWzK4vy-

pH3OJabXY~2KTThaEOV8T1pF49iclfRcwubLHv3TPUqwyWuGvIpNWNStcPhzhzKS
u0F0EXa-zc-
wz51g5lQug0qHDevGYyFXBXtIV3JY8uOyqIxoYEH9d8P7xwqp75qXnfs4gyhMDx7p
qAadRYvEg5OQST5-nWVoFszlYfc~jTee7kRaGvfVSmovEfKA__&Key-Pair-
Id=APKAJKNBJ4MJBJNC6NLQ

Grace, J. (2014). Taking the Interactive Science Notebook Plunge. Retrieved from http://www.classroomscience.org/taking-the-interactive-science-notebook-plunge

Grant, M. M., & Branch, R. M. (2005, Fall). PBL in a Middle School: Tracing Abilities Through the Artifacts of Learning. *Journal of Research on Technology in Education*, *38*(1), 65-98. Retrieved from http://ezproxy.cui.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=18566893&site=ehost-live

Groff, J. (2013). Technology-rich innovative learning environments. Retrieved from http://www.oecd.org/education/ceri/Technology-Rich%20Innovative%20Learning%20Environments%20by%20Jennifer%20Groff.pdf

Gulamhussein, A. (2013). *Effective Professional Development in the Era of High Stakes Accountability* [Research Report]. Retrieved from Center for Public Education: www.centerforpubliceducation.org/system/files/Professional%20Development.pdf

Guo, S., & Yang, Y. (2012). PBL: An effective approach to link teacher professional development and students' learning. *Journal of Educational Technology Development and Exchange*, *5*(2), 41-56. Retrieved from file:///C:/Users/afsie/AppData/Local/Microsoft/Windows/INetCache/IE/IA2KS3ZH/4-Guo.pdf

Guskey, T. R. (2003). *How Classroom Assessments Improve Learning*. Alexandria, Va.: ASCD.

Guzey, S. S., & Roehrig, G. H. (2016). Teaching science with technology: Case studies of science teachers' development of technology, pedagogy, and content knowledge. *CITE*. Retrieved from https://www.citejournal.org/volume-9/issue-1-09/science/teaching-science-with-technology-case-studies-of-science-teachersdevelopment-of-technology-pedagogy-and-content-knowledge/

Habegger, S. (2008, September/October). The principal's Role in successful schools: Creating a positive school culture. Principal, 42-46. Retrieved from https://www.naesp.org/sites/default/files/resources/1/Principal/2008/S-O_p42.pdf

Habok, A., & Nagy, J. (2016). In-service teachers' perceptions of project-based learning. *Springerplus*. https://doi.org/ 10.1186/s40064-016-1725-4

Hannah, R. (2013). *The Effect of Classroom Environment on Student Learning* (Doctoral dissertation). Retrieved from https://scholarworks.wmich.edu/honors_theses/2375/

Harrigan, G. (2014). *A Case Study of Teachers' and Administrators' Experiences Integrating PBL* (Doctoral dissertation). Retrieved from http://Scholarworks.waldenu.edu/dissertations

Hasselbring, T. S., & Glaser, W. (2000). Use of computer technology to help students with special needs. *The Future of Children*, *10*(2), 102-122. https://doi.org/https://psycnet.apa.org/doi/10.2307/1602691

Hazen, R. M. (2002, December). Why Should You Be Scientifically Literate? *Bioscience*. Retrieved from http://www.actionbioscience.org/education/hazen.html

Hightower, A. M., Delgado, R. C., Lloyd, S. C., Wittenstein, R., Sellers, K., & Swanson, C. (2011). *Improving Student Learning by Supporting Quality Teaching: Key Issues,* *Effective Strategies* [White Paper]. Retrieved from edweek.org: https://www.edweek.org/media/eperc_qualityteaching_12.11.pdf

Hmelo-Silver, C. E. (2004, September). Problem-based learning: What and how do students learn? *Educational Psychology Review*, *16*, 235. https://doi.org/https://doi.org/10.1023/B:EDPR.0000034022.16470.f3

Holbrook, J. (2009). Meeting challenges to sustainable development through science and technology education. *Science Education International*, *20*(1/2), 44–59. https://doi.org/https://files.eric.ed.gov/fulltext/EJ890655.pdf

Hou, H. (2010, July). Exploring the behavioral patterns in PBL with online discussion: Quantitative content analysis and progressive sequential analysis. *The Turkish Online Journal of Educational Technology*, *9*(3), 52-60.

How People Learn: Brain, Mind, Experience, and School: Expanded Edition. (2000). Washington, D.C.: National Academy Press.

Implementing Group Work in the Classroom. (2018). Retrieved from https://uwaterloo.ca/centre-for-teaching-excellence/teaching-resources/teaching-tips/alternatives-lecturing/group-work/implementing-group-work-classroom

Intelligence in Men and Women Is A Gray and White Matter. (2005, January 22). Retrieved 2019, from https://www.sciencedaily.com/releases/2005/01/050121100142.htm

Irvin, J., Meltzer, J., & Dukes, M. S. (2007). *Taking Action on Adolescent Literacy: An Implementation Guide for School Leaders*. Alexandria, Va.: ASCD.

Jacques, S., Bissey, S., & Martin, A. (2016). Multidisciplinary project-based learning within a collaborative framework: A case study on urban drone conception. *iJet*, *11*(12), 36-44. http://dx.doi.org/10.3991/ijet.v11i12.5996

James, N. (2007). The use of email interviewing as a qualitative method of inquiry in educational research. *British Educational Research Journal*, *33*(6), 963-976. http://dx.doi.org/doi:10.1080/01411920701657074

Jantz, G. L. (2014). Brain differences between genders: Do you ever wonder why men and women think differently? Retrieved from https://www.psychologytoday.com/blog/hope-relationships/201402/brain-differences-between-genders

Jenkins, S., Williams, M., Moyer, J., George, M., & Foster, E. (2016, July 8). The shifting paradigm of teaching: Personalized learning according to teachers. Retrieved August 25, 2019, from https://knowledgeworks.org/resources/teacher-conditions-personalized-learning/

Joersz, J. R. (2017). Changing the way that math is taught: Conceptual versus procedural knowledge. *Learning to Teach*, *5*(1), 1-5. Retrieved from http://utdr.utoledo.edu/cgi/viewcontent.cgi?article=1008&context=learningtoteach

Johnson, M., & Hayes, M. J. (2016, January 1). A comparison of problem-based and didactic learning pedagogies on an electronics engineering course. *International Journal of Electrical Engineering Education*, *53*(1), 3-22. https://doi.org/https://doi.org/10.1177/0020720915592012

Kamara, I. (2015). *CHOOSING SCIENCE: The Role of Social Values* (Doctoral dissertation). Retrieved from https://gupea.ub.gu.se/bitstream/2077/52224/1/gupea_2077_52224_1.pdf

Kanter, D. E. (2009, December 15). Doing the project and learning the content: Designing a project-based science curriculum for meaningful understanding. *Science Education*, 525-551. http://dx.doi.org/10.1002/sce.20381

Katz, L. G. (1994). *The project approach* [ERIC Digest]. Urbana IL: ERIC Clearinghouse on Elementary and Early Childhood Education.

Katz, L. G., & Chard, S. C. (2000). *Engaging Children's Minds: The Project Approach* (Second ed.). Stamford, Connecticut: Ablex Publishing Corporation.

Kelly, J. S. (2002, Spring/Summer). Collaborative learning: Higher education, interdependence, and the authority of knowledge, a critical study. *Journal of The National Collegiate Honors Council*, 91-100. Retrieved from http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1090&context=nchcjournal

Kemp, S. (2014). CONSTRUCTIVISM AND PROBLEM-BASED LEARNING. Retrieved from http://www.tp.edu.sg/staticfiles/TP/files/centres/pbl/pbl_sandra_joy_kemp.pdf

Kim, B. (2001). Social Constructivism. *Emerging perspectives on learning, teaching, and technology*. Retrieved from https://cmapsconverted.ihmc.us/rid=1N5QXBJZF-20SG67F-32D4/Kim%20Social%20constructivism.pdf

Kirkwood, A., & Price, L. (2014). Technology-integrated learning and teaching in higher education: what is 'enhanced,' and how do we know? A critical literature reviews. *Learning, Media, and Technology*, *39*(1), 6-36. https://doi.org/https://doi.org/10.1080/17439884.2013.770404

Klopfer, E., Groff, J. S., Hass, J., & Osterweil, S. (2009). *Using the Technology of Today, in the Classroom Today: The Instructional Power of Digital Gaming and Social Networking and How Teachers Can Leverage It* [Technical Report]. Retrieved from Research Gate: https://www.researchgate.net/publication/263125941_Using_the_Technology_of_Today_in_the_Classroom_Today_The_Instructional_Power_of_Digital_Gaming_and_Social_Networking_and_How_Teachers_Can_Leverage_I

Knapp, M. S., Copland, M. A., & Talbert, J. E. (2003). *Leading for Learning: Reflective Tools for School and District Leaders* [Research Report]. Retrieved from Center for Study of Teaching and Policy: https://files.eric.ed.gov/fulltext/ED482827.pdf

Korthagen, F. A. (2009). Situated learning theory and the pedagogy of teacher education: Towards an integrative of teacher behavior and teacher learning. *Teaching and Teacher Education*, *26*(2010), 98-106. https://doi.org/10.1016/j.tate.2009.05.001

Krajcik, J., Czerniak, C., & Berger, C. (1999). *Teaching Children Science: A Project-Based Approach*. Boston: McGraw-Hill College.

Krajcik, J., Mcneill, K. L., & Reiser, B. J. (2007, November 13). Learning-goals-driven design model: Developing curriculum materials that align with national standards and incorporate project-based pedagogy. *Science Education*, 1-32. http://dx.doi.org/10.1002/sec.20240

Krajcik, J. S., & Czerniak, C. M. (2014). *Teaching Science in Elementary and Middle School: A Project-Based Approach* (4th ed.). New York, NY: Routledge.

Krajcik, J. S., Marx, R. W., Blumenfeld, P., & Soloway, E. (19*94*, May). A collaborative model for helping middle-grade science teachers learn project-based instruction. *The Elementary School Journal*, 94(5). https://doi.org/ 10.1086/461779

Krange, I., & Ludvigsen, S. (2008). What does it mean? Students' procedural and conceptual problem-solving in a CSCL environment designed within the field of science education. *International Journal of Computer-Supported Collaborative Learning*, *3*(1), 25-51. https://doi.org/10.1007/s11412-007-9030-4

Kwan, T., & Chan, E. (2004). Using the theory of learning and awareness to bring about learning through a school-based environmental field project. *International Research in*

Geographical and Environmental Education, *13*(4), 303-319. http://dx.doi.org/1038-2046/04/04 0303-29

Kwek, S. (2011). *Innovation in the Classroom: Design Thinking for 21st Century Learning* (Doctoral dissertation). Retrieved from http://www.stanford.edu/group/redlab/cgibin/publications_resources.php

Laboy-Rush, D. (2009). Integrated STEM Education through Project-Based Learning. Retrieved from https://www.rondout.k12.ny.us/common/pages/DisplayFile.aspx?itemId=16466975

Larmer, J., Mergendoller, J., & Boss, S. (2015). *Setting the Standard for Project-Based Learning*. Alexandria, Va: ASCD.

Lattimer, H., & Riordan, R. (2011). PBL engages students in meaningful work. *Middle School Journal*, *43*(2), 18-23. Retrieved from http://ezproxy.cui.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=67026699&site=ehost-live

Learner-Centered Assessment. (2018). Retrieved from https://uwaterloo.ca/centre-for-teaching-excellence/teaching-resources/teaching-tips/assessing-student-work/grading-and-feedback/learner-centred-assessment

Learning Theories and Transfer of Learning. (2007). Retrieved from http://otec.uoregon.edu/learning_theory.htm

Leithwood, K., Seashore Louis, K., Anderson, S., & Wahlstrom, K. (2004). How leadership influences student learning. Retrieved from http://www.wallacefoundation.org/knowledge-center/Documents/How-Leadership-Influences-Student-Learning.pdf

Lenroot, R. K., & Giedd, J. N. (2010). Sex differences in the adolescent brain. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2818549/

Lipponen, L., Rahikainen, M., Lallimo, J., & Hakkarainen, K. (2003). Patterns of participation and discourse in elementary students' computer-supported collaborative learning. *Learning and Instruction*, *13*(2003), 487-509. https://doi.org/10.1016/S0959-4752(02)00042-7

Lochmiller, C. R., & Lester, J. N. (2017). *An Introduction to Educational Research: Connecting Methods to Practice*. Thousand Oaks, California: Sage.

Lujan, H. L., & DiCarlo, S. E. (2006, March 1). Too much teaching, not enough learning: what is the solution? *Advances in Physiology Education*, *30*(1), 17-22. https://doi.org/10.1152/advan.00061.2005

Male and Female Brains Are Not the Same. (2018). Retrieved from https://www.multiplyingconnections.org/

Marton, F., & Booth, S. (1997). *Learning and Awareness*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Marton, F., Runesson, U., & Tsui, A. B. (2004). *Classroom Discourse and the Space of Learning*. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.

Maxwell, J. A. (2013). *Qualitative Research Design; An Interactive Approach* (Third ed.). Thousand Oaks, California: SAGE.

McConnell, T. J., Parker, J. M., & Eberhardt, J. (2013). Problem-based learning as an effective strategy for science teacher professional development. *The Clearing House*, *86*, 216-223. http://dx.doi.org/10.1080/00098655.2013.826486

McCormick, R. (1997, January). Conceptual and Procedural Knowledge. *International Journal of Technology and Design Education*, 7(1), 141-159. http://dx.doi.org/10.1023/A:1008819912213

McCright, A. M. (2012, December). Enhancing students' scientific and quantitative literacies through an inquiry-based learning project on climate change. *Journal of Scholarship of Teaching and Learning*, 12(4), 86-102.

McGroarty, E., & Robbins, J. (2012). *Controlling Education from The Top: Why Common Core Is Bad for America* [White Paper]. Retrieved from Pioneer Institute: https://truthinamericaneducation.com/wp-content/uploads/2012/07/Controlling-Education-From-the-Top-PRINT.pdf

McKnight, K., O'Malley, K., Ruzic, R., Horsley, M. K., Franey, J. J., & Bassett, K. (2015, July 27). Teaching in a digital age: How educators use technology to improve student learning. *Journal of Research on Technology in Education*, *48*(3), 194-211. https://doi.org/https://doi.org/10.1080/15391523.2016.1175856

McLeod, S. (2018). Maslow's Hierarchy of Needs. Retrieved from https://www.simplypsychology.org/maslow.html

McNamee, D. (2014, August 22). Why is scientific literacy among the general population important? *Medical News Today*. Retrieved from https://www.medicalnewstoday.com/articles/281470.php

Menzes, A., & Maier, A. (2014). *Fast Start: Training Better Teachers Faster, with Focus, Practice, and Feedback* [Descriptive Report]. Retrieved from TNTP: https://files.eric.ed.gov/fulltext/ED559704.pdf

Michaels, S., Shouse, A. W., & Schweingruber, H. A. (2008). *Ready, Set, SCIENCE! Putting Research to Work in K-8 Science Classrooms.* https://doi.org/ 10.17226/11882

Moeller, B., & Reitzes, T. (2011). *Integrating Technology with Student-Centered Learning. A Report to the Nellie Mae Education Foundation* [Report]. Retrieved from ERIC: https://eric.ed.gov/?id=ED521868

Moran, K. A. (2015). *TEACHER EMPOWERMENT: SCHOOL ADMINISTRATORS LEADING TEACHERS TO LEAD (*Doctoral dissertation, YOUNGSTOWN STATE UNIVERSITY). Retrieved from https://etd.ohiolink.edu/!etd.send_file?accession=ysu1443197279&disposition=inline

Motivating Students. (2019). Retrieved from https://cft.vanderbilt.edu/guides-sub-pages/motivating-students/

Moursund, D. (2003). *PBL using information technology*. Eugene, OR: ISTE.

Mulford, B. (2003). SCHOOL LEADERS: CHANGING ROLES AND IMPACT ON TEACHER AND SCHOOL EFFECTIVENESS. Retrieved from www.oecd.org/education/school/2635399.pdf

National Association of Elementary School Principles. (2013). Retrieved from https://www.naesp.org/2013-conference-recap

National Education Association. (2012). *Preparing 21st Century Students for a Global Society: An Educators' Guide to the Four-Cs*. Retrieved from http://www.nea.org/assets/docs/A-Guide-to-Four-Cs.pdf

National Foundation for the Improvement of Education. (1999). *Creating a Teacher Mentoring Program* [Guideline Report]. Retrieved from https://eric.ed.gov/?id=ED455230

National Research Council. 1997. *Science Teaching Reconsidered: A Handbook*. Washington, DC: The National Academies Press. https://doi.org/10.17226/5287.

Navarette, L., & Watson, S. (2013). English Language Learners – The Impact of Language and Socio-Cultural Factors on Learning. Retrieved from https://council-for-learning-disabilities.org/english-language-learners-impact-of-language-and-socio-cultural-factors-on-learning

Nextgenscience.org. (2013). *Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards* [Educational Standards]. Retrieved from https://www.nextgenscience.org/sites/default/files/Appendix%20H%20-%20The%20Nature%20of%20Science%20in%20the%20Next%20Generation%20Science%20Standards%204.15.13.pdf

NYC Department of Education. (2009). *Project-Based Learning: Inspiring Middle School Students to Engage in Deep and Active Learning* [Guide]. Retrieved from http://schools.nyc.gov/documents/teachandlearn/project_basedFinal.pdf

Oberg, C. (2010). Guiding classroom instruction through performance assessment. *Journal of Case Studies in Accreditation and Assessment*. Retrieved from http://ezproxy.cui.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1055507&site=ehost-live

Oliver, P. (2010). *The Students' Guide to Research Ethics* (Second ed.). Berkshire, England: Open University Press.

Oliver-Hoyo, M., & Allen, D. (2006). The use of triangulation methods in qualitative educational research. *Journal of College Science Teaching*, *35*(4), 42-47. Retrieved from http://ezproxy.cui.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=19271211&site=ehost-live

Organization for Economic Cooperation and Development. (2008). *21ST CENTURY LEARNING: RESEARCH, INNOVATION, AND POLICY DIRECTIONS FROM RECENT OECD ANALYSES Learning* [Policy Brief]. Retrieved from http://www.oecd.org/site/educeri21st/40554299.pdf

Osborne, J. (2003). Attitudes toward science: a review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079. http://dx.doi.org/10.1080/0950069032000032199

Ozdemir, E. (2006). *An Investigation on The Effects of PBL On Students' Achievement in and Attitude toward Geometry* (Doctoral dissertation, Middle East Technical University). Retrieved from https://etd.lib.metu.edu.tr/upload/3/12607166/index.pdf

Park, S. H., & Ertmer, P. A. (2007). Impact of problem-based learning (PBL) on teachers' belief regarding technology use. *Journal of Research on Technology in Education, 40*(2), 247-267. Retrieved from https://files.eric.ed.gov/fulltext/EJ826078.pdf

Peng, W. J., McNess, E., Thomas, S., W, X. R., Zhang, C., Li, J. Z., & Tian, H. S. (2014, January). Emerging perceptions of teacher quality and teacher development in China. *International Journal of Education Development*, *34*, 77-89. https://doi.org/https://doi.org/10.1016/j.ijedudev.2013.04.005

Pepper-Rollins, S. (2017). *Teaching in The Fast Lane: How to Create Active Learning Experiences*. Alexandria, VA: ASCD.

