ABSTRACT

PROJECT-BASED LEARNING VERSUS TEXTBOOK/LECTURE LEARNING IN MIDDLE SCHOOL SCIENCE

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As schools continue to become more diverse, it is important to look at science teaching methods that will meet the needs of all students. In this study, 172 students in a middle school in Northwestern Illinois were taught using two methods of teaching science. Half of the students were taught using project-based science (PBS) and the other half of the students were taught using textbook/lecture science (TLS). Students were given pre, post, and delayed posttests on disease. This quasi-experiment found statistically significant difference between PBS and TLS, with PBS students having a higher mean score for all three tests than the TLS students. However, statistically significant delayed posttest results showed that black students seemed to retain information better when taught using TLS. These results may suggest that both PBS and TLS have a place in the science classroom to enhance the learning of all students, especially on content driven assessments.
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PROJECT-BASED LEARNING VERSUS TEXTBOOK/LECTURE LEARNING IN MIDDLE SCHOOL SCIENCE

BY

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DEDICATION

To my children McKenzie and Ben, son-in-law Alex, grandson Cohen, and husband Larry
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CHAPTER 1

INTRODUCTION

A primary goal of science education at the middle school level is to help students learn about their world (American Association for the Advancement of Science (AAAS) 2000; National Research Council (NRC), 2005, 2012). In order to teach students biology, chemistry, and physics, teachers are using experiments, projects, and lectures. Middle school science educators and administrators are continually searching for teaching methods that enhance students’ knowledge of science concepts to develop a better understanding of the world in which they live. Science educators should employ methods of instruction to increase all students understanding, improve motivation, and help develop a lifelong interest in science (Krajcik, Czerniak, & Berger, 2003).

Science educators, however, live in a world where they are held accountable every year through state-mandated assessments. The teaching method must motivate but also prepare students for testing. Simply stated, students must demonstrate their knowledge of science by taking a paper and pencil test. The Illinois State Assessment Test (ISAT) was the evaluation tool that was given to seventh grade students living in Illinois. Educators and administrators understood the importance of these standardized tests and strived to find the best way to teach so that students would master science content and meet adequate yearly progress (AYP) on the science portion of the test.

Unfortunately, results of state tests do not show that all middle school students are meeting AYP goals on standardized tests. According to the Illinois school Report Card (2013)
approximately 87 percent of white students met or exceeded on the ISAT science achievement test and only 62 percent of black students met or exceeded on the ISAT science test. Vocabulary, test bias and environmental factors may be a cause of the poor performances. The 2011 National Assessment of Educational Progress (NAEP) showed white eighth grade students in Illinois had an average score of 161 on standardized science test while black eighth grade students scored an average score of 120. In order to be considered proficient in science a student needed a score between 170 and 214. The average score on this test did not show proficiency for either group. This is a large science achievement gap between black and white students as well as low mean score for both races. The challenge for science educators is to examine the way science is taught and search for methods that will increase the number of students who score at or above the proficiency level in science (Geier et al., 2008). Curriculum that is motivating, and engage student understanding of fundamental world phenomenon will allow all students to have higher order thinking and should improve test scores (NRC, 2012 NGSS, 2013).

There is also a discrepancy between male and female scores on the ISAT Science test for seventh graders. The ISBE (2013) report card reveals that 81 percent of the females met or exceeded on their ISAT science scores but only 77 percent of the males met or exceeded. However, it was interesting to note that more males scored in the exceeds category on the science test than the females. Males had four percent more exceeding the standards than the females. These science related gaps in gender and race need to be addressed by science educator (NSTA, 2003). Science teaching methods may be able to reduce the gaps in test scores (Wilson et al., 2010; Colley, 2005).

One traditional method of teaching science is with the use of textbooks. Textbook/lecture science (TLS) is based on many topics covered with vocabulary, lectures, directed reading, and a
few hands-on activities (Pine et al., 2006). In the National Center for Educational Statistics’ 2003 survey, 54% of eighth grade science teachers reported that they rely primarily on science textbooks for the course content. Textbook companies have designed the content of their books based on the National Science Standards (National Research Council, 2005). However, the Next Generation Science Standards (NGSS) support inquiry and cooperative group learning. Implementation of NGSS begins the fall of 2015 with Illinois PARCC assessment to include science. This is why inquiry and cooperative group learning may not be found in many science classrooms (NGSS, 2013). NGSS also is focused more on core ideas and problem solving to understand real world phenomenon instead of just content. Therefore, science practices such as asking questions, analyzing data, and carrying out investigations should be a vital part of the science curriculum (NGSS, 2013).