Prince, M. (2004, July). Does Active Learning Work? A Review of the Research. *Journal of Engineering Education*, *93*(3), 223-231. Retrieved from http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/Prince_AL.pdf

Railsback, J. (2002). Project-based instruction: Creating excitement for learning. Retrieved from http://www.nwrel.org/request/2002aug/index.html

Rainie, L., & Anderson, J. (2017). The Future of Jobs and Jobs Training. Retrieved from http://www.pewinternet.org/2017/05/03/the-future-of-jobs-and-jobs-training/

Reaching Students: What Research Says About Effective Instruction in Undergraduate Science and Engineering. (n.d.). https://doi.org/10.17226/18687

Red Clay Consolidated School District. (2011). *Professional Learning Communities (PLC) Overview and Guidelines* [Guidelines]. Retrieved from https://www.redclayschools.com/cms/lib/DE01903704/Centricity/Domain/100/RCCSDPLCOverviewGuidelines14-15.pdf

Reeves, S., Peller, J., & Kitto, S. (2013). Ethnography in qualitative educational research: AME Guide No.80. *Medical Teacher*, *35*(8), e1365-e1379. http://dx.doi.org/doi:10.3109/0142159X.2013.804977

Remmen, K. B., & Froyland, M. (2014). Implementation of guidelines for effective fieldwork designs: exploring learning activities, learning processes, and student engagement in the classroom and the filed. *International Research in Geographical and Environmental Education*, *23*(2), 103-125. http://dx.doi.org/10.1080/10382046.2014.891424

[Research Report]. Retrieved from Educational Testing Services: https://www.ets.org/Media/Research/pdf/RR-01-19-Wenglinsky.pdf

Reyna, V. F., & Farley, F. (2006). Risk and Rationality in Adolescent Decision Making: Implications for Theory, Practice, and Public Policy. *Psychological Science in The Public Interest*, *7*(1), 1-44. https://doi.org/10.1111/j.1529-1006.2006.00026.X

Ruiz-Primo, M. A., & Furtak, E. M. (2006). Informal formative assessment and scientific inquiry: Exploring teachers' practices and student learning. *EDUCATIONAL ASSESSMENT*, *11*(3&4), 205-235. Retrieved from web.stanford.edu/dept/SUSE/SEAL/Reports_Papers/RuizPrimoFurtak_InformalFormative.pdf

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, *25*, 54-67. https://doi.org/10.1006/ceps.1999.1020

Rye, J., Landenberger, R., & Warner, T. A. (2013). Incorporating concept mapping in PBL: Lessons from watershed investigations. *Journal of Science Education and Technology*, *22*, 379-392. http://dx.doi.org/10.1007/s10956-012-9400-1

Saleh, A., Cox, D. W., Fowler, T., & Duncan-Shemwell, B. (2010). Student and facilitator engagement to develop leadership competencies in a PBL environment. *Academic Leadership*, *8*(2), 1-8. Retrieved from http://ezproxy.cui.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=57804381&site=ehost-live

Sangasubana, N. (2011). How to conduct ethnographic research. *The Qualitative Report*, *16*, 567-573. Retrieved from http://nsuworks.nova.edu/tqr/vo116/iss2/14

Schaps, E. (1992). The Role of Supportive School Environments in Promoting Academic Success. Retrieved from https://www.collaborativeclassroom.org/research-articles-and-papers-the-role-of-supportive-school-environments-in-promoting-academic-success

Schwartz, J. E. (2007). *Elementary Mathematics Pedagogical Content Knowledge: Powerful Ideas for Teachers* (First ed.). Upper Saddle River, New Jersey: Pearson.

Science Teaching Reconsidered: A Handbook [Handbook]. (1997). Retrieved from https://www.nap.edu/catalog/5287/science-teaching-reconsidered-a-handbook

Scott, C. L. (2015). *The Futures of Learning 2: What Kind of Learning for the 21st Century?* [Research Report]. Retrieved from unesco.org: http://unesdoc.unesco.org/images/0024/002429/242996E.pdf

Seo, K. K., Templeton, R., & Pellegrino, D. (2008). Creating a ripple effect: Incorporating multimedia-assisted PBL in teacher education. *Theory into Practice*, *47*, 259-265. http://dx.doi.org/10.1080/00405840802154062

Sheninger, E. C., & Murray, T. C. (2017). *Learning Transformed*. Alexandria, Va.: ASCD.

Singer, S. R., Nielsen, N. R., & Schweingruber, H. A. (Eds.). (2012). *Discipline-Based Education Research Understanding and Improving Learning in Undergraduate Science and Engineering*. https://doi.org/10.17226/13362

Spinks, S. (2002). Adolescent Brains are Works in Progress. Retrieved from http://www.pbs.org/wgbh/pages/frontline/shows/teenbrain/work/adolescent.html

Sprinthall, R. C. (2012). *Basic Statistical Analysis* (9th ed.). Boston: Pearson Allyn & Bacon.

Stanovich, P. J., & Stanovich, K. E. (2003). Using Research and Reason in Education: How Teachers Can Use Scientifically Based Research to Make Curricular & Instructional

Decisions. Retrieved from https://www.nichd.nih.gov/publications/pubs/Pages/using_research_stanovich.aspx

Star, J. R., & Stylianides, G. J. (2012, December 23). Procedural and conceptual knowledge: Exploring the gap between knowledge type and knowledge quality. *Canadian Journal of Science, Mathematics, and Technology Education*, *13*(2), 169-181. https://doi.org/10.1080/14926156.2013.784828

Stepanek, J. (1999). *The Inclusive Classroom Meeting the Needs of Gifted Students: Differentiating Mathematics and Science Instruction* [White Paper]. Retrieved from Northwest Regional Educational Laboratory: http://educationnorthwest.org/sites/default/files/12.99.pdf

Subban, P. (2006). Differentiated instruction: A research basis. *International Education Journal*, *7*(7), 935-947. Retrieved from https://files.eric.ed.gov/fulltext/EJ854351.pdf

Parsons, J., & Taylor, L. (2011). Improving student engagement. *Current Issues in Education*, *14*(1). Retrieved from https://cie.asu.edu/ojs/index.php/cieatasu/article/view/745

Teen Brain: Behavior, Problem-solving, and Decision Making. (2016). Retrieved from https://www.aacap.org/aacap/families_and_youth/facts_for_families/FFF-Guide/The-Teen-Brain-Behavior-Problem-Solving-and-Decision-Making-095.aspx

Thomas, J. W. (2000). A Review of Research on Project-Based Learning. Retrieved from http://www.bie.org/images/uploads/general/9d06758fd346969cb63653d00dca55c0.pdf

Thornton, K., Buckley, D., Miller, Z., Padilla, M. J., & Wysession, M. E. (2013). *Interactive Science*. Upper Saddle River, NJ: Pearson.

Tinzmann, M. B., Jones, B. F., Fennimore, T. F., Bakker, J., Fine, C., & Pierce, J. (1990). What Is the Collaborative Classroom? Retrieved from http://methodenpool.uni-koeln.de/koopunterricht/The%20Collaborative%20Classroom.htm

Toshalis, E., & Nakkula, M. J. (2012). Motivation, Engagement, and Student Voice. Retrieved from https://studentsatthecenterhub.org/wp-content/uploads/2012/04/Exec-Toshalis-Nakkula-032312.pdf

Tschanmen-Moran, M., Woolfolk Hoy, A., & Hoy, W. K. (1998, Summer). Teacher efficacy: Its meaning and measure. *Review of Educational Research*, *68*(2), 202-248. Retrieved from http://mxtsch.people.wm.edu/Scholarship/RER_TeacherEfficacy.pdf

Tseng, K., Chang, C., Lou, S., & Chen, W. (2013). Attitudes toward science, technology, engineering, and mathematics (STEM) in a PBL (PjBL) environment. *International Journal of technology and Design Education*, *23*, 87-102. http://dx.doi.org/10.1007/s10798-011-9160-x

UNESCO. (2010). *Current challenges in basic science education*. Retrieved from https://unesdoc.unesco.org/ark:/48223/pf0000191425

United Nations Educational, Scientific, and Cultural Organization. (2004). *Changing Teaching Practices: using curriculum differentiation to respond to students' diversity* [White Paper]. Retrieved from http://unesdoc.unesco.org/images/0013/001365/136583e.pdf

US Department of Education. (2017). *Reimagining the Role of Technology in Education* [2017 National Education Technology Plan Update]. Retrieved from https://tech.ed.gov/files/2017/01/NETP17.pdf

US Office of Special Education Program. (2015). *Supporting and Responding to Behavior: Evidence-Based Classroom Strategies for Teachers* [Technical Assistance Document].

Retrieved from https://www.pbis.org/common/cms/files/pbisresources/Supporting%20and%20Responding%20to%20Behavior.pdf

Usher, A., & Kober, N. (2012). *Student Motivation— An Overlooked Piece of School Reform* [Summary Report]. Retrieved from Center for Education Policy: https://files.eric.ed.gov/fulltext/ED532666.pdf

Using Multimedia Tools to Help Students Learn Science. (2016). Retrieved from http://www.cited.org/output_pages/printDefault.aspx?page_id=148

Vasquez, J. (2014/2015, December/January). STEM-beyond the acronym. *Educational Leadership*, *72*(4), 10-15. Retrieved from www.ascd.org/publications/educational-leadership/dec14/vol72/num04/STEM—Beyond-the-Acronym.aspx

Victoria Department of Education and Training. (2017). *High Impact Teaching Strategies Excellence in Teaching and Learning* [White Paper]. Retrieved from www.education.vic.gov.au/Documents/.../teachers/support/highimpactteachstrat.docx

Weigel, J., Weigel, M., Gardner, H., & James, C. (2009, February). Learning: Peering backward and looking forward in the digital era. *International Journal of Learning and Media*. https://doi.org/10.1162/ijlm.2009.0005

Wenglinsky, H. (2001). *Teacher Classroom Practices and Student Performance: How Schools Can Make a Difference*. Retrieved from Educational Testing Services.Org: https://www.ets.org/Media/Research/pdf/RR-01-19-Wenglinsky.pdf

(n.d.). "What is theory of change" n.d., Retrieved from https://www.theoryofchange.org/what-is-theory-of-change/

Wigfield, A., & Cambria, J. (2010, January 18). Students' achievement values, goal orientations, and interests: Definitions, development, and relations to achievement outcomes. *Developmental Review*, *3*(2010), 1-35. https://doi.org/https://doi.org/10.1016/j.dr.2009.12.001

Willis, J. (2007). *Brain-Friendly Strategies for the Inclusion Classroom*. Alexandria, Va: ASCD.

Wolfe, V. (2012). *Project-Based Learning (PBL): Keys to Supporting PBL Administrator's Edition* [Gray Literature]. Retrieved from https://issuu.com/wolftune/docs/admin_handbook_pbl:

Yoder, N. (2014). *Teaching the Whole Child: Instructional Practices That Support Social-Emotional Learning in Three Teacher Evaluation Frameworks* [Research-to-Practice Brief]. Retrieved from American Institute for Research: https://gtlcenter.org/sites/default/files/TeachingtheWholeChild.pdf

Zaiontz, C. (2019). Real Statistics Resource Pack for Excel 2018 [Computer Software]. Retrieved from http://www.real-statistics.com/free-download/real-statistics-resource-pack/

Appendices

Appendix A: NIH CERTIFICATE

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Afsaneh Miller** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 01/23/2018.

Certification Number: 2390549.

APPENDIX AA: IRB LETTER OF APPROVAL

CONCORDIA
UNIVERSITY IRVINE

INSTITUTIONAL REVIEW BOARD DECISION

☐ Exempt Review 45 CFR 46.101 ☑ Expedited Review 45 CFR 46.110 ☐ Full Board Review 45 CFR 46

Review Date	September 7, 2018
IRB#	4526
Title of Project	THE IMPACT OF THE USE OF PBL AND INTEGRATION OF TECHNOLOGY ON SCIENCE ACHIEVEMENT OF MIDDLE SCHOOL STUDENTS
Researcher/s	Afsaneh Miller

☑ **APPROVED**

Effective duration of IRB Approval: September 7, 2018 to September 6, 2019

All requirements of IRB have been met in this revised proposal.

For Exempt Approved, Please Note: *while your project is exempt from providing Informed Consent information to the IRB, your project must still obtain participants' informed consent.*
For Expedited and Full Board Approved, Please Note:
a.The IRB's approval is only for the project protocol named above. Any changes aresubject to review and approval by the IRB.
b.Any adverse events must be reported to the IRB.
c.An annual report or report upon completion is required for each project. If the project isto continue beyond the twelve month period, a request for continuation of approvalshould be made in writing. Any deviations from the approved protocol should be noted.

☐ **NEEDS REVISION AND RESUBMISSION**

☐ **NOT APPROVED**

Printed Name IRB Reviewer Eugene P. Kim, Ph.D.

Signature of IRB Reviewer Kim, Eugene Digitally signed by Kim, Eugene Date: 2018.09.07 13:46:04 -07'00'

Appendix A1: Study Timeline

Timeline

1. Complete all coursework: Summer 2017

2. Request IRB Approval: Summer/Fall 2018

1. Conduct a research study and collect data: Fall 2018/Spring 2019

2. Collect standardized testing results: Spring 2019

3. Analyze collected data: Spring/Summer 2019

4. Finalize Study: Summer 2019

Appendix B: EXCERPTS FROM THE CLASSROOM PROCEDURES USED DURING THE STUDY

<u>Science classroom Conduct Policy:</u>

1. Treat all others with kindness, respect, and consideration.
    - Do not make fun of anyone in the class.
    - Do not use disrespectful verbal or body language.
    - Do not bother others.
    - Do not take things that do not belong to you without asking for permission.
    - Keep your hands and feet to yourself!
    - Do not shout or talk out of turn!
2. Come to class on time, ready to participate, and learn.
    - Make sure you have all the l materials needed for class with you.
    - Do not lose your science packets!
    - Write down all assignments or assessments in your planner.
    - Bring your iPad charged to at least 70%!

3. Always do your best.
    - Complete all your work!
    - Do your very best and put in 100% effort when working in a group!
    - Prepare for your assessments.

4. Follow all laboratory instructions the first time given.
    - Follow all laboratory safety rules.
    - Students who are violating laboratory safety rules will be excused from the experiment without receiving credit for the performance of the lab.

Appendix C: PARENT / STUDENT PARTICIPANT LETTER OF INFORMED CONSENT

THE IMPACT OF USE OF PBL AND INTEGRATION OF TECHNOLOGY ON SCIENCE ACHIEVEMENT OF MIDDLE SCHOOL STUDENTS

The study in which you are being asked to participate is designed to investigate the impact of the use of PBL and the integration of technology on the science achievement of middle school students. Afsaneh Miller is conducting this study under the supervision of Belinda Dunnick Karge, Ph.D., Concordia University School of Education. The Institutional Review Board has approved this study, Concordia University Irvine, in Irvine, CA.

PURPOSE: The purpose of implementing technology-integrated PBL in a middle school science classroom is to learn if the use of this method of teaching would enhance the existing science curriculum while adhering to the curriculum standards and lesson pacing guidelines. Furthermore, the purpose of this project is to see if the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom would lead to changes in students' attitude and aptitude resulting in an improved overall academic achievement for science. An additional purpose of this study is to learn if access to an easy to use, lesson-planning platform along with administrative support could serve to change the attitude of teachers with basic knowledge of technology toward implementation of technology-integrated PBL in their classrooms to improve students' levels of academic achievement.

DESCRIPTION: Project-based instruction will begin with the selection of a topic of study for the project that takes into consideration students' prior knowledge and curriculum standards. The text selected will then serve to organize and drive classroom activities resulting in a series of artifacts, or products, which culminate in a final product that addresses the driving question. In the last phase, the researcher (Mrs. Afsaneh Miller) will work with the students to review and evaluate their final product before the concluding event, where students share their results with the school community.

PARTICIPATION: Participation in this study is voluntary, refusal to participate will involve no penalty or loss of benefits to which the participants are otherwise entitled and the participants may discontinue participation at any time without penalty or loss of benefits, to which they are otherwise entitled.

CONFIDENTIALITY OR ANONYMITY: Participants' confidentiality will be maintained using aliases, composite profiles so that individuals cannot be identified. Additionally, only group data from this study will be reported. Participant records identifying the participants will be maintained by storing the records in a locked filing cabinet. Electronic records will be maintained in the researcher's password-protected computer. All electronic, as well as hard copies of the data collected for this study, will be destroyed by December 20, 2021.

DURATION: The Academic year 2018-2019

RISKS: Participation in this study is voluntary. Participation in this study will not place the participants at undue risk. Although all students will receive regular science instruction using PBL, the researcher would only collect and use data from students who consented to be participants in the study. Students' identities will be protected using anonymous surveys, pseudonyms, and group data reporting. All the data (electronic and hard copy) collected for the study will be at the end of the study by December 20, 2021.

BENEFITS: The researcher (Mrs. Afsaneh Miller) is interested in studying the impact of the use of PBL and the integration of technology on science achievement of middle school students in a science classroom. PBL promotes student learning by helping students to construct knowledge through a variety of learning experiences. Use of PBL in science helps young learners to ask questions, hypothesize, design experiments, gather and analyze data, produce artifacts, and communicate ideas through a process of investigation and collaboration. As they learn fundamental science concepts and principles, students become better prepared to deal with the scientific, technological, and social issues that face them in the future.

VIDEO/AUDIO/PHOTOGRAPH:

I understand this research will be photographed Initials___.

CONTACT: This study has been reviewed and approved by the Instructional Review Board at Concordia University, Irvine. Also, it has the support of XXX School, XXX Campus Director Mrs. Kellie Cameron. If you have any questions about the study, or if you would like additional information to assist you in reaching a decision, please feel free to contact me at amiller@XXXschools.com. You may also direct questions about research participants' rights and research-related concerns and issues to Belinda Dunnick Karge, Ph.D., Professor of Doctoral Programs Concordia University School of Education. Dr. Karge may be reached via email at Belinda.karge@cui.edu or 949-214-3333.

RESULTS: Following the completion of the research, the researcher will report multiple perspectives as well as contrary findings. The privacy of the participants will be protected through the use of aliases, composite profiles, and group data reporting so that individuals cannot be identified. Data collected will be reported honestly following APA (2010) guidelines for obtaining permission to reprint and adapt the work of others. Copies of the final data report will be provided to participants at XXX Private Schools, XXX Campus.

CONFIRMATION STATEMENT:

______ I have read the information above and agree to participate in your study.

SIGNATURE:

Signature: ______________________________Date:

Printed Name: __________________________

Appendix C1: TEACHERS AND ADMINISTRATORS INFORMED CONSENT

THE IMPACT OF USE OF PBL AND INTEGRATION OF TECHNOLOGY ON SCIENCE ACHIEVEMENT OF MIDDLE SCHOOL STUDENTS

The study in which you are being asked to participate is designed to investigate the impact of administrative support on the teacher's use of PBL and the integration of technology on science achievement of middle school students. Afsaneh Miller is conducting this study under the supervision of Belinda Dunnick Karge, Ph.D., Concordia University School of Education. The Institutional Review Board has approved this study, Concordia University Irvine, in Irvine, CA.

PURPOSE: The purpose of implementing technology-integrated PBL in a middle school science classroom was to learn if the use of this method of teaching would enhance the existing science curriculum while adhering to the curriculum standards and lesson pacing guidelines. Furthermore, the purpose of this project was to see if the addition of technology-integrated PBL to other effective teaching strategies used in a science classroom would lead to changes in students' attitude and aptitude resulting in an improved overall academic achievement for science. An additional purpose of this study was to learn if access to an easy to use, lesson-planning platform along with administrative support could serve to change the attitude of teachers with basic knowledge of technology toward implementation of technology-integrated PBL in their classrooms to improve students' levels of academic achievement.

DESCRIPTION: Project-based instruction will begin with the selection of a topic of study for the project that takes into consideration students' prior knowledge and curriculum standards. The text selected will then serve to organize and drive classroom activities resulting in a series of artifacts, or products, which culminate in a final product that addresses the driving question. In the last phase, the researcher (Mrs. Afsaneh Miller) will work with the students to review and evaluate their final product before the concluding event, where students share their results with the school community. The researcher will survey the teachers and the administrators in her organization after her study.

PARTICIPATION: Participation in this study is voluntary, refusal to participate will involve no penalty or loss of benefits to which the participants are otherwise entitled and the participants may discontinue participation at any time without penalty or loss of benefits, to which they are otherwise entitled.

CONFIDENTIALITY OR ANONYMITY: Participants' confidentiality will be maintained using aliases, composite profiles so that individuals cannot be identified. Additionally, only group data from this study will be reported. Participant records identifying the participants will be maintained by storing the records in a locked filing cabinet. Electronic records will be maintained in the researcher's password-protected computer. All electronic, as well as hard copies of the data collected for this study, will be destroyed by December 20, 2021.

DURATION: 1 week

RISKS: Participation in this study is voluntary and will not place the participants at undue risk. The researcher (Mrs. Afsaneh Miller) will only collect and use data from participants who consented to be part of the study. Participant identities will be protected using anonymous surveys, pseudonyms, and group data reporting. All the data (electronic and hard copy) collected for the study will be at the end of the study by December 20, 2021.

BENEFITS: The researcher is interested in studying the impact of administrative support on the use of PBL and the integration of technology on science achievement of middle school students in a science classroom. PBL promotes student learning by helping students to construct knowledge through a variety of learning experiences. Use of PBL in science helps young learners to ask questions, hypothesize, design experiments, gather and analyze data, produce artifacts, and communicate ideas through a process of investigation and collaboration. As they learn fundamental science concepts and principles, students become better prepared to deal with the scientific, technological, and social issues that face them in the future. The information gathered in this study will be useful to other educators and administrators interested in implementing PBL and instruction in their schools and classrooms.

VIDEO/AUDIO/PHOTOGRAPH: I understand this research will be photographed Initials___.

CONTACT: This study has been reviewed and approved by the Instructional Review Board at Concordia University, Irvine. Also, it has the support of XXX School, XXX Campus Director Mrs. Kellie Cameron. If you have any questions about the study or if you would like additional information to assist you in reaching a decision, please feel free to contact me at amiller@XXXschools.com. You may also direct questions about research participants' rights and research-related concerns and issues to Belinda Dunnick Karge, Ph.D., Professor of Doctoral Programs Concordia University School of Education. Dr. Karge may be reached via email at Belinda.karge@cui.edu or 949-214-3333.

RESULTS: Following the completion of the research, the researcher will report multiple perspectives as well as contrary findings. The privacy of the participants will be protected through the use of aliases, composite profiles, and group data reporting so that individuals cannot be identified. Data collected will be reported honestly following APA (2010) guidelines for obtaining permission to reprint and adapt the work of others. Copies of the final data report will provide to participants at XXX Private Schools, XXX Campus.

CONFIRMATION STATEMENT:

______ I have read the information above and agree to participate in your study.

SIGNATURE:

Signature: ______________________________Date:

Printed Name: __________________________

Appendix C2: PHOTOGRAPHY/VIDEO/AUDIO USE - INFORMED CONSENT

As part of this research project, I will be making photograph recording as well as videotape recordings of you during participation in the study. Please indicate what uses of this photograph or videotape recording you are willing to consent to by initialing below.

You are free to initial any number of spaces from zero to all the spaces, and your recordings will in no way affect your credit for participation. I will only use the photograph or videotape recordings in a way that you agree to. In any use of this photograph or videotape, names or faces would not be identified. If you do not initial any of the spaces below, the photographs/videotapes/audiotapes will be destroyed.

Please indicate the type of informed consent.

The photograph/videotape can be shown/played to subjects in other experiments.	Please initial _________
The photograph/videotape can be used for scientific publications.	Please initial _________
The photograph/videotape can be shown/played at a meeting of scientists.	Please initial _________

I have read the above description and give my consent for the use of the photograph/videotape/audiotape as indicated above.

Signature: ______________________________Date: ______________________

Printed Name: __________________________

Appendix C3: PARENTAL INFORMED CONSENT

Date XXX

Dear Parent(s),

As part of completing my Doctor of Education degree at Concordia University located in Irvine, California, I would like to conduct a study during the 2018-2019 academic year to investigate the impact of the use of PBL and the integration of technology on science achievement of middle school students.

I am writing to ask permission to use the data I may collect from your child during this process. Participation in this study involves the selection of a topic of study for the project that takes into consideration students' prior knowledge and curriculum standards. The text selected will then serve to organize and drive classroom activities resulting in a series of artifacts, or products, which culminate in a final product that addresses the driving question the lesson attempted to answer. In the last phase, I will work with the students to review and evaluate their final product before the concluding event, where students share their results with the school community. Mrs. Kellie Cameron has approved this study for implementation at XXX Private Schools, XXX Campus.

This study could contribute valuable insight and theory to the successful use of technology-integrated project-based learning, considering the level of importance placed on students' attitude and aptitude for learning at the middle school level. The outcome of this study may be useful for the development of improved training models, environments, and implementation strategies that promote the efficient use of technology-integrated PBL in middle school science classrooms.

The benefits to your child for participating in this study include the promotion of student learning by helping students to construct knowledge through a variety of learning experiences. The use of project-based learning in science helps young learners to ask questions, hypothesize, design experiments, gather and analyze data, produce artifacts, and communicate ideas through a process of investigation and collaboration. As they learn fundamental science concepts and principles, students become better prepared to deal with the scientific, technological, and social issues that face them in the future.

Only Dr. Belinda Dunnik Karge, my University Supervisor, and I will have access to your child's identity and to information that can be associated with your child's identity. All data and documentation associated with this study will be destroyed by December 31, 2021.

Participation in this study is voluntary, refusal to participate will involve no penalty or loss of benefits to which the student participants are otherwise entitled and the participants may discontinue participation at any time without penalty or loss of benefits, to which they are otherwise entitled. The use of data from your child is voluntary. You may contact me at any time regarding your child's participation. My phone number is XXX-XXX-XXXX, and my e-mail is amiller@XXXschools.com.

Sincerely,

Mrs. Afsaneh Miller

Please check the appropriate box below and sign the form:

- ☐ I permit my child's data to be used in this study. I understand that I will receive a signed copy of this consent form. I have read this form and understand it.
- ☐ I do not permit my child's data to be included in this project.

Students' Name: ____

Signature of Parents/Guardian: ________________________________

Printed Name of Parents/Guardian ____________________________

Date ______________________

Appendix C4: CHILD ASSENT FORM

Dear ___________________

As part of completing my Doctor of Education degree at Concordia University located in Irvine, California, I would like to conduct a study during the 2018-2019 academic year to investigate the impact of the use of PBL and the integration of technology on science achievement of middle school students.

I am asking you to help because I believe that project-based learning will help you to construct knowledge through a variety of learning experiences. The use of project-based learning in science will help you to ask questions, hypothesize, design experiments, gather and analyze data, produce artifacts, and communicate ideas through a process of investigation and collaboration. As you learn fundamental science concepts and principles, you will become better prepared to deal with the scientific, technological, and social issues that face them in the future.

If you agree to be in my study, I am going to ask you to participate in a survey about project-based learning. Additionally, you will participate in project-based learning as part of our day-to-day classroom activities. Your workload will not be increased by participating in this study. You will not be asked to do or complete additional academic tasks beyond what is currently expected for the science classroom. You can ask questions about this study at any time. If you decide at any time you do not want to finish the study, you can stop by letting me know that you no longer wish to be part of the study.

If you sign this paper, it means that you have read this and that you wish to be in the study. If you do not want to be in the study, do not sign this paper. Being in the study is up to you, and no one will be upset if you do not sign this paper or if you change your mind later.

Signature of person obtaining assent: ______________________Date: ________________

Printed Name of the person obtaining assent: Afsaneh Miller

Your Signature: _____________________________________ Date: __________________

Your Printed Name: _____________________________________

Appendix D: STUDENT PARTICIPANT TECHNOLOGY-INTEGRATED PROJECT-BASED LEARNING SURVEY

My name is Mrs. Afsaneh Miller. I am the middle school science instructor as well as a Doctoral Candidate at Concordia University. I want to ask you to complete the following survey. I am researching your level of understanding of technology-integrated project-based learning (PBL) and attitudes toward science education.

Although I would like to ask you to complete the following survey, participation in this survey is voluntary. If you decide to complete the survey, but change your mind, you may stop at any time. Your responses, answers, and comments will be kept anonymous and confidential. I will be using the results of this survey in writing my doctoral dissertation without including any information that will make it possible to identify you. The information gathered in this study will be useful to other educators and administrators interested in implementing technology-integrated PBL and instruction in their schools and classrooms. Thank you for agreeing to help me!

1. What is your grade level?
a. O Sixth
b. O Seventh
c. O Eight

2. What is your gender?
a. O Male
b. O Female

3. Are you in the same school now as you were last year?
a. O Yes
b. O No

4. How many years have you attended this school? ___________________

5. What are your favorite academic subjects at school? Mark all that apply.
a. O Language arts
b. O Math
c. O Science
d. O History
e. O Spanish
f. O Art
g. O Literature

In the following section, please circle the number that best characterizes the extent to which you agree or disagree with the statement.
1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, and 5 = Strongly Agree.

How Students Learn

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
6. I learn best in a traditional classroom with a teacher directing the learning.	1	2	3	4	5

7. I learn best when allowed to use a variety of materials in addition to the textbook to research and learn the information I need to know about the subject.	1	2	3	4	5
8. I learn best by talking and thinking about topics during whole-class discussions.	1	2	3	4	5
9. I learn best when I can gather the information myself working in collaborative groups instead of a teacher just giving the information.	1	2	3	4	5

Use of technology in the classroom

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
10. I am comfortable using an iPad, a laptop computer, and an iPhone.	1	2	3	4	5
11. I like using personal digital devices in the classroom.	1	2	3	4	5
12. I learn more when I use personal digital devices in the classroom.	1	2	3	4	5
13. I am distracted when allowed to use personal digital devices in the classroom.	1	2	3	4	5

Working in Collaborative groups

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
14. I like working in groups.	1	2	3	4	5
15. I like having jobs & responsibilities as part of working with a small group.	1	2	3	4	5
16. Completing a group project requires that all the group members participate in the process.	1	2	3	4	5
17. I like working towards creating a final product in class to show I have mastered the concepts studied.	1	2	3	4	5
18. I like it when the projects involve the investigation of real-world topics as they relate to the community and the concepts taught.	1	2	3	4	5
19. I like going beyond the classroom to gain real-life experience and do hands-on activities.	1	2	3	4	5

20. I like writing and reflecting about what I learn in class.	1	2	3	4	5
21. I like receiving short lessons from my teacher based on my needs.	1	2	3	4	5
22. I like being evaluated based on my ongoing collection of completed work rather than relying only on tests.	1	2	3	4	5
23. I like it when my teacher models' different roles and acts as more than just a teacher.	1	2	3	4	5

24. In your opinion, what are three benefits of working in groups?
a) ____
b) ____
c) ____

25. In your opinion, what are three challenges you may have faced when working in groups.
a) ____
b) ____
c) ____

Attitude and Aptitude

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
26. I like to set personal goals.	1	2	3	4	5
27. I have the potential to achieve my personal goals.	1	2	3	4	5
28. I like being able to have a choice and voice over how I learn.	1	2	3	4	5
29. I like to take responsibility for my success.	1	2	3	4	5
30. I am curious about the world around me and like to learn new things.	1	2	3	4	5
31. I believe that academic success is important.	1	2	3	4	5
32. My parents expect me to be successful at school.	1	2	3	4	5
33. I like to win in a competitive environment.	1	2	3	4	5
34. I like to be academically challenged.	1	2	3	4	5
35. I believe that my ability and confidence grow with my effort.	1	2	3	4	5

36. I believe that my teachers show enthusiasm about the subjects they teach.	1	2	3	4	5
37. I believe that my school is a place where I accepted and valued as part of a community of learners.	1	2	3	4	5
38. I like working collaboratively in a supportive environment with authentic problems.	1	2	3	4	5

Students' attitudes toward Science Education

	Strongly Disagree		Neither Agree nor Disagree		Strongly Agree
39. I like to learn by doing an activity or an experiment rather than by reading about the topic.	1	2	3	4	5
40. I believe that my science lessons are relevant to my everyday life.	1	2	3	4	5
41. The science curriculum at my grade level has an appropriate level of difficulty.	1	2	3	4	5
42. I believe that science lessons are fun.	1	2	3	4	5
43. I am considering a career in a scientific field after I complete my education.	1	2	3	4	5

Project-based Learning

	Strongly Disagree		Neither Agree nor Disagree		Strongly Agree
44. PBL is when students work on a project assigned by the teacher to help them learn.	1	2	3	4	5
45. PBL is when students choose a project to work on to show that they have learned the lesson.	1	2	3	4	5

46. PBL is when students can do a project in place of a test.	1	2	3	4	5
47. PBL is when students learn by investigating an interesting problem presented by the teacher.	1	2	3	4	5
48. PBL is when students learn by investigating a problem with real-life applications.	1	2	3	4	5

49. What kind of skills do you think your teacher would like you to learn by working on a project?
50. Do you think that working on projects is an effective way of learning science? Why or why not?
51. How do you compare doing projects in a science classroom with a more traditional classroom? Which type of teaching do you prefer, and why?

Thank You So Much for Your Participation!
Mrs. Afsaneh Miller

Appendix E: TEACHER PROJECT-BASED LEARNING SURVEY

Dear Colleagues
My name is Afsaneh Miller. I am the middle school science instructor at the XXX campus, as well as a doctoral candidate at Concordia University located in Irvine, California. I am researching teacher's and administrator's level of understanding technology-integrated project-based learning (PBL) and its impact on students' motivation and content retention.
Although I would like to ask you to complete the following survey, participation in this survey is voluntary. If you decide to complete the survey, but change your mind, you may stop at any time. Your responses, answers, and comments will be kept anonymous and confidential. I will be using the results of this survey in writing my doctoral dissertation without including any information that may make it possible to identify you. The information gathered in this study will be useful to other educators and administrators interested in implementing PBL and instruction in their schools and classrooms.
I hope that you will consider helping me by completing this survey.
Thank you!

1. What is your gender?
a. O Male
b. O Female

2. Are you in the same school now as you were last year?
a. O Yes
b. O No

3. At which campus are you currently teaching? (**Optional)**
a. O Prep
b. O HAC
a. O AH
b. O NT

4. How many years have you been in your current position? ___________

5. How many years have you been an educator? ____________________

6. What is the highest degree you have received?" ____________________

What grade level do you currently teach? Select all that apply.

	Pre-K		4		10
	JK		5		11
	K		6		12
	1		7		
	2		8		
	3		9		

7. What academic subjects do you currently teach? Mark all that apply.
a. O Language arts
b. O Math
c. O Science

d. O History
e. O Spanish
f. O Art
g. O Literature
h. O Physical Education
I. O Other______________________

In the following section, please circle the number that best characterizes the extent to which you agree or disagree with the statement.
1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, and 5 = Strongly Agree.

Perceptions and Attitudes Toward Collaborative Work

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
8. I like to use complex tasks with multiple solutions.	1	2	3	4	5
9. I like to teach in a class in which students execute experiments or complete projects.	1	2	3	4	5
10. I like to assign group work that encourages discussion.	1	2	3	4	5
11. I like to use activities that encourage students to reflect on their learning.	1	2	3	4	5
12. I like to use a variety of teaching materials in addition to the textbook.	1	2	3	4	5
13. I like to have my students go beyond the classroom to gain real-life, hands-on experience.	1	2	3	4	5
14. I believe that students gain insight by doing experiments and hands-on activities.	1	2	3	4	5
15. I believe that working in groups helps students to develop their social skills.	1	2	3	4	5
16. It is challenging to assess group projects and determine if everyone has contributed and participated in the project completion.	1	2	3	4	5

17. In your opinion, what are three benefits of your students working in groups?
a) ____
b) ____
c) ____

18. In your opinion, what are three challenges you may have faced when your students were working in groups.

a) ____

b) ____

c) ____

Understanding How Students Learn

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
19. Students learn best in a traditional classroom with a teacher directing the learning.	1	2	3	4	5
20. Students learn best when allowed to use a variety of materials in addition to the textbook to research and learn the information I need to know about the subject.	1	2	3	4	5
21. Students learn best by talking and thinking about topics during whole-class discussions.	1	2	3	4	5
22. Students learn best when they gather the information themselves working in collaborative groups instead of a teacher just giving the information.	1	2	3	4	5

Use of technology in the classroom

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
23. I am comfortable using an iPad, a laptop computer, and an iPhone.	1	2	3	4	5
24. I like using personal digital devices in the classroom.	1	2	3	4	5
25. I believe that students learn more when they use personal digital devices in the classroom.	1	2	3	4	5
26. I believe that students' understanding increases when allowed to link	1	2	3	4	5

technological, mathematical
& scientific concepts.

Use of PBL in the classroom

27. Project-based learning is…. (Check all that apply)
    - a. O when students work on a project assigned by the teacher to help them learn.
    - b. O when students choose a project to work on to show that they have learned the lesson.
    - c. O when students can do a project in place of a test.
    - d. O when students learn by investigating an exciting problem presented by the teacher.
    - e. O when students learn by investigating a problem with real-life applications.

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
27. I am familiar with the project-based learning pedagogy.	1	2	3	4	5
28. I have implemented projects in my classroom.	1	2	3	4	5
29. I am skilled at searching for projects to use in my classroom.	1	2	3	4	5
30. I am confident in my ability to design effective and engaging projects.	1	2	3	4	5
31. I like it when my students produce a final product that demonstrates an understanding of the concepts taught.	1	2	3	4	5
32. I think that technology-integrated PBL contributes to student learning.	1	2	3	4	5
33. I am motivated to implement technology-integrated PBL in my classroom.	1	2	3	4	5

34. I would be interested in learning more about how I could implement technology-integrated PBL in my classroom using the existing curriculum**.**
    - a. O Yes
    - b. O No

Role of Administrative Support for Teachers

	Strongly Disagree		Neither Agree nor Disagree		Strongly Agree
35. Administrative support is imperative to the implementation of innovative teaching strategies such as technology-integrated PBL in my classroom.	1	2	3	4	5
36. The administrators at my school site have always supported my decisions and role as an educator.	1	2	3	4	5
37. The administrators at my school site make me feel like I am making a difference.	1	2	3	4	5
38. The administrators at my school site are interested in my professional development and give me opportunities to grow.	1	2	3	4	5
39. I receive constructive feedback about my work from my school site administrators.	1	2	3	4	5
40. I can easily access my administrators to discuss problems and concerns.	1	2	3	4	5
41. My school site administrators ensure that I have adequate planning time.	1	2	3	4	5
42. My school site administrators encourage the use of innovative teaching strategies to engage students better.	1	2	3	4	5
43. My administrators make sure that I have space, time, and equipment I need to plan and teach.	1	2	3	4	5

44. How do you compare technology-integrated project-based learning with traditional teaching methodology?
45. In your opinion, what are the benefits and challenges of using technology-integrated project-based learning in your classroom?
46. What concerns or constraints may keep you from implementing technology-integrated project-based learning in your classroom?