The Third International Mathematics and Science Study (TIMSS, 2011) compared the achievement in science of over 500,000 fourth, eighth and twelfth-grade students around the world. TIMSS found that fourth grade science scores in the United States were high compared to other countries, but by eighth grade, United States students’ scores and knowledge of science concepts were behind other countries. In 2011, fourth grade average scores placed the United States seventh out of 57 countries, but by eighth grade the average scores had placed the United Sates students in 23rd place out of 57 countries. The use of science textbooks was cited as one of the reasons for this drop in scores. Kesidou and Roseman (2002) reviewed middle school curriculum and found that too many topics and lack of real world phenomena were major problems with science texts. It was noted that at age 13, students in the United States were exposed to 67 science textbook topics during the school year while students in Japan were only exposed to 11 different topics. According to the National Standards for Science Education, fewer
science concepts should be taught in more depth with an emphasis on real-world application (NRC, 2005, 2012). Kesidou and Roseman (2002) stress that teachers should focus on fewer topics and build on core ideas.

Instead of teaching from a textbook, another approach to teaching science is project-based science (PBS). PBS allows students to formulate a driving question; to use technology, cooperative learning, and inquiry; and to produce an artifact while investigating a real world problem. Each of these areas of PBS will be defined later in the chapter. PBS focuses on students’ interests and allows for a deeper understanding of the topic (Rivet & Krajcik, 2004).

Researchers from the University of Michigan suggest that PBS improves learner outcomes for all students with the most significant gains for black students (Geier et al., 2008; Marx et al., 2004; Rivet & Krajcik, 2004). Male students’ scores in science were also found to increase through the use of inquiry and hands-on science, both intricate parts of PBS (Geier et al., 2008). National organizations such as the American Association for the Advancement of Science (AAAS) (2000) and the National Research Council (NRC) (2005, 2012) and (NGSS) (2013) advocate less emphasis on memorizing facts and vocabulary and more emphasis on an investigation of real world phenomena that are relevant to the students.

The comparative value of project-based science versus Textbook/lecture science has remained largely unanswered. In the area of content learning, fair comparisons are challenging because textbook students are taught from a multitude of short fact-based expositions, whereas PBS focuses in depth on a smaller number of topics (Pine et al., 2006). Little research has been done comparing content knowledge results of both methods of learning with the paper and pencil test. In this study a comparison will be made between PBS and TLS to evaluate the ability of
seventh grade students to learn content knowledge based on an assessment of a multiple choice test.

Conceptual Framework

An analysis of both methods of teaching will be based on constructivist theory: the learner constructs knowledge instead of passively absorbing it (Brooks & Brooks, 1993). Developmental psychologist Piaget (1963) believed that an individual must have real life experiences to construct their understanding and problem solving skills. According to Joseph, Bravman, Windschitl, Mikel and Green (2000) in the book *Cultures of Curriculum*, there are three themes in the constructivist classroom. The first theme is the centrality of the learner; the second theme is complex inquiry, and the final theme is engagement of the learner. These three themes will be used to compare and contrast the PBS method of teaching to TLS. To better understand the three themes of the constructivist classroom, the theories of Bruner (1996), Kilpatrick (1936), and Vygotsky (1979) will be used to explain each theme. The three subheadings of centrality of the learner, complex inquiry and engagement of learner will better explain the constructivist theory.

**Centrality of the Learner**

Every learner in a constructivist classroom must actively work to acquire new knowledge. Students evaluate what they already know and apply that knowledge in order to learn new concepts. Bruner (1996) suggests that learning is an active process in which the learner is the transformer of existing ideas and concepts. In PBS, students gather information about a topic that interests them and then construct an artifact. Every student’s artifact should
address the driving question being studied by the class and show what has been learned (Krajcik et al., 2003). The artifact must be both personally meaningful and learner centered.