Thank You So Much for Your Participation!
Mrs. Afsaneh Miller

Appendix F: ADMINISTRATOR PROJECT-BASED LEARNING SURVEY

Dear Colleagues
My name is Afsaneh Miller. I am the middle school science instructor at the XXX campus, as well as a doctoral candidate at Concordia University located in Irvine, California. I am researching teacher's and administrator's level of understanding technology-integrated project-based learning (PBL) and its impact on students' motivation and content retention.
Although I would like to ask you to complete the following survey, participation in this survey is voluntary. If you decide to complete the survey, but change your mind, you may stop at any time. Your responses, answers, and comments will be kept anonymous and confidential. I will be using the results of this survey in writing my doctoral dissertation without including any information that may make it possible to identify you. The information gathered in this study will be useful to other educators and administrators interested in implementing PBL and instruction in their schools and classrooms.
I hope that you will consider helping me by completing this survey.
Thank you!

1. What is your gender?
   a. O Male
   b. O Female

2. Are you in the same school now as you were last year?
   a. O Yes
   b. O No

3. How many years have you been in your current position? ___________

4. How many years have you been an educator? ____________________

5. What is the highest degree you have received?" ____________________

In the following section, please circle the number that best characterizes the extent to which you agree or disagree with the statement.
1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, and 5 = Strongly Agree.

Perceptions and Attitudes Toward Collaborative Work

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
8. I like to see teachers use complex tasks with multiple solutions.	1	2	3	4	5
9. I like classes in which students execute experiments or complete projects.	1	2	3	4	5

10. I like group work that encourages discussion.	1	2	3	4	5
11. I like activities that encourage students to reflect on their learning.	1	2	3	4	5
12. I like to see teachers use a variety of teaching materials in addition to the textbook.	1	2	3	4	5
13. I like to have students go beyond the classroom to gain real-life, hands-on experience.	1	2	3	4	5
14. I believe that students gain insight by doing experiments and hands-on activities.	1	2	3	4	5
15. I believe that working in groups helps students to develop their social skills.	1	2	3	4	5
16. It is challenging to assess group projects and determine if everyone has contributed and participated in the project completion.	1	2	3	4	5

17. In your opinion, what are three benefits of your students working in groups?
a) ____
b) ____
c) ____

18. In your opinion, what are three challenges you may have faced when your students were working in groups.
a) ____
b) ____
c) ____

Understanding of How Students Learn

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
19. Students learn best in a traditional classroom with a teacher directing the learning.	1	2	3	4	5
20. Students learn best when allowed to use a variety of materials in addition to the textbook to research and learn the information I need to know about the subject.	1	2	3	4	5

21. Students learn best by talking and thinking about topics during whole-class discussions.	1	2	3	4	5
22. Students learn best when they gather the information themselves working in collaborative groups instead of a teacher just giving the information.	1	2	3	4	5

Use of technology in the classroom

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
23. I am comfortable using an iPad, a laptop computer, and an iPhone.	1	2	3	4	5
24. I like to see teachers and students using personal digital devices in the classroom.	1	2	3	4	5
25. I believe that students learn more when they use personal digital devices in the classroom.	1	2	3	4	5
26. I believe that students' understanding increases when allowed to link technological, mathematical & scientific concepts.	1	2	3	4	5

Use of PBL in the classroom

27. Project-based learning is…. (Check all that apply)

a. O when students work on a project assigned by the teacher to help them learn.
b. O when students choose a project to work on to show that they have learned the lesson.
c. O when students can do a project in place of a test.
d. O when students learn by investigating an exciting problem presented by the teacher.
e. O when students learn by investigating a problem with real-life applications.

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
28. I am familiar with the project-based learning pedagogy.	1	2	3	4	5

29. I have previously personally implemented projects in a classroom.	1	2	3	4	5
30. I am personally skilled at searching for projects to use in the classroom.	1	2	3	4	5
31. I am confident in my ability to help teachers design effective and engaging projects.	1	2	3	4	5
32. I like a student-generated final product that demonstrates an understanding of the concepts taught.	1	2	3	4	5
33. I think that technology-integrated PBL contributes to student learning.	1	2	3	4	5
34. I would like to see teachers implement technology-integrated PBL in the classroom.	1	2	3	4	5

35. I would be interested in learning more about how technology-integrated PBL could be implemented in the classroom using the existing curriculum**.**

   a. O Yes
   b. O No

Role of Administrative Support for Teachers

	Strongly Disagree		**Neither Agree nor Disagree**		**Strongly Agree**
36. Administrative support is imperative to the implementation of innovative teaching strategies such as technology-integrated PBL in the classroom.	1	2	3	4	5
37. I have always supported the teachers' decisions and role as an educator.	1	2	3	4	5
38. I believe that educators at my school site make a difference.	1	2	3	4	5
39. I strive to provide teachers with opportunities for growth and professional development.	1	2	3	4	5
40. I routinely provide constructive feedback to my staff.	1	2	3	4	5

41. Teachers and staff can easily reach me as needed.	1	2	3	4	5
42. I actively engage with my staff to ensure that they have adequate planning time.	1	2	3	4	5
43. I encourage the use of innovative teaching strategies to engage students better.	1	2	3	4	5
44. I strive to ensure that my staff has the needed space, time, and equipment to plan and teach.	1	2	3	4	5

45. How do you compare technology-integrated project-based learning with traditional teaching methodology?
46. In your opinion, what are the benefits and challenges of using technology-integrated project-based learning in your classroom?
47. What concerns or constraints may keep you from implementing technology-integrated project-based learning in your classroom?

Thank You So Much for Your Participation!
Mrs. Afsaneh Miller

Appendix G: Student Email with Survey Link

From: Afsaneh Miller
To: _________

Subject: Survey of Students in Grades six, seven and eight

I am writing to request your participation in a brief survey. I would like to get more feedback about your experiences with science and technology-integrated project-based learning. Your responses to this survey will help me evaluate the effectiveness of technology-integrated project-based learning in a science classroom so that I can design better projects and improve science teaching at the middle school level. The survey will take about 30 minutes to complete. Please click the link below to go to the survey website (or copy and paste the link into your Internet browser) and then begin the survey.

Survey link: https://docs.google.com/forms/u/0/?tgif=c/XXXXXX

Your participation in the survey is voluntary and anonymous. All responses will be kept confidential. No personally identifiable information can be associated with your responses in any reports of these data. Your Google login credentials will not be recorded in association with this survey. The Concordia University, Irvine, Institutional Review Board has approved this survey. Should you have any comments or questions, please feel free to contact me at amiller@XXXXschools.com.

Thank you very much for your time and cooperation.

Sincerely,

Afsaneh Miller, JH Science Instructor
XXXXX Schools
XXXXX Campus

Appendix H: TEACHER/ADMINSTRATOR EMAIL WITH SURVEY LINK

From: Afsaneh Miller
To: _________

Subject: Survey of Teacher & Administrators

I am writing to request your participation in a brief survey. I would like to get more feedback about your experiences with science and technology-integrated project-based learning. Your responses to this survey will help me evaluate the effectiveness of technology-integrated project-based learning in a science classroom so that I can design better projects and improve science teaching at the middle school level. The survey is very brief and will only take about 30 minutes to complete. Please click the link below to go to the survey website (or copy and paste the link into your Internet browser) and then begin the survey.

Teacher Survey link: https://docs.google.com/forms/u/0/?tgif=c/XXXXXX

Administrator Survey link: https://docs.google.com/forms/u/0/?tgif=c/XXXXXX

Your participation in the survey is voluntary and anonymous. All responses will be kept confidential. No personally identifiable information can be associated with your responses in any reports of these data. Your Google login credentials will not be recorded in association with this survey. The Concordia University, Irvine, Institutional Review Board has approved this survey. Should you have any comments or questions, please feel free to contact me at amiller@XXXXschools.com.

Thank you very much for your time and cooperation.

Sincerely,

Afsaneh Miller, JH Science Instructor
XXXXX Schools
XXXXX Campus

Appendix I: PBL Lesson Plans

<table>
<tr><td colspan="3">Name of the Project</td><td>Time Needed to Complete Project:</td></tr>
<tr><td>Course: Science</td><td colspan="2">Teacher's Name: Afsaneh Miller</td><td>Grade Level:</td></tr>
<tr><td colspan="4">Cross-Curricular content areas/Academic Skills</td></tr>
<tr><td colspan="4">Content Standards:</td></tr>
<tr><td colspan="4">Project Learning Objectives & Outcomes:</td></tr>
<tr><td colspan="4">Connection to Existing Classroom Curriculum:</td></tr>
<tr><td colspan="4">Pre-requisite Skills Required to complete projects (including critical thinking, collaboration, creation, communication)</td></tr>
<tr><td colspan="4">Required technological equipment and skills:</td></tr>
<tr><td colspan="4">Required Materials:</td></tr>
<tr><td colspan="4">Issue/idea/Question to be investigated (connection to real-life):</td></tr>
<tr><td colspan="4">Project Overview:
• Name of the project
• What will the students be doing?
• What will the students use/need to create and complete the project?
• Will cross-curricular educational activities, be included in this project?
• What is the outcome of the project?</td></tr>
<tr><td colspan="4">Driving Question (s)</td></tr>
<tr><td colspan="4">The Lesson Planner</td></tr>
<tr><td>Activity</td><td>Teacher Notes</td><td>Estimated Time Needed</td><td>Deliverables</td></tr>
<tr><td>-Project Topic Discussion.
-Lesson Rubric Discussion
-Project Outline</td><td>-Introduce Topic
-Establish prior knowledge
-Help students build personal connections with the topic</td><td>One to Two Periods</td><td>Project Outline</td></tr>
<tr><td>-Preliminary Background Research</td><td>-Provide directions as needed
-Provide assistance and instruction with needed academic and technological skills
-Provide students with needed opportunities to conduct experiments, interviews, field trips, and other activities that allow them to research their topic.</td><td>One to Two Periods</td><td>Research Notes in students Interactive Science Folders (Journals)</td></tr>
<tr><td>-Project/Product Assembly
-Submit a project for preliminary review & feedback
-Make needed changes based on preliminary feedback
-Present final project/product to the class & guests
Self-assessment
Group Assessment</td><td>Provide Assessment guidelines and rubrics
Provide Feedback and assessment</td><td>Three to Four Periods</td><td>Preliminary & Final Project

Project Presentation</td></tr>
</table>

Appendix J: PBL Essential Elements Checklist

PBL Essential Elements Check List	Student Projects Contained the Following Essential Elements				
	1 Least evident	**2**	**3**	**4**	**5 Most evident**	**NA**
Significant Scientific Content: The project focused on demonstrating students' knowledge and understanding based on California science content standards.						
21st Century Skills: The project demonstrated students' understanding of twenty-first-century skills such as critical thinking, problem-solving, collaboration, self-management, effective communication, use of technology, grade/age-appropriate literacy skills, and initiative.						
In-depth Scientific Inquiry: The project focused on demonstrating students' active, in-depth involvement where students' generated standards-based questions within a real-world context connected to the students' interests, researched, experimented, and developed their answers.						
Use of Driving Questions: The project focused on a significant open-ended, engaging driving question/problem at the appropriate level of challenge for students.						
Student Engagement & Ownership: The project focused on a significant open-ended, engaging driving question/problem at the appropriate level of challenge for students. The project used real-world processes and connected to students' interests. The project allowed students to make choices regarding the products they created, how they completed their work, guided by the teacher.						
Reflection and Revision: The project focused on allowing students to reflect on their learning, the project's design, and the presentation. Students were able to both give and receive feedback on their work, revise their products, and conduct further research and experimentation.						
Public Involvement: The project required students to showcase what they learned by creating a product that was presented to the members of the school community.						

Appendix K: PBL Lesson Plan Evaluation Rubric

	0 (was not evident)	Poor (1)	Fair (2)	Average (3)	Good (4)	Excellent (5)
The lesson plan met the goal of the project/lesson.						
Lesson plan contained relevant essential question(s).						
Lesson plan demonstrated a connection between the lesson and the real-life.						
Lesson plan design showed a precise definition of the teacher and the students' roles.						
Lesson plan design provided students with opportunities for application of the acquired knowledge.						
Interdisciplinary aspects of the project were evident.						
Students presented a final product within the allotted period.						
Project design demonstrated evidence of collaborative group work						
Project design required students to research their areas of interest.						
Project design demonstrated students' skills required for the successful completion of the projects.						

Appendix L: Classroom Informal and Formal Observation Rubric

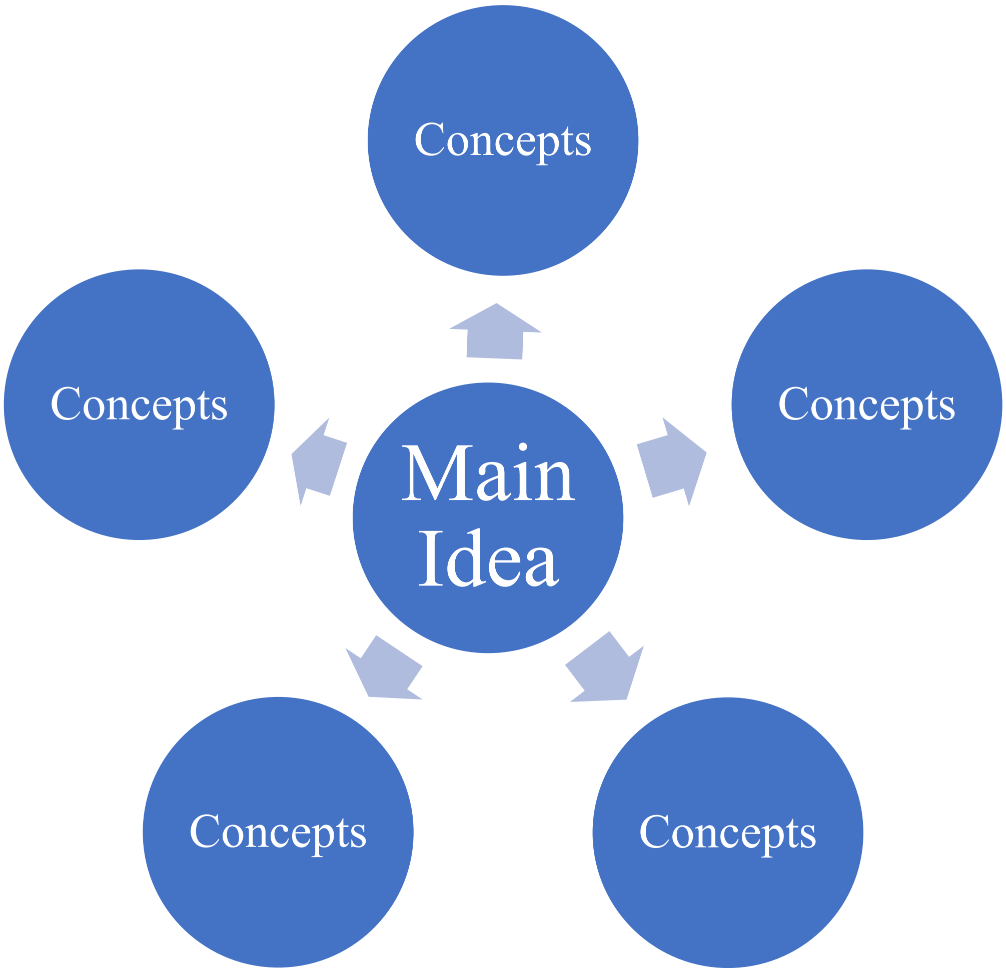
Class:
Curriculum Content Area
Date:
Name of Observer:

Observations	**Rating**			
	Excellent (1)	**Good (2)**	**Fair (3)**	**Not Applicable**
Students know the classroom rules and behavioral expectations.				
The classroom consequences fair, transparent, and consistently applied.				
The student responds positively to the teacher's role as an advisor and strives to meet the high expectations established by the teacher.				
The students respond positively to the teacher feedback to improve understanding.				
The students are provided with advice and support as needed to understand the content and accomplish tasks.				
Collaborative Teamwork/Active Learning Environment				
The students are actively generating ideas/facts.				
Students are actively participating in classroom discussions and learning activities.				
Students are willing to take risks in the process of learning.				
Students can monitor individual and team progress and learning process.				
Technology-integrated PBL Environment				
The students are given rigorous learning opportunities that require the application, evaluation, and synthesis of knowledge.				
The students can use technology to collect, evaluate, and use the information for learning.				
The students can use technology to research to solve a problem and create original works that demonstrate learning.				
The students can use technology to produce a collaborative product that demonstrates learning.				
The students are connecting the classroom content to real-life experiences.				
The students are connecting their ideas to the classroom academic content.				
The students are connecting new ideas to previously learned knowledge.				
The students are using multiple and varied resources for their research.				
The students can reevaluate their ideas when faced with new information.				

The students were able to work collaboratively to revise and improve individual and teamwork based on teacher feedback.				
Team Product Presentation & Assessment				
Students understand how the assessment process				
All students participated in the creation of the team's final product.				
The information presented in the final product was scientifically and academically correct and relevant.				
The final product presented by the team was a high-quality product.				
Team members can demonstrate and verbalize understanding of the lesson content through the presentation of the team product.				
Observer's Notes and Comments				

(Delisle, 1997

Appendix M: Concept Map



Appendix N: Student Problem Development Checklist

Student Check List for Developing a Problem

In developing the problem, we considered the need for…	Yes	No
appropriateness of the content when we developed our problem.		
the availability of skills and resources either in or out of the classroom.		
our experience and ability level in dealing with this type of problem.		
the current curriculum and learning goals of the class.		
our curricular interests and learning styles.		
creating a driving question.		
developing individual and group evaluation strategies.		

(Delisle, 1997)

Appendix O: Project Plan

Project Title: (will vary depending on the project)

Project Instruction: (will vary depending on the project)

Student Project Design Plan (student Interactive Science Folder (Journal))

Individual / Group notes on the progress of the project: (student Interactive Science Folder (Journal))

Project Timeline: (Student Interactive Science Folder/Journal)

Final Presentation Guidelines and expectations: (will vary depending on the project)

Assessment Rubrics (Will vary depending on the project)

Appendix P: Individual Student Self-Evaluation Form

Student:	**Class:**		**Date:**
Activity	**Excellent**	**Good**	**Fair**
I believe I contributed ideas /facts for the benefit of the team.			
I suggested some ideas for further research and learning.			
I used multiple and varied resources for the report.			
I helped my team to think through problems.			
I shared new information I came across with my team.			
I helped my team complete tasks in a timely fashion.			

(Delisle, 1997)

Appendix Q: Individual Student Written Reflections Instructions

In your reflections, please describe the general process followed by the group to achieve the team learning goals, your contributions to the team effort, and suggestions for future improvements.

Appendix R: Classroom Observation Protocol

<table>
<tr><td colspan="2">Date:

The length and description of the activity/lesson being observed:</td></tr>
<tr><td>Descriptive Notes</td><td>Reflective Notes & Thoughts</td></tr>
<tr><td colspan="2">Classroom Physical Setting</td></tr>
<tr><td colspan="2">Students' Attitudes and Demeanor</td></tr>
<tr><td colspan="2">Students' Conversations</td></tr>
<tr><td colspan="2">Classroom activities and Interactions</td></tr>
<tr><td colspan="2">Researcher's Behavior & involvement</td></tr>
</table>

(Creswell, 2013)

Appendix S: Project Formative Assessment Rubric

PBL Formative Assessment Rubric						
	1	**2**	**3**	**4**	**5**	**NA**
Classroom Climate Students work well within the PBL structure.						
Student Background Knowledge Students have the needed background knowledge to perform the required tasks.						
Engagement with the Problem/driving question Students engage with the problem by sharing personal experiences.						
Student Participation and Collaboration Students volunteered to do various jobs for their team. Students participated by generating ideas, sharing information, and generated questions and helped develop the team's action plan.						
Student Creativity Students were able to use creativity to solve problems.						
Reflection and Revision Students evaluated resources, ideas, hypotheses, and brought up additional questions. Students provided constructive feedback to their peers.						
Use of Technology and Product Production Students incorporated information gathered into the product and participated in the creation of the product and the report. Students' were able to use technology effectively in the process of product production.						
Student Self Evaluation Students evaluated themselves as both individuals and the members of the group.						
Determination of Mastery The teacher to determine and evaluate proficiency in the content evaluated in the students' presentations and products.						
Teacher Comments						

(Delisle, 1997)

Appendix T: Project Presentation (Summative) Assessment Rubric

	1	2	3
Significant Scientific Content & In-depth Scientific Inquiry	The presentation does not include explanations of central concepts of the study, used inappropriate, irrelevant and incorrect descriptions of facts and details needed to support the project and answer the driving question. The presentation was not well organized and did not make sense. The presentation lacked an introduction or conclusion and was not adequately timed.	The presentation included adequate explanations of central concepts of the study, using appropriate, relevant, and correct descriptions of facts and details needed to support the project and answer the driving question. The presentation was adequately organized and made sense. The presentation contained an introduction and a conclusion. The presentation was adequately timed.	The presentation included explanations of central concepts of the study, using appropriate, relevant, and accurate descriptions of facts and details needed to support the project and answer the driving question. The presentation was well organized and made sense. The presentation contained an introduction and a conclusion. The presentation was timed well.
21st Century Skills	The student was unable to demonstrate twenty-first-century skills through participation in the presentation and collaboration with others, use of technology to share main ideas and add interest to the team.	Student adequately demonstrated 21st-century skills through participation in the presentation moreover, collaboration with others, some use of technology to share main ideas and add interest in the team presentation.	Student demonstrated 21st century skills through participation in the presentation and collaboration with others, use of technology to share the main ideas and add interest to the team presentation.
Student Engagement & Participation	The student was not able to show how the team's driving question/problem connected to a real-world process, as well as students' interests by explaining how they were able to make choices regarding the products he/she created, completed their work as guided by the teacher.	The student was able to show adequately how the team's driving question/ the problem connected to a real-world process, as well as students' interests by explaining how they were able to make choices regarding the products he/she created, completed their work as guided by the teacher	The student was able to show how the team.' driving question/problem connected to a real-world the process, as well as students' interests by explaining how they were able to make choices regarding the products he/she created, completed their work as guided by the teacher.
Team Members Participation in Presentations	The student did not participate in the team presentation.	Student somewhat participated In the team presentation	The student fully participated in the team presentation.

(https://www.bie.org/object/document/pbl_essential_elements_checklist)

Appendix U: Interactive Science Folder (Journal) Student Instructions

Interactive Science Folder Instruction Sheet

While you are in the science classroom, you are a scientist. Scientists record their ideas, thoughts, experiment results, and anything else they would like to record. As a scientist, you are required to maintain an interactive science folder.

You will use your folder to record and store all the information you receive in the science classroom. You will need to take excellent care of your folder. If you ever lose your folder, you will need to recreate the folder from the beginning!

Please leave your folder in the science classroom. Your folders will be graded periodically. To ensure that you receive the best grade possible, please refer to your Interactive Science Folder Rubric as you complete each assignment.

Below you will see the instructions for your very first assignment:

1. Design a cover for your folder. The cover needs to have the following:
   a. Your first and last name
   b. Grade level and Period
   c. Teacher's Name
   d. You may appropriately decorate your folder cover!

2. The pages in your folder are starting with "0" on the very first page.
3. Please number all pages you may create or receive each day and place in your folder in the same order listed on your Table of content.
4. Keep your folder very neat. Use your best handwriting. **Use minimal tape whiteout only!**
5. You will need to do some drawings as part of your assignments. You are only required to do neat drawings. They do not have to be works of art☺
6. Please label all your scientific drawings.
7. Please do not do random doodles in or on your folder!
8. **Optional:** A good learning strategy in science is the use of a student-created dictionary. I have included an example.

Appendix U: Interactive Science Folder (Journal) Grading Rubric & Scoring Sheet

Your folder will be graded using the "interactive Science Folder Grading Shee." Your folder will be graded based on four categories:

- Meeting Requirements
- Quality of work (includes neatness and handwriting)
- Creativity
- Timeliness

There are 1-5 points possible for each category each time the folder is checked and graded.

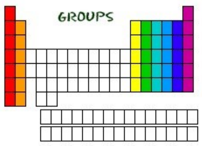
The number of points received in each category will then be added up to determine the final number of points received each time the journal is checked. The grading key below explains how your score for each category will be determined.

5	• All the requirements have been met and exceed expectations. • The student work is of high quality and extremely organized. • The student work showed a high level of creativity. All artistic forms of work are neat and colorful. • The student work was completed on time.
4	• All the requirements have been met. • The student work is of good quality and organized • The student work showed a good level of creativity. All artistic forms of work are neat and colorful. • The student work was completed on time
3	• All the requirements have been partially met (1-2 items missing). • The student work is of acceptable quality and organized • The student work showed an acceptable level of creativity. All artistic forms of work are neat and colorful. • The student work was completed on time
2	• All the requirements have not been met (3 or more items missing) • The student work is of low quality and disorganized • The student work showed some creativity. All artistic forms of work are somewhat neat and colorful. • The student work was completed on time
1	• Many of the assignment requirements are not present. • The student work is of poor quality and disorganized • The student work showed little evidence of creativity. All artistic forms of work are poorly done. • The student work was not submitted on time.

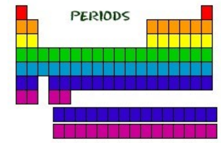
Appendix U: Interactive Science Folder (Journal) Scoring Sheet

Date Checked	Meeting Requirements	Quality of the Student Work	Creativity	Timeliness	Total Score
Total Score					

Appendix V: Experimental Classroom Periodic Table Project Instructions



Design Your Own Periodic Table



Design Your Own Periodic Table Project. (n.d.). Retrieved from https://lhsblogs.typepad.com/files/design-your-own-periodic-table-project.pdf

Project Goal

Research information about the various groups of elements in the periodic table. Research the basic structure of the periodic table. Research the properties of elements and look for patterns among elements in the same family. Create a "Periodic Table," which demonstrates how objects we use every day, topics we discuss, foods we eat, and more, contain characteristics that allow us to group them using different patterns.

Project Guidelines

Where to begin:

1. Choose a topic that has characteristics that can be categorized in at least two different ways. Good characteristics to look at maybe, but are not limited to:
   Dates, colors, cost, company, size, genre, or any physical or chemical properties that can divide the subject into various groups and periods. Be creative.

2. Decide upon and research these characteristics. Organize the item vertically and horizontally to show a pattern or relationship. **Your periodic table must contain a minimum of 40 elements, arranged in a minimum of 5 groups and four periods (or the reverse).** Not every space within a group or period needs to be filled. **You must have a title for your groups and periods and follow all the rules of the periodic table, as discussed in our benchmark lesson.**

3. Each "element" on your periodic table must include:
   - Element Name
   - Chemical Symbol (1 or 2 letters)
   - Atomic Number – arrange the elements first, then number them, **blank spaces must include a number!**
   - Atomic Mass – some numeric characteristic of the element that **must increase as you go down and across the table (size, style, cost, etc.)**
   - Your choice – picture, state of matter, price, etc.

4. **A "Key" is required** for the information given for each "element" on the periodic table by drawing a sample square with sample information, and then **label what characteristic each piece of information represents**.

5. The final copy of your periodic table must be in color and on unlined paper. The size of your periodic table must be between 22" x 14" (half sheet of poster board) and 22" x 28" (a full sheet of poster board). Remember that bigger does not always necessarily mean better, so choose a size that best fits your table.

6. **Title your periodic table at the top** of your poster board. Your name and class period can be written on the back.

Hints for Planning:

- Remember that a chemical symbol can be 1or 2 letters, but only the first letter is capitalized.
- Remember that atomic mass can be in decimal or whole number form.
- You cannot use the same characteristic for 2 different pieces of information. For example, 2003 can only be used for atomic mass or atomic number, not both.

Suggestions:

- Sketch out each square and manipulate the pieces to help discover patterns (like we did with the periodic people).
- Old catalogs and magazines are helpful for getting topic ideas or information and can be cut out to use as part of the table.
- Some topics ideas include candy, TV shows, movies, mall stores, music, sports teams, animals, clothes, countries, states, make-up, and food.

Project Rubric

Basics + ______ /10

Poster is:

- Titled (4 pts)
- Neat (3 pts)
- Colorful (2 pts)
- Correct Size (1 pt.)

Organization + ______ /10

- Groups - vertical (4 pts organization)
  (1 pt. title)
- Periods - horizontal (4 pts organization)
  (1 pt. title)

20 Elements + ______ /20

- 1 pt. credit for extra elements (up to 5)

Square Information + ______ /20

- Atomic Number (3 pts)
- Atomic Symbol (3 pts)

- Element Name (3 pts)
- Atomic Mass (8 pts)
- Choice (3 pts)

Key + ______ /15

- Atomic Number w/explanation (3pts)
- Element/Chemical Symbol w/explanation (3pts)
- Element/Chemical Name w/explanation (3 pts)
- Atomic Mass w/explanation (3 pts)
- Choice w/explanation (3 pts)

Total +______ / 75

(Design Your Own Periodic Table, 2018)

Appendix V1: Control Classroom Periodic Table Project Instructions

Name: ______________________

Materials:
Periodic Table
Notes on the Periodic Table
Pencil
Book(s) on elements
(optional)
Procedure:
You are a part of a collection of scientists who have been chosen to assist a group of alien scientists. To be able to converse scientifically, you must learn their language, and most importantly, you must arrange their elements according to the trends that exist in the periodic table. Below are clues for the alien's elements. So far, the aliens have only discovered elements in groups 1, 2, and 13-18, and periods 1-5. Although the names of the elements are different, they must correspond to our elements if our belief of universal elements holds true. Read each clue carefully and then place the symbol for that clue's element in the blank periodic table provided.

1. Livium (Lv): This element is responsible for life. It has 2 electron energy levels and 4 electrons available for bonding in the outermost energy level.

2. Computerchipium (Cc): This element is important for its use as a semiconductor in computers.

3. Lightium (L): This is the lightest of elements; aliens used to use it in their aircraft until their aircraft caught fire in a horrific accident.

4. Breathium (Br): When combined with Lightium (L), it makes the alien's most common liquid whose formula is L2Br.

5. Francium (F): A metal found in period 4, group 13.

6. Moonium (Mo): An element with an atomic number of 34.

7. Explodium (Ex): This element is the most reactive metal on the alien's table.

8. Violetium(V): This element is found as part of a compound in bananas. When burned, it has a violet colored flame.

9. Sparkium (Sp) and Burnium (Bu) are members of the alkali metal group, along with Violetium(V) and Explodium (Ex). Their reactivity, from least to greatest, is Sp, Bu, V, Ex.

10. Balloonium (Ba): A noble gas used to fill balloons.

11. Toothium (To): This element is added to juices to help build strong bones and teeth.

12. Metalloidium (M) and Poisonium (Po): Two metalloids found in period 4. Po is more massive than M.

13. Lowigium (Lo): A period of four halogen.

14. Darkbluium (Dk): Has an atomic mass of 115.

15. Hugium (Hu): The element on the alien's periodic table that has the most mass.

16. Glucinium (Gl): The element found in period 2, group 2.

17. Reactinium (Re): The most reactive non-metal on the periodic table.

18. Balloonium (Ba), Signium (Si), Stableium (Sb), Supermanium (Sm), and Hugium (Hu) are all noble gases. They are arranged above from least to most massive.

19. Cannium (Cn): This element helps to preserve foods; it is used in can manufacturing.

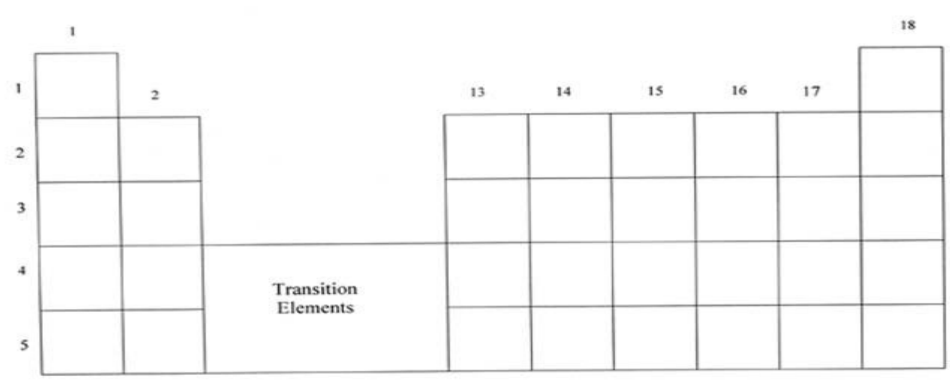
20. Burnium (Bu), Blue-whitium (Bw), Bauxitium (Xi), Computerchipsium (Cc), Bringer-oflightium (Bl), Stinkium (Sk), Purium (P), and Stableium (Sb) are all found in period 3. Bu has 1 electron in its outer energy level, Bw has 2, Xi has 3, Cc has 4, Bl has 5, Sk has 6, P hasv7, and Sb has 8.

21. Scottishium (Sc): A metal element found in group 2.

22. Infectium (If): This element, mixed with alcohol, is used on cuts.

23. Abundantcium (Ab): One of the most abundant gasses in the universe. It has 7 protons, seven neutrons, and 7 electrons.

24. Some additional clues: The number after the symbol indicates the number of electrons in the outer energy level: Notalonium (Na): 5 Earthium (E): 6 Boracium (B): 3



Provided by the Control Classroom Teacher

Appendix W: Interview Questions for Teacher Participant

1. How do you define a project?
2. Can you provide examples of projects that you are currently working on or have previously completed in your class?
3. To what level do you utilize projects as part of the learning process in your class?
4. What are some instructional strategies that you use to implement projects in your classroom?
5. What is your opinion of project-based learning?
6. Do you feel that project-based learning is an effective method of teaching? Why or why not?
7. What is your opinion of the appropriate length of time for a project?
8. How do you compare project-based learning with a research-based instructional strategy such as inquiry-based science?
9. What are your thoughts on allowing students to design their projects?
10. What do you see as advantages or disadvantages of implementing project-based learning in a middle school classroom?
11. What things will prevent you from implementing project-based learning in your classroom?

Appendix X: Introduction to Matter Lesson Plan

Introduction to Matter
Chapter 1
Standards:
SCI.CA.8.IE.9.f;
SCI.CA.8.
PS.6.a;
SCI.CA.8.
PS.7.c;
SCI.CA.8.PS.8.a, b
Lesson 1: Describing Matter
Lesson Objectives

- Identify properties used to describe matter
- Define matter, mass, and volume.
- Identify the physical properties of matter.
- List examples of chemical properties of matter.

Key Vocab:

- Matter
- Substance
- Chemistry
- Physical properties
- Chemical Properties

Driving Questions:

- What Properties describe matter?

Lesson Notes:

- Matter is…….
- Matter Vs. Substance
- Matter in chemistry
- Properties of matter can be physical or chemical.
- Physical properties of matter
    - Hardness (Moh's hardness scale)
    - Freezing and Boiling points
    - Thermal conductivity
    - Electrical conductivity
    - Solubility
- Chemical properties of matter
    - Flammability
    - Reactivity
    -

Lesson 2: Classifying Matter
Lesson Objectives:

- Describe what makes up matter
- Describe the properties of the mixture

- Define matter, mass, and volume.
- Identify the physical properties of matter.
- List examples of chemical properties of matter.
-

Key Vocab:

- Element
- Molecule
- Mixture
- Atom
- Chemical bond
- Compound
- Chemical formula
-

Driving Questions:

- What is matter made of?
- What are the two types of mixtures?

Lesson notes:

- Matter can be made up of smaller particles such as atoms, molecules, and elements.
- atoms, molecules and elements, chemical bonds
- Compounds
- Chemical formulas
- Mixtures (homogeneous vs. heterogeneous)
    - Solutions (Homogenous)
        - Solid in solid (Alloy)
        - Liquid in Liquid
        - Gas in gas
        - Solid in liquid
    - Suspensions (heterogeneous)
    - Colloids (Homogeneous)
        - Colloid vs. solution
    - Light beam Scattering
- Separating Mixtures
    - Magnetic attraction
    - Filtration
    - Evaporation
    - Distillation
    -

Lesson 3: Measuring Matter
Lesson Objectives

- Describe the units used to measure mass and volume
- Explain how to determine the density of the material
- Describe elements and atoms.
- Describe compounds, molecules, and crystals.

- Define mixture and identify types of mixtures.
-

Key Vocab:

- Weight
- Mass
- The international system of units
- Volume
- Density

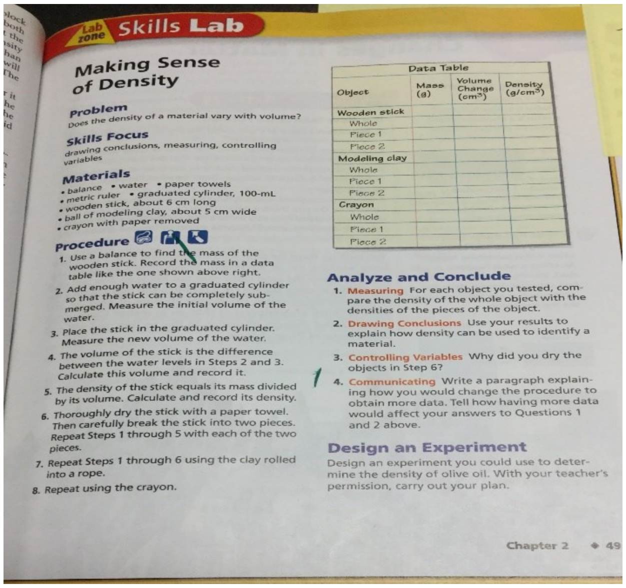
Driving Questions:

- What units are used to express mass and volume?
- How is density determined?