In a classroom that uses textbooks and lecture as the method of teaching, students are not usually given choices of what they want to study. However, they can gain knowledge by reading or discussing the information with their teachers and classmates. The teacher is the dispenser of knowledge instead of the students actively constructing the knowledge. The central focus of this type of approach is the teacher (Tal, Krajcik, & Blumenfeld, 2006).

**Complex Inquiry**

The next theme of the constructivist classroom is the complexity of integrating information and subject matter. Kilpatrick (1936) believed in the use of projects to engage the learner. An example of a project may be to have students find ways to make their school more energy efficient. He felt that projects and inquiry were excellent cognitive development for the learner (Kilpatrick, 1936). Science classrooms should be rich with inquiry (NRC, 2005). Students need to ask questions, form hypotheses, design and perform experiments, gather and analyze data on their inquiries and share this information with others (NRC, 2005, 2012). NGSS (2013) supports projects and inquiry by encouraging teachers to use science practices in all their lesson plans. The science practices include asking questions, developing models, planning and carrying out investigation, analyzing data, using mathematics, constructing explanations, engaging in argument, and evaluating information. Project-based science follows the NGSS and allows students to do science inquiry to construct knowledge.

In a study of middle school students, the comparison of inquiry based instruction and textbook instruction showed no significant difference in students’ ability to do inquiry (Pine et
In TLS, students also do experiments. These experiments are found in the textbook and are designed to help students better understand the content and concepts. For example, students may do an experiment where they touch three petri dishes to see if washing their hands reduces bacteria growth. Instead of students designing the activity, this experiment is predesigned. This is significant because less cognitive thinking is involved, and it is not complex inquiry. Further research needs to be conducted to see which instructional method increases students’ ability to do inquiry.

**Engagement of Learner**

The final theme for a constructivist classroom is the engagement of learners. Vygotsky (1979) theorized that learning occurs through social interactions. Concept development and understanding happens when individuals enter into meaningful discussions with peers and teachers (Vygotsky, 1979). When students participate in PBS, students are engaged in the learning process at the beginning of the unit. Students and the teacher work together to develop a driving question based on students’ interests. They collaborate with other students when doing inquiry activities related to this driving question. They work together sharing ideas and concepts while completing their artifacts. The teacher becomes a facilitator helping students with resources that will enable them to construct their own knowledge. In PBS, students are the ones who begin the learning process by generating a driving question (Krajcik et al., 2003; NGSS, 2013).

While PBS students are talking about a driving question that they have help develop, TLS teachers must find a topic in order to engage their students. The TLS teacher must work as the facilitator to actively engage his or her students by prompting discussion on various science
topics within a large group setting. If students are interested in the topic they will be fully engaged. However, PBS students come up with questions that they are interested (NGSS, 2013). These student-centered questions drives the curriculum and makes for a more motivated group of students (Blumenfeld et al., 2000). A more detailed examination of constructivist theory is presented in chapter two.

Problem Statement

Low scores and achievement gaps that occur in race and gender have caused educators to take a closer look on how they teach science. According to the NRC (2005, 2012) and NGSS (2013), science should be taught through inquiry situated in real-world meaningful contexts. The National Science Standards are challenging schools to make changes in their approaches to the teaching of science (Lynch, Kuipers, Pyle, & Szeeze, 2005). Students need to use technology to investigate and support their conclusions with evidence. However, the most common method of teaching science in United States classrooms remains lecture and discussion (Weiss, Bailower, McMahon, & Smith, 2001).

The NRC (2005, 2012) and AAAS (2000) are recommending that science educators teach through inquiry and real life experiences. The NGSS (2013) are endorsing science to be taught using science practices, crosscutting concepts, and core ideas. The Pine et al. (2006) study suggests that many science educators still teach science by lecturing and directing students to read the textbook. The discrepancy that exists between the NRC, AAAS, NGSS and Pine et al. may be due to the fact that little research has been done to suggest that other methods of teaching science are superior to using textbooks. To support science educators to change the way in
which they teach and to reduce the race and gender gap, data-driven research needs to be conducted to demonstrate which method of teaching is most effective (Pine et al., 2006).

Lead researchers in PBS based at the University of Michigan have done numerous studies in urban Detroit with middle school students. (Marx et al., 2004; Rivet & Krajcik, 2004; Rivet & Krajcik, 2008) These urban schools were randomly