Lesson notes:

- Weight
    - Units
        - SI unit = Newtons
        - 1 kg=9.8 N
        - 1 kg = 1000 g
        - 1 g= 0.01 N

    - Spring scale
    - Depends on gravity
- Mass
    - Units
        - SI Unit = Kg (grams)
    - Balance Scale
    - Always constant
- Volume
    - Geometric objects (Length x width x height)
    - Cubic units
    - Non-geometric objects (Archimedes principle, water displacement)
- Density
    - Derived quantity
    - Characteristic property
    - Formula: D= Mass/Volume
    - Units
    - Solids vs. Liquids
        - Solids (measure, sink or float)
        - Liquids (Density gradient)
- Lab:
    - Making Sense of density (Thornton et al., 2013)



Lab zone **Skills Lab**

Making Sense of Density

Problem
Does the density of a material vary with volume?

Skills Focus
drawing conclusions, measuring, controlling variables

Materials
- balance
- water
- paper towels
- metric ruler
- graduated cylinder, 100-mL
- wooden stick, about 6 cm long
- ball of modeling clay, about 5 cm wide
- crayon with paper removed

Procedure
1. Use a balance to find the mass of the wooden stick. Record the mass in a data table like the one shown above right.
2. Add enough water to a graduated cylinder so that the stick can be completely submerged. Measure the initial volume of the water.
3. Place the stick in the graduated cylinder. Measure the new volume of the water.
4. The volume of the stick is the difference between the water levels in Steps 2 and 3. Calculate this volume and record it.
5. The density of the stick equals its mass divided by its volume. Calculate and record its density.
6. Thoroughly dry the stick with a paper towel. Then carefully break the stick into two pieces. Repeat Steps 1 through 5 with each of the two pieces.
7. Repeat Steps 1 through 6 using the clay rolled into a rope.
8. Repeat using the crayon.

Data Table

Object	Mass (g)	Volume Change (cm^3)	Density (g/cm^3)
Wooden stick			
Whole			
Piece 1			
Piece 2			
Modeling clay			
Whole			
Piece 1			
Piece 2			
Crayon			
Whole			
Piece 1			
Piece 2			

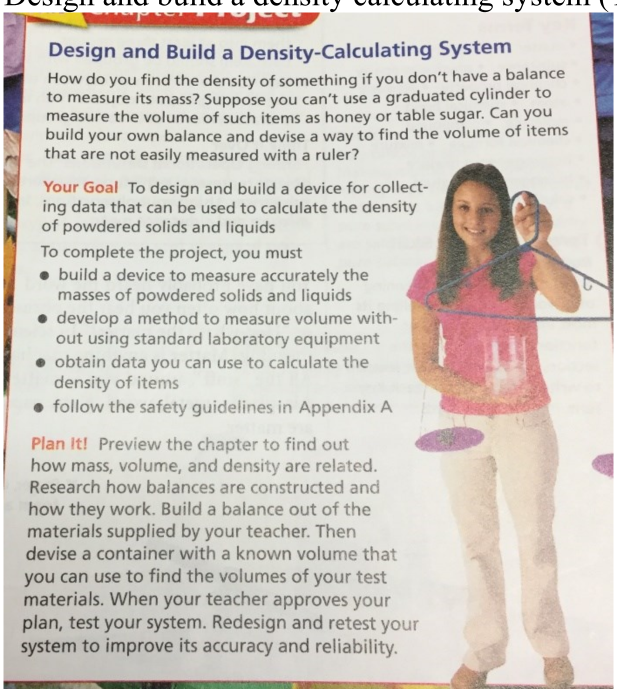
Analyze and Conclude
1. **Measuring** For each object you tested, compare the density of the whole object with the densities of the pieces of the object.
2. **Drawing Conclusions** Use your results to explain how density can be used to identify a material.
3. **Controlling Variables** Why did you dry the objects in Step 6?
4. **Communicating** Write a paragraph explaining how you would change the procedure to obtain more data. Tell how having more data would affect your answers to Questions 1 and 2 above.

Design an Experiment
Design an experiment you could use to determine the density of olive oil. With your teacher's permission, carry out your plan.

Chapter 2 ◆ 49

(Thornton et al., 2013)

- Activity:
  - Design and build a density calculating system (Thornton et al., 2013)



Design and Build a Density-Calculating System

How do you find the density of something if you don't have a balance to measure its mass? Suppose you can't use a graduated cylinder to measure the volume of such items as honey or table sugar. Can you build your own balance and devise a way to find the volume of items that are not easily measured with a ruler?

Your Goal To design and build a device for collecting data that can be used to calculate the density of powdered solids and liquids

To complete the project, you must
- build a device to measure accurately the masses of powdered solids and liquids
- develop a method to measure volume without using standard laboratory equipment
- obtain data you can use to calculate the density of items
- follow the safety guidelines in Appendix A

Plan It! Preview the chapter to find out how mass, volume, and density are related. Research how balances are constructed and how they work. Build a balance out of the materials supplied by your teacher. Then devise a container with a known volume that you can use to find the volumes of your test materials. When your teacher approves your plan, test your system. Redesign and retest your system to improve its accuracy and reliability.

(Thornton et al., 2013)

Lesson 4: Changes in Matter
Lesson Objectives:
- Explain what physical change is

- Explain what a chemical change is
- Describe how energy changes when matter changes
- Define and give examples of physical changes in matter.
- Define and give examples of chemical changes in matter.
- State the law of conservation of mass.

Key Vocab:

- Physical change
- Chemical change
- Law of conservation of mass
- Temperature
- Thermal energy
- Exothermic change
- Endothermic change
- Chemical energy

Driving Questions:

- What happens to a substance in a physical change?
- What happens to a substance in a chemical change?
- How are changes in energy and matter related?

Lesson notes:

- Physical change
    - Change of state
    - Changes in shape and form
- Chemical change
    - Combustion
    - Electrolysis
    - Tarnishing
    - Oxidation
    - Signs of Chemical Change
        - Production of Oder
        - Color change
        - Gas production
        - Formation of a solid substance (precipitate)
    - Reversing Chemical Change
- Conservation of Mass
    - Law of conservation of mass
        - Sum of Parts
        - Open chamber
        - Closed chamber
    - Demonstration
- Temperature and Thermal Energy
    - Temperature
    - Thermal Energy
    - Endothermic Change & Changes in matter
    - Exothermic change & Changes in matter

  - Chemical energy
- Demonstration:
  - Law of conservation of mass

Big Idea(s): What is matter?		
Name of the Project: Design and build a Density Calculating System		**Time Needed to Complete Project:** 4 periods
Course: Science	**Teacher's Name:** Afsaneh Miller	**Grade Level:** 8
Cross-Curricular content areas/Academic Skills: California Common Core Standards: *ELA/Literacy –* **RST.6–8.1** Cite specific textual evidence to support analysis of science and technical texts. (MS-ESS1-3), (MS-ESS1-4) **RST.6–8.7** Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or Table). (MS-ESS1-3) **WHST.6–8.2. a–f** Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. (MS-ESS1-4) **SL.8.5** Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. (MS-ESS1-1), (MS-ESS1-2)		
Discipline-Specific California Science Content Standards: ▪ Develop a model to predict and describe phenomena. (MS-PS1-1), (MS-PS1-4) ▪ Develop a model to describe unobservable mechanisms. (MS-PS1-5) ▪ Undertake a design project, engaging in the design cycle to construct and implement a solution that meets specific design criteria and constraints. (MS-PS1-6) ▪ Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-PS1-3)		
Project Learning Objectives & Outcomes: • Build a device to measure the masses of powdered solids and liquids accurately • Develop a method to measure volume without using standard laboratory equipment • Obtain data you can use to calculate the density of items • Follow safety guidelines		
Connection to Existing Classroom Curriculum: To build a balance and devise a way to find the volume of items that are not easily measured with a ruler.		
Pre-requisite Skills Required to complete projects • critical thinking • collaboration • creation • communication		
Required technological equipment and skills: • Follow lab safety protocols • Use a tri-beam balance • Measure volume • Measure mass		
Required Materials: • balance • varies according to student design		
Issue/idea/Question to be investigated (connection to real-life): To build a balance and devise a way to find the volume of items that are not easily measured with a ruler.		
Project Outcome:		

• A device to measure the masses of powdered solids and liquids accurately without using standard laboratory equipment to calculate the density of items.			
Driving Question (s) 1. How do you find the density of something if you do not have a balance to measure its mass? 2. Can you build a balance and devise a way to find the volume of items that are not easily measured with a ruler?			
The Lesson Planner			
Activity	**Teacher Notes**	**Estimated Time Needed**	**Student Deliverables**
Lesson Background	Direct Instruction	Two Periods	Class notes
-Project Topic Discussion. -Lesson Rubric Discussion -Project Outline	-Introduce Topic -Establish prior knowledge -Help students build personal connections with the topic	1 Periods	Class participation in group activities
Stages of the Project			
-Preliminary Background Research	-Provide directions as needed -Provide assistance and instruction with needed academic and technological skills -Provide students with needed opportunities to conduct experiments, interviews, field trips, and other activities that allow them to research their topic.	One period	Research Notes in students Interactive Science Folder
Question/Think/Predict -Generate and develop ideas	Provide directions as needed -Provide assistance and instruction with needed academic and technological skills -Provide students with needed opportunities to conduct experiments, interviews, field trips and other activities that allow them to research their	One period	Student-generated notes in Interactive Science Folder
Plan and conduct project/investigation -Develop ideas/design -Collaborate with others -Plan and carry out investigations and activities	Provide directions as needed -Provide assistance and instruction with needed academic and technological skills -Provide students with needed opportunities to conduct experiments, interviews, field trips and other activities that allow them to research their	One period	Student-generated notes & artifacts in students Interactive Science Folder
Information and data analysis -Analyze and critique data/outcomes	Provide directions as needed -Provide assistance and instruction with needed academic and technological skills -Provide students with needed opportunities to conduct experiments, interviews, field trips and other activities that allow them to research their	One period	Student-generated notes & artifacts in students Interactive Science Folder
Project/investigation evaluation and assessment -Communicate -Explain/reflect -Analyze and critique	Provide Assessment guidelines and rubrics Provide Feedback and assessment	One period	Student-generated notes & artifacts in students Interactive Science Folder Completed Rubrics

Development and design -Project/Product Assembly	Provide directions as needed -Provide assistance and instruction with needed academic and technological skills -Provide students with needed opportunities to conduct experiments, interviews, field trips and other activities that allow them to research their	One period	Student-generated notes & artifacts in students Interactive Science Folder
Outcome Communication -Submit a project for preliminary review & feedback -Make needed changes based on preliminary feedback -Present final project/product to the class & guests	Provide Assessment guidelines and rubrics Provide Feedback and assessment	One period	Student-generated notes & artifacts in students Interactive Science Folder Reflections Preliminary & Final Project Project Presentation Completed Rubrics

Appendix X1: Criterion-Referenced Diagnostic Test

Name ______________________________ Date ____________ Class _____________

DIAGNOSTIC TEST 1

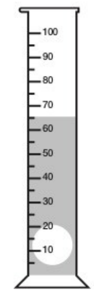
1. Which of these properties of an iron nail is a physical property?
A does not burn when a flame is applied
B reacts with hydrochloric acid to release hydrogen gas
C composed of only one piece instead of fragments
D rusts

2. A group of two or more atoms held together by chemical bonds is called
A an element.
B a compound.
C a molecule.
D a solution.

3. On a cold morning, Fawn awoke to find frost on her bedroom windows. Which type of process is the formation of frost?
A color change
B physical change
C chemical change
D electromagnetic change

4. Which of the following examples in nature represents a chemical change?
A water freezing in a pond
B a tree branch breaking
C a tree burning after a lightning strike
D steam rising from pavement

Directions: *Use the diagram below to answer question 5.*



5. Curtis wanted to measure the volume of a rock using the method shown above. Which of the following SI units should he use?
A grams
B meters
C milliliters
D kilometers

6. How do crystalline and amorphous solids differ?
A Crystalline solids do not melt at a distinct temperature.
B Amorphous solids are made up of crystals.
C Crystalline solids have a regular pattern of particles, but amorphous solids do not.
D Amorphous solids are always soft.

GO ON

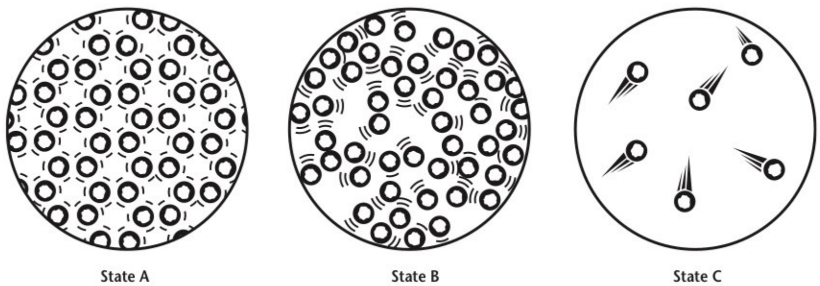
Appendix X1: Criterion-Referenced Diagnostic Test

Name ______________________________ Date ____________ Class ______________

DIAGNOSTIC TEST 1 *(continued)*

Directions: *Use the diagram below to answer question 7.*

States of a Substance



7. The diagram compares the particles in three different states of matter. What process causes particles in State A to change to State B?

- **A** condensation
- **B** evaporation
- **C** freezing
- **D** melting

8. What must happen in order for water to change state?

- **A** It must maintain its thermal energy level.
- **B** It must absorb or release energy.
- **C** It must be insulated.
- **D** It must convert thermal energy to solar energy.

9. A balloon is inflated with air and is then pulled down to the bottom of a lake, where the pressure of the water is greatest. What happens to the air in the balloon as it is submerged?

- **A** Its pressure decreases.
- **B** Its volume decreases.
- **C** Its pressure remains the same.
- **D** It condenses.

10. Atoms consist of which three types of particles?

- **A** compounds, protons, neutrons
- **B** electrons, neutrons, protons
- **C** elements, electrons, neutrons
- **D** molecules, electrons, protons

11. What observation led Dmitri Mendeleev to create the first periodic table?

- **A** Atoms contain neutrons.
- **B** Different elements have different chemical symbols.
- **C** Atoms of different elements have the same number of protons.
- **D** Some elements have similar chemical or physical properties.

12. The elements in one period of the periodic table

- **A** have the same number of electrons.
- **B** have the same number of protons.
- **C** decrease in atomic mass from left to right.
- **D** increase in atomic number from left to right.

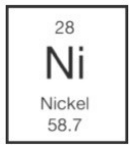
GO ON

Appendix X1: Criterion-Referenced Diagnostic Test

Name ______________________________ Date ____________ Class ______________

DIAGNOSTIC TEST 1 *(continued)*

Directions: *Use the illustration below to answer question 13.*



13. How many protons does a nickel atom have?

A 14
B 28
C 30.7
D 58.7

14. Which of the following is a property of metals?

A They are dull.
B They are good conductors.
C They break easily.
D They are not malleable.

15. Which of the following statements about nonmetals is true?

A Nonmetals are usually very shiny.
B Many nonmetals are liquids at room temperature.
C Nonmetals are good electrical conductors.
D Many nonmetals are gases at room temperature.

16. Which lists the three main types of nuclear radiation from **least** penetrating to **most** penetrating?

A alpha, gamma, beta
B alpha, beta, gamma
C gamma, beta, alpha
D beta, gamma, alpha

GO ON

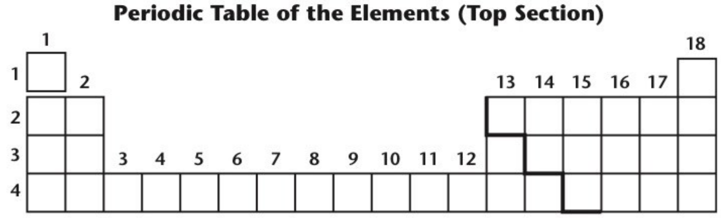
Appendix X1: Criterion-Referenced Diagnostic Test

Name ______________________________ Date ____________ Class ______________

DIAGNOSTIC TEST 1 *(continued)*

Directions: *Use the diagram below to answer question 17.*

Periodic Table of the Elements (Top Section)



17. Which group of the periodic table contains elements made of atoms with only one valence electron?

A Group 1
B Group 3
C Group 17
D Group 18

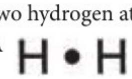
18. Which electrical attraction holds atoms together in ionic bonding?

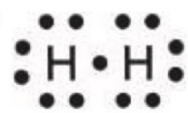
A attraction between nuclei
B attraction between an electron pair shared by both nuclei
C attraction between ions of opposite charge
D attraction between ions of the same charge

19. Which of the following is a general property of ionic compounds?

A soft
B easily bent without breaking
C high melting points
D do not form crystals

20. Which of the following diagrams shows two hydrogen atoms bonded together?

A


B


C


D


21. Which type of chemical bond occurs in metals and **not** in nonmetals?

A covalent bonds
B double bonds
C ionic bonds
D metallic bonds

22. The best evidence for a chemical reaction is

A the formation of a new substance.
B the production of a gas.
C a change in color.
D the formation of a solid.

GO ON

Appendix X1: Criterion-Referenced Diagnostic Test

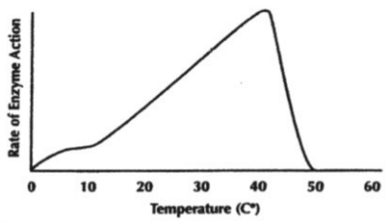
Name ______________________________ Date ____________ Class ______________

DIAGNOSTIC TEST 1 *(continued)*

23. In a chemical reaction, the total mass of the reactants is

A less than the total mass of the products.
B greater than the total mass of the products.
C exactly equal to the total mass of the products.
D unrelated to the total mass of the products.

Directions: *Use the graph below to answer question 24.*



24. A scientist tested the effect of temperature (from 0° C to 30° C) on enzyme activity, and published his results. A second scientist repeated the experiment, but tested temperatures between 0° C and 60° C, with the results shown above. What did the second trial show that the first trial did not?

A Activity increases with temperature.
B Activity decreases quickly above 40° C.
C Activity decreases with temperature.
D Activity decreases quickly above 0° C.

25. Which occurs during a synthesis reaction?

A Compounds break down into simpler products.
B Two or more substances combine to form a more complex substance.
C One element replaces another element in a compound.
D Two elements in different compounds trade places.

26. The half-life of a radioactive isotope is the length of time needed for half of the atoms in a sample to

A decay.
B double in size.
C become radioactive.
D change into carbon.

27. Which of the following is present in the largest amount in a solution?

A solute
B solvent
C colloid
D suspension

28. How does the maximum amount of salt that will dissolve in a given amount of water change if the temperature of the water is increased?

A It increases steadily.
B It decreases steadily.
C It remains the same.
D It increases at first but then decreases close to the boiling point.

GO ON

Appendix X1: Criterion-Referenced Diagnostic Test

Name ______________________________ Date ____________ Class ______________

DIAGNOSTIC TEST 1 *(continued)*

29. A solution turns red litmus paper blue. The solution is
- **A** neutral.
- **B** sulfuric acid.
- **C** salt water.
- **D** a base.

30. Any substance that forms hydrogen ions (H^+) in water is
- **A** an acid.
- **B** a base.
- **C** an indicator.
- **D** a salt.

STOP

Appendix X1: Criterion-Referenced Diagnostic Test

Name ______________________________ Date ____________ Class ______________

DIAGNOSTIC TEST 1 REPORT

Objective	Test Items	Number Correct	Proficient? Yes or No	Remediation
PS Ch01 L01: Identify the properties used to describe matter.	1			
PS Ch01 L02: Describe what makes up matter.	2			
PS Ch01 L03: Describe the units used to measure mass and volume.	5			
PS Ch01 L04: Explain what a chemical change is.	4			
PS Ch01 L04: Explain what a physical change is.	3			
PS Ch02 L01: Describe the motion of particles in a solid.	6			
PS Ch02 L02: Explain what happens to a substance during changes between liquid and gas.	8			
PS Ch02 L02: Explain what happens to a substance during changes between solid and liquid.	7			
PS Ch02 L03: Explain how pressure and volume of a gas are related.	9			
PS Ch03 L01: Describe the modern model of the atom.	10			
PS Ch03 L02: Explain how Mendeleev discovered the pattern that led to the periodic table.	11			
PS Ch03 L02: Explain how the periodic table is useful.	17			
PS Ch03 L02: Identify the data about elements found in the periodic table.	12, 13			
PS Ch03 L03: Summarize the properties of metals.	14			
PS Ch03 L04: Summarize the properties of nonmetals.	15			
PS Ch03 L05: Describe how radioactive isotopes are useful.	26			
PS Ch03 L05: Identify the types of particles and energy produced by radioactive decay.	16			
PS Ch04 L02: Explain how ions form.	18			
PS Ch04 L02: Identify properties of ionic compounds.	19			

(continued)

Appendix X1: Criterion-Referenced Diagnostic Test

Name ______________________________ Date ____________ Class ______________

DIAGNOSTIC TEST 1 REPORT

Objective	Test Items	Number Correct	Proficient? Yes or No	Remediation
PS Ch04 L03: Describe how atoms are held together in a covalent bond.	20			
PS Ch04 L04: Describe the structure of a metal crystal.	21			
PS Ch05 L01: Identify ways to tell that a chemical reaction has occurred.	22			
PS Ch05 L02: Explain how mass is conserved during a chemical reaction.	23			
PS Ch05 L02: Identify three categories of chemical reactions.	25			
PS Ch05 L03: Identify factors that affect the rate of a chemical reaction.	24			
PS Ch06 L01: Identify how mixtures are classified.	27			
PS Ch06 L02: Identify the factors that affect the solubility of a substance.	28			
PS Ch06 L03: Describe the properties of bases.	29			
PS Ch06 L04: Identify the types of ions acids and bases form in water.	30			

Appendix X2: Criterion-Referenced Benchmark Test

Name ______________________________ Date ____________ Class ______________

BENCHMARK TEST 1

1. Which of the following is a chemical property of a substance?

A the ability to conduct heat
B the ability to melt
C the ability to burn
D the ability to reflect light

2. The chemical formula for a molecule of sulfuric acid is H_2SO_4. How many different elements make up the compound sulfuric acid?

A 2
B 3
C 6
D 7

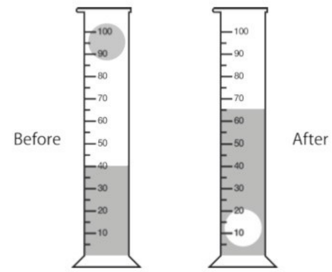
3. Potting soil usually contains soil, organic matter, and perlite (small white balls that help keep the soil loose). Which of the following terms could be used to classify potting soil?

A mixture
B formula
C element
D compound

4. What information about a mineral or rock is needed to determine its density?

A shape and mass
B volume and mass
C volume and shape
D volume and hardness

Directions: *Use the diagram below to answer question 5.*



5. A rock was dropped into water in a graduated cylinder. What is the correct volume of the rock?

A 25 mL
B 40 mL
C 65 mL
D 105 mL

6. Which of the following is an example of a physical change?

A burning
B melting
C rusting
D corroding

GO ON

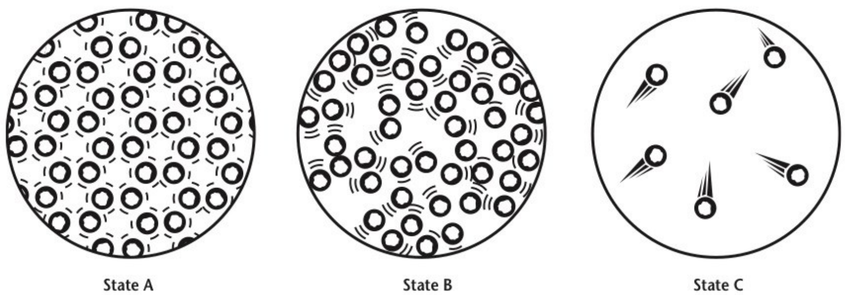
Appendix X2: Criterion-Referenced Benchmark Test

Name ______________________________ Date ____________ Class ______________

BENCHMARK TEST 1 *(continued)*

Directions: *Use the diagram below to answer question 7.*

States of a Substance



7. If the diagrams show the particles of a single substance, which of the states in the diagram represents a liquid?

A state A
B state B
C state C
D states A and B

8. Which is an exothermic change?

A ice melting
B water turning to steam
C frying an egg
D coal burning

9. What process turns dry ice from a solid directly into a gas?

A condensation
B evaporation
C sublimation
D vaporization

10. What does a graph of Charles' Law describe?

A an inverse relationship between gas volume and temperature
B an inverse relationship between gas temperature and mass
C a direct relationship between gas volume and pressure
D a direct relationship between gas volume and temperature

11. John Dalton thought that atoms are most like

A smooth, hard balls.
B chocolate chip cookies.
C onions with many layers.
D peaches with solid pits inside.

GO ON

Appendix X2: Criterion-Referenced Benchmark Test

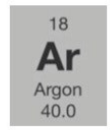
Name ______________________________ Date ____________ Class ______________

BENCHMARK TEST 1 *(continued)*

12. According to the model of atoms we now use, an atom
- **A** cannot be broken down into smaller pieces.
- **B** consists of a sphere of positive electricity in which negative electrons are embedded like raisins in a raisin muffin.
- **C** consists of a positive nucleus surrounded by electrons that orbit the nucleus in well-defined orbits.
- **D** consists of a positive nucleus around which electrons form a negatively charged cloud.

13. Dmitri Mendeleev discovered patterns in the properties of elements when he arranged them in order by
- **A** number of electrons.
- **B** number of neutrons.
- **C** atomic size.
- **D** atomic mass.

Directions: *Use the diagram below to answer question 14.*



14. What is the average atomic mass of argon?
- **A** 9
- **B** 18
- **C** 22.0
- **D** 40.0

15. In the periodic table, how are elements in the same group related to each other?
- **A** They have the same atomic mass.
- **B** They have very different properties.
- **C** They have the same atomic number.
- **D** They have similar properties.

16. If an element is shiny, a good heat conductor, and can be reshaped without breaking, the element is most likely
- **A** an isotope.
- **B** a liquid.
- **C** a gas.
- **D** a metal.

GO ON

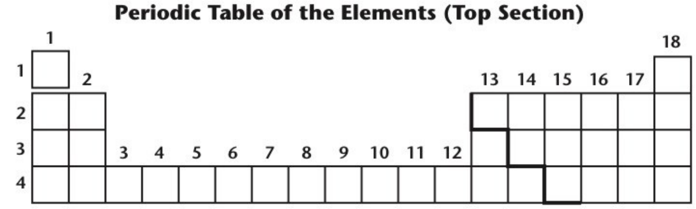
Appendix X2: Criterion-Referenced Benchmark Test

Name ______________________________ Date ____________ Class ______________

BENCHMARK TEST 1 *(continued)*

Directions: *Use the diagram below to answer question 17.*

Periodic Table of the Elements (Top Section)



17. Where are almost all nonmetals located in the periodic table?
A to the left of the zigzag line
B to the right of the zigzag line
C in rows 3 and 4
D in Groups 1 through 4

18. Which statement is true about the Group 1 metals?
A The metals of the group are called alkaline earth metals.
B The metals all have very high densities.
C They are always found as uncombined elements in nature.
D They are the most reactive metals in the periodic table.

19. Atoms of most elements are **less** likely to react when they have
A 2 valence electrons.
B 4 valence electrons.
C 6 valence electrons.
D 8 valence electrons.

20. Which compound is made of atoms joined by covalent bonds?
A $NaCl$
B CaF_2
C MgO
D H_2O

21. Atoms of the element nitrogen can share three pairs of electrons, forming
A a single bond.
B a double bond.
C a triple bond.
D no bond.

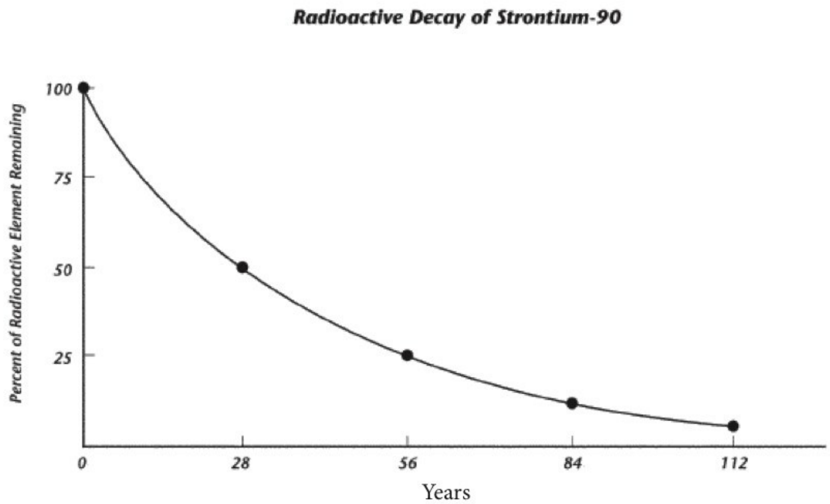
GO ON

Appendix X2: Criterion-Referenced Benchmark Test

Name ______________________________ Date ____________ Class ______________

BENCHMARK TEST 1 *(continued)*

Directions: *Use the graph below to answer question 22.*



22. According to the graph, how many years will it take for 50 percent of a sample of strontium-90 to decay?

A 28 years
B 56 years
C 84 years
D 112 years

23. Which is a property shared by most molecular compounds?

A high boiling point
B conducts electric current
C low melting point
D nonpolar bonds

24. A covalent bond in which electrons are shared equally is

A a double bond.
B ionic.
C nonpolar.
D polar.

25. What produces a metallic bond?

A attraction between oppositely charged ions
B attraction between a positive ion and electrons around it
C attraction of two nuclei to a pair of electrons
D attraction between metal and hydrogen ions

26. Which of the following is a chemical change?

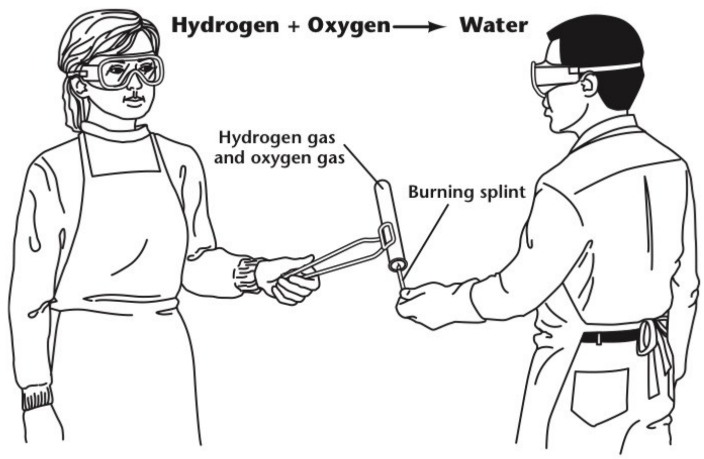
A toasting a marshmallow
B melting ice
C breaking a toothpick in half
D boiling water

Appendix X2: Criterion-Referenced Benchmark Test

Name ______________________________ Date ____________ Class ______________

BENCHMARK TEST 1 *(continued)*

Directions: *Use the diagram below to answer question 27.*



27. Which statement is true about the chemical reaction shown?

A In the reaction, there are two products and one reactant.
B Water forms from the reaction between hydrogen and oxygen.
C In the equation, H_2O is a chemical symbol.
D The chemical equation for the reaction is balanced.

28. Which of the following is a decomposition reaction?

A $P_4 + 3\ O_2 \rightarrow P_4O_6$
B $2\ Na + 2\ H_2O \rightarrow H_2 + 2\ NaOH$
C $2\ H_2O_2 \rightarrow 2\ H_2O + O_2$
D $2\ Cu_2O + C \rightarrow 4\ Cu + CO_2$

29. A log burned and became a pile of ashes. The mass of the ashes was less than the mass of the log before it burned. What can you conclude based on the law of conservation of mass?

A The chemical reaction created matter.
B The chemical reaction destroyed matter.
C Not all of the products and reactants could be measured because the chemical reaction took place in an open system.
D The chemical reaction did not work as expected because it took place in a closed system.

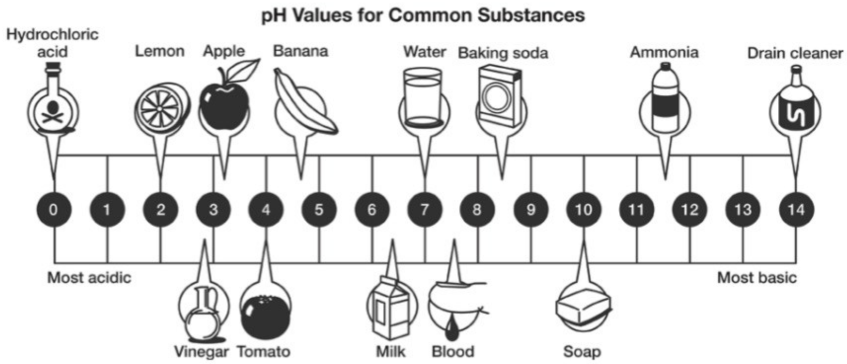
GO ON

Appendix X2: Criterion-Referenced Benchmark Test

Name ______________________________ Date ____________ Class ______________

BENCHMARK TEST 1 *(continued)*

Directions: *Use the diagram below to answer question 30.*



30. Based on the pH values given on the pH scale, which of the following solutions has the lowest concentration of H^+ ions?
A hydrochloric acid
B lemon juice
C baking soda
D drain cleaner

31. The activation energy of a chemical reaction is the amount of energy required to
A combine two elements into a compound.
B break the chemical bonds in the products.
C produce heat energy.
D break the chemical bonds in the reactants.

32. The air in your classroom is an example of a
A colloid.
B solution.
C suspension.
D fog.

33. When baking soda mixes with vinegar, the solution feels cool. This temperature change is an indication that
A an exothermic reaction is occurring.
B energy is being absorbed by the reaction.
C no reaction is taking place.
D matter is being released.

34. If the pressure of a gas above a liquid is increased, the solubility of the gas in the liquid usually
A increases.
B decreases.
C remains the same.
D first increases then decreases.

35. What is the name of a substance that produces hydroxide ions (OH^-) in water?
A acid
B base
C salt
D pH

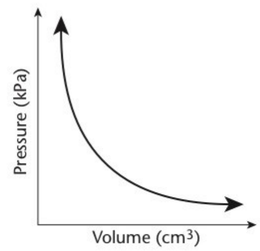
GO ON

Appendix X2: Criterion-Referenced Benchmark Test

Name ______________________________ Date ____________ Class ______________

BENCHMARK TEST 1 *(continued)*

Directions: *Use the graph below to answer question 36.*



36. What gas law is shown in the figure? Describe the relationship between gas pressure and gas volume shown by the graph. ______________________________

____

____

37. Compare and contrast evaporation and boiling. ______________________________

____

____

38. A sample of an unknown element is a solid that crumbles easily into a powder and does not conduct electricity. Is this element a metal or a nonmetal? Explain your reasoning.

____

____

____

39. When dissolved in water, why are ionic compounds better conductors of electricity than molecular compounds? ______________________________

____

____

40. Describe four ways that a chemist might be able to speed up a chemical reaction.

____

____

____

STOP

Appendix X2: Criterion-Referenced Benchmark Test

Name ______________________________ Date ____________ Class ______________

BENCHMARK TEST 1 REPORT

Objective	Test Items	Number Correct	Proficient? Yes or No	Remediation
PS Ch01 L02: Describe the properties of a mixture.	3			
PS Ch01 L01: Identify the properties used to describe matter.	1			
PS Ch01 L02: Describe what makes up matter.	2			
PS Ch01 L03: Describe the units used to measure mass and volume.	5			
PS Ch01 L03: Explain how to determine the density of a material.	4			
PS Ch01 L04: Describe how energy changes when matter changes.	8			
PS Ch01 L04: Explain what a physical change is.	6			
PS Ch02 L01: Describe the motion of particles in a liquid.	7			
PS Ch02 L02: Explain what happens to a substance during changes between liquid and gas.	37			
PS Ch02 L02: Explain what happens to a substance during changes between solid and gas.	9			
PS Ch02 L03: Explain how pressure and volume of a gas are related.	10, 36			
PS Ch03 L01: Describe how atomic theory developed.	11			
PS Ch03 L01: Describe the modern model of the atom.	12			
PS Ch03 L02: Explain how Mendeleev discovered the pattern that led to the periodic table.	13			
PS Ch03 L02: Explain how the periodic table is useful.	15			
PS Ch03 L02: Identify the data about elements found in the periodic table.	14			
PS Ch03 L03: Describe how metals are classified in the periodic table.	18			
PS Ch03 L03: Summarize the properties of metals.	16			
PS Ch03 L04: Summarize the properties of nonmetals.	17, 38			

(continued)

Appendix X2: Criterion-Referenced Benchmark Test

Name _______________ Date _______ Class ________

BENCHMARK TEST 1 REPORT

Objective	Test Items	Number Correct	Proficient? Yes or No	Remediation
PS Ch03 L05: Describe how radioactive isotopes are useful.	22			
PS Ch04 L01: Explain what determines an element's chemistry.	19			
PS Ch04 L02: Identify properties of ionic compounds.	39			
PS Ch04 L03: Describe how atoms are held together in a covalent bond.	20, 21			
PS Ch04 L03: Explain how bonded atoms become partially charged.	24			
PS Ch04 L03: Identify properties of molecular compounds.	23			
PS Ch04 L04: Describe the structure of a metal crystal.	25			
PS Ch05 L01: Identify ways to tell that a chemical reaction has occurred.	26			
PS Ch05 L02: Explain how mass is conserved during a chemical reaction.	29			
PS Ch05 L02: Identify the information included in a chemical equation.	27			
PS Ch05 L02: Identify three categories of chemical reactions.	28			
PS Ch05 L03: Explain how activation energy is related to chemical reactions.	31, 33			
PS Ch05 L03: Identify factors that affect the rate of a chemical reaction.	40			
PS Ch06 L01: Identify how mixtures are classified.	32			
PS Ch06 L02: Identify the factors that affect the solubility of a substance.	34			
PS Ch06 L04: Identify the types of ions acids and bases form in water.	30, 35			

Appendix X3: Criterion-referenced Chapter Pretest (Test B)

Introduction to Matter

Chapter Test B

Multiple Choice

Write the letter of the correct answer on the line at the left.

____ **1.** The volume of an irregular object can be measured by

a. multiplying the object's length, width, and height.
b. multiplying the object's density by its mass.
c. submerging the object in water in a graduated cylinder.
d. placing the object on a triple-beam balance.

____ **2.** The density of corn syrup is 1.33 g/mL, and the density of vegetable oil is
0.91 g/mL. Which liquid(s) will float on water?

a. both corn syrup and vegetable oil
b. corn syrup but not vegetable oil
c. vegetable oil but not corn syrup
d. neither vegetable oil nor corn syrup

____ **3.** Anything that has mass and takes up space is called

a. matter. **b.** energy.
c. heterogeneous. **d.** homogeneous.

____ **4.** Soil, a salad, and sugar water are all examples of

a. elements. **b.** compounds.
c. mixtures. **d.** atoms.

____ **5.** What holds atoms together in a molecule?

a. density **b.** gravity
c. physical bonds **d.** chemical bonds

____ **6.** The metric system of measurement is based on the number

a. 1. **b.** 10.
c. 12. **d.** 100.

____ **7.** The ability to do work or because change describes

a. temperature. **b.** density.
c. matter. **d.** energy.

____ **8.** One example of a physical change is

a. burning paper. **b.** baking cookies.
c. toasting marshmallows. **d.** dissolving salt in water.

Appendix X3: Criterion-referenced Chapter Pretest (Test B)

Introduction to Matter *(continued)*

____ **9.** How do liquid water, ice, and water vapor differ from each other?

a. They are different states of matter.
b. They are different compounds.
c. They are made of different kinds of molecules.
d. They are made of different kinds of atoms.

____ **10.** Being able to identify good sources of scientific information and apply the knowledge to problems in your life is a part of having

a. scientific hypotheses. **b.** scientific inquiry.
c. scientific literacy. **d.** scientific laws.

____ **11.** One example of a chemical change is

a. filtering a mixture. **b.** burning wood.
c. boiling water. **d.** crushing a can.

Completion

Fill in the line to complete each statement.

12. The fact that matter is not created or destroyed in any chemical or physical change is called the ________________________________.

13. A(n) _____________________ is a group of two or more atoms that are held together by chemical bonds.

14. Hardness, texture, color, and freezing point are examples of _____________________ properties of matter.

15. A volume of 25 milliliters is the same as a volume of _____________________ cubic centimeters.

16. A(n) _____________________ is formed when two or more substances are so evenly mixed that you cannot see the different parts.

True or False

If the statement is true, write true. *If it is false, change the underlined word or words to make the statement true.*

_____________ **17.** A <u>substance</u> is a single kind of matter that has a specific composition.

_____________ **18.** A substance that undergoes a <u>chemical</u> change is still the same substance after the change.

_____________ **19.** The smallest particle of an element is called a(n) <u>atom</u>.

_____________ **20.** To find the <u>mass</u> of a rectangular object, you multiply the object's length, width, and height.

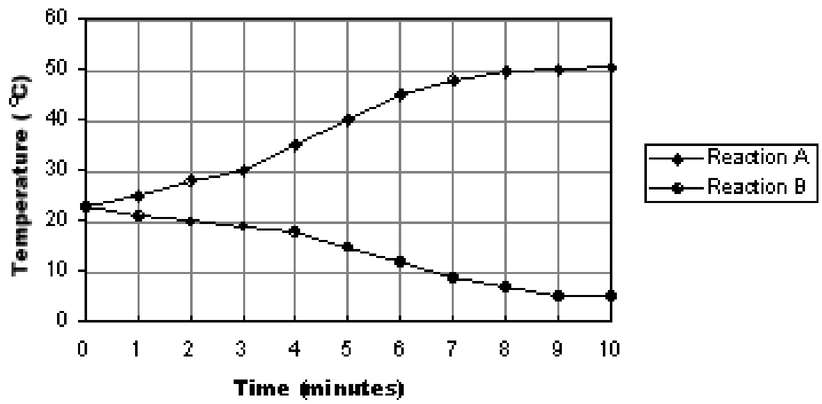
_____________ **21.** A change that produces one or more new substances is called a <u>physical</u> change.

Appendix X3: Criterion-referenced Chapter Pretest (Test B)

Introduction to Matter ***(continued)***

Using Science Skills

Use the graph to answer each question.



22. Identify and label the dependent and independent variables. Describe the relationship between the dependent and independent variables.

____

____

____

____

23. How did the temperature change in reaction A differ from that in reaction B?

____

____

____

____

Essay

Write an answer for each of the following questions on a separate sheet of paper.

24. Explain how you could find out whether an unknown liquid is water.

25. Explain the differences in finding the density of a solid rectangular object and finding the density of an irregular solid object.

26. Explain the difference between a mixture and a compound.

Appendix X3: Criterion-referenced Chapter Pretest (Test B)

Introduction to Matter *(continued)*

Using Science Skills

Use the diagram to answer each question.

Densities of Some Common Materials

Material	Density (g/cm^3)
Air	0.0013
Gasoline	0.7
Wood (oak)	0.85
Water (ice)	0.9
Water (liquid)	1.0
Aluminum	2.7
Steel	7.8
Silver	10.5
Lead	11.3
Mercury	13.5
Gold	19.3

27. If samples of silver and lead each had volumes equal to 1 cm^3, which sample would have the greater mass? What would the difference in the masses be?

____

____

28. How does the density of liquid water compare with the density of ice?

____

____

29. A 54-gram sample of an unknown material has a volume equal to 20 cm^3. Based on its density, could the sample be aluminum? Explain.

____

____

Appendix X3: Criterion-referenced Chapter Pretest (Test B)

Introduction to Matter *(continued)*

Essay

Write an answer for each of the following questions on a separate sheet of paper.

30. When an electric current is passed through the water during the process of electrolysis, two gases are formed. One gas has a boiling point of –183°C, and the other has a boiling point of –253°C. Is this event a physical change or a chemical change? Explain.

31. Is the melting of an ice cube considering a physical change or a chemical change? Explain your reasoning.

Appendix X4: Criterion-referenced Chapter Posttest (Test A)

Introduction to Matter

Chapter Test A

Multiple Choice

Write the letter of the correct answer on the line at the left.

____ **1.** Anything that has mass and takes up space is called
a. matter. **b.** energy.
c. heterogeneous. **d.** homogeneous.

____ **2.** What holds atoms together in a molecule?
a. density **b.** gravity
c. physical bonds **d.** chemical bonds

____ **3.** The density of corn syrup is 1.33 g/mL, and the density of vegetable oil is 0.91 g/mL. Which liquid(s) will float on water?
a. both corn syrup and vegetable oil
b. corn syrup but not vegetable oil
c. vegetable oil but not corn syrup
d. neither vegetable oil nor corn syrup

____ **4.** Soil, a salad, and sugar water are all examples of
a. elements. **b.** compounds.
c. mixtures. **d.** atoms.

____ **5.** The volume of an irregular object can be measured by
a. multiplying the object's length, width, and height.
b. multiplying the object's density by its mass.
c. submerging the object in water in a graduated cylinder.
d. placing the object on a triple-beam balance.

____ **6.** How do liquid water, ice, and water vapor differ from each other?
a. They are different states of matter.
b. They are different compounds.
c. They are made of different kinds of molecules.
d. They are made of different kinds of atoms.

____ **7.** One example of a physical change is
a. burning paper. **b.** baking cookies.
c. toasting marshmallows. **d.** dissolving salt in water.

____ **8.** The ability to do work or cause change describes
a. temperature. **b.** density.
c. matter. **d.** energy.

Appendix X4: Criterion-referenced Chapter Posttest (Test A)

Introduction to Matter

____ **9.** One example of a chemical change is

a. filtering a mixture. **b.** burning wood.
c. boiling water. **d.** crushing a can.

____ **10.** Being able to identify good sources of scientific information and apply the knowledge to problems in your life is a part of having

a. scientific hypotheses. **b.** scientific inquiry.
c. scientific literacy. **d.** scientific laws.

____ **11.** The metric system of measurement is based on the number

a. 1. **b.** 10.
c. 12. **d.** 100.

Completion

Fill in the line to complete each statement.

12. Hardness, texture, color, and freezing point are examples of ____________________ properties of matter.

13. A(n) ____________________ is a group of two or more atoms that are held together by chemical bonds.

14. The fact that matter is not created or destroyed in any chemical or physical change is called the ______________________________.

15. A(n) ____________________ is formed when two or more substances are so evenly mixed that you cannot see the different parts.

16. A volume of 25 milliliters is the same as a volume of ____________________ cubic centimeters.

True or False

If the statement is true, write true. *If it is false, change the underlined word or words to make the statement true.*

____________ **17.** A change that produces one or more new substances is called a <u>physical</u> change.

____________ **18.** A <u>substance</u> is a single kind of matter that has a specific composition.

____________ **19.** The smallest particle of an element is called a(n) <u>atom</u>

____________ **20.** To find the <u>mass</u> of a rectangular object, you multiply the object's length, width, and height.

____________ **21.** A substance that undergoes a <u>chemical</u> change is still the same substance after the change.

Appendix X4: Criterion-referenced Chapter Posttest (Test A)

Introduction to Matter *(continued)*

Using Science Skills

Use the diagram to answer each question.

Densities of Some Common Materials

Material	Density (g/cm^3)
Air	0.0013
Gasoline	0.7
Wood (oak)	0.85
Water (ice)	0.9
Water (liquid)	1.0
Aluminum	2.7
Steel	7.8
Silver	10.5
Lead	11.3
Mercury	13.5
Gold	19.3

22. How does the density of liquid water compare with the density of ice?

____

____

23. If samples of silver and lead each had volumes equal to 1 cm^3, which sample would have the greater mass? What would the difference in the masses be?

____

____

24. A 54-gram sample of an unknown material has a volume equal to 20 cm^3. Based on its density, could the sample be aluminum? Explain.

____

Appendix X4: Criterion-referenced Chapter Posttest (Test A)

Introduction to Matter *(continued)*

Essay

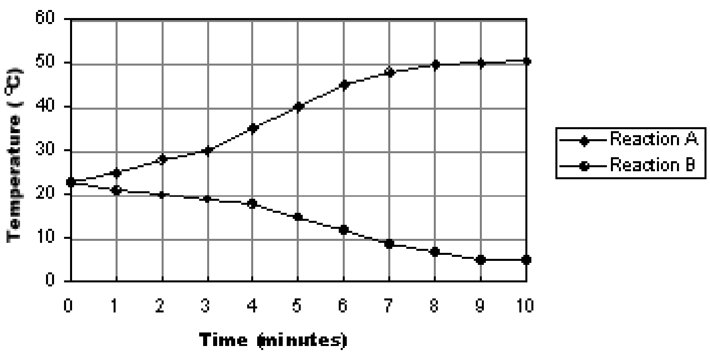
Write an answer for each of the following questions on a separate sheet of paper.

25. Explain the differences in finding the density of a solid rectangular object and finding the density of an irregular solid object.

26. Explain the difference between a mixture and a compound.

Using Science Skills

Use the diagram to answer each question.



27. How did the temperature change in reaction A differ from that in reaction B?

____

____

28. Identify and label the dependent and independent variables. Describe the relationship between the dependent and independent variables.

____

____

Appendix X4: Criterion-referenced Chapter Posttest (Test A)

Introduction to Matter *(continued)*

Essay

Write an answer for each of the following questions on a separate sheet of paper.

29. Explain how you could find out whether an unknown liquid is water.

30. Is the melting of an ice cube considered a physical change or a chemical change? Explain your reasoning.

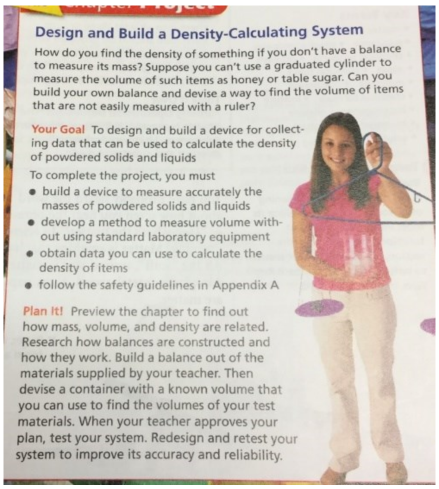
31. When an electric current is passed through the water during the process of electrolysis, two gases are formed. One gas has a boiling point of –183°C, and the other has a boiling point of –253°C. Is this event a physical change or a chemical change? Explain.

Appendix Y: Student Guidelines for the "design and build a density calculating System" project

<u>Grade: 8</u>

<u>Project Title: Design and Build a density calculating system</u>

<u>Project Instruction:</u>



Design and Build a Density-Calculating System

How do you find the density of something if you don't have a balance to measure its mass? Suppose you can't use a graduated cylinder to measure the volume of such items as honey or table sugar. Can you build your own balance and devise a way to find the volume of items that are not easily measured with a ruler?

Your Goal To design and build a device for collecting data that can be used to calculate the density of powdered solids and liquids

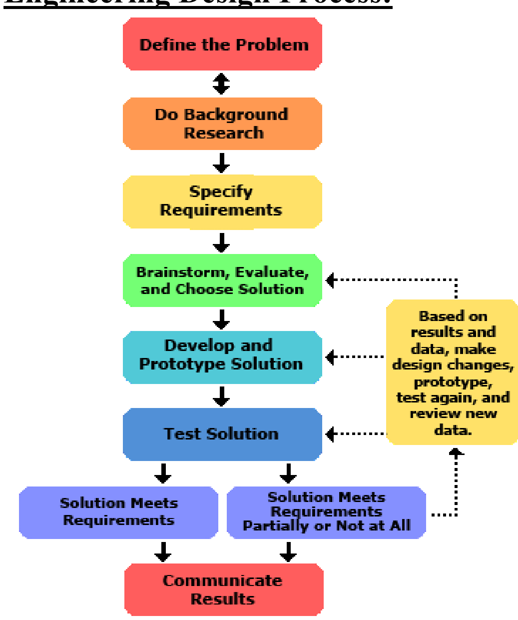
To complete the project, you must

- build a device to measure accurately the masses of powdered solids and liquids
- develop a method to measure volume without using standard laboratory equipment
- obtain data you can use to calculate the density of items
- follow the safety guidelines in Appendix A

Plan It! Preview the chapter to find out how mass, volume, and density are related. Research how balances are constructed and how they work. Build a balance out of the materials supplied by your teacher. Then devise a container with a known volume that you can use to find the volumes of your test materials. When your teacher approves your plan, test your system. Redesign and retest your system to improve its accuracy and reliability.

(Thornton et al., 2013)

<u>Engineering Design Process:</u>



Appendix Y

Use the <u>Problem Development Checklist</u> to help you define the problem for your investigation.

In developing the problem, we considered the need for…	**Yes**	**No**
appropriateness of the content when we developed our problem.		
the availability of skills and resources either in or out of the classroom.		
our experience and ability level in dealing with this type of problem.		
the current curriculum and learning goals of the class.		
our curricular interests and learning styles.		
creating a driving question.		
developing individual and group evaluation strategies.		

<u>Student Project Design Plan:</u> Please keep notes on your thoughts and background research as you brainstorm, evaluate, and choose a design (model) for your cell project.

<u>Individual & Group notes on the progress of the project:</u> Please keep notes on your progress. You may partner and work with a classmate, but remember that you are required to produce your model and write your report. Please keep really good notes on the progress of your project.

Appendix Y

Project Timeline: Please create a project timeline using the template below.

Task	Due Date
1. Research and gather information for your project.	
2. Design and construct a balance	
3. Create a scale drawing of the final product (must be color-coded and fully labeled).	
4. Select containers and develop a method to measure the volume	
5. Test Balance, redesign, and retest if necessary.	
6. Make density measurements of objects.	
7. Project presentation	

Appendix Y

Final Presentation Guidelines and expectations

Project Formative Assessment Rubric

PBL Formative Assessment Rubric		
	Yes	**No**
Classroom Climate: Students work well within the PBL structure.		
Student Background Knowledge: Students have the needed background knowledge to perform the required tasks.		
Engagement with the Problem/driving question: Students engage with the problem by sharing personal experiences.		
Student Participation and Collaboration: Students volunteered to do various jobs for their team. Students participated by generating ideas, sharing information, and generated questions and helped develop the team's action plan.		
Student Creativity: Students were able to use creativity to solve problems.		
Reflection and Revision: Students evaluated resources, ideas, hypotheses, and brought up additional questions. Students provided constructive feedback to their peers.		
Use of Technology and Product Production: Students incorporated information gathered into the product and participated in the creation of the product and the report. Students' were able to use technology effectively in the process of product production.		
Student Self Evaluation: Students evaluated themselves as both individuals and the members of the group.		
Determination of Mastery: The teacher to determine and evaluate proficiency in the content evaluated in the students' presentations and products.		
Teacher Comments		

Appendix Y

Project Presentation (Summative) Assessment Rubric

	1	2	3
Significant Scientific Content & In-depth Scientific Inquiry	The presentation does not include explanations of central concepts of the study, used inappropriate, irrelevant and incorrect descriptions of facts and details needed to support the project and answer the driving question. The presentation was not well organized and did not make sense. The presentation lacked an introduction or conclusion. The presentation was not adequately timed.	▪The presentation included adequate explanations of central concepts of the study, using appropriate, relevant, and accurate descriptions of facts and details needed to support the project and answer the driving question. ▪The presentation was adequately organized and made sense. ▪The presentation contained an introduction and a conclusion. ▪The presentation was adequately timed.	▪The presentation included explanations of central concepts of the study, using appropriate, relevant, and accurate descriptions of facts and details needed to support the project and answer the driving question. ▪The presentation was well organized and made sense. ▪The presentation contained an introduction and a conclusion. ▪The presentation was timed well.
21st Century Skills	▪The student was unable to demonstrate twenty-first-century skills through participation in the presentation and collaboration with others, use of technology to share main ideas, and add interest to the team.	▪Student adequately demonstrated 21st-century skills through participation in the presentation moreover, collaboration with others, some use of technology to share main ideas and add interest in the team presentation.	▪Student demonstrated 21st century skills through participation in the presentation and collaboration with others, use of technology to share the main ideas and add interest to the team presentation.
Student Engagement & Participation	The student was not able to show how the team's driving question/problem connected to a real-world process, as well as students' interests by explaining how they were able to make choices regarding the products he/she created, completed their work as guided by the teacher.	The student was able to adequately show how the team's driving question/ problem connected to a real-world process, as well as students' interests by explaining how they were able to make choices regarding the products he/she created, completed their work as guided by the teacher	The student was able to show how the team.' driving question/problem connected to a real-world the process, as well as students' interests by explaining how they were able to make choices regarding the products he/she created, completed their work as guided by the teacher.
Team Members Participation in Presentations	The student did not participate in the team presentation.	Student somewhat participated In the team presentation	The student fully participated in the team presentation.

Appendix Y

Individual Student Self-Evaluation Form

Student:	**Class:**		**Date:**
Activity	**Excellent**	**Good**	**Fair**
I believe I contributed ideas /facts for the benefit of the team.			
I suggested some ideas for further research and learning.			
I used multiple and varied resources for the report.			
I helped my team to think through problems.			
I shared new information I came across with my team.			
I helped my team complete tasks in a timely fashion.			

Individual Student Written Reflections Instructions

In your reflections, please describe the general process followed by you (or your group) to achieve yours (or the teams' learning goals), your effort (or contributions to the team effort), and suggestions for how you could improve in the future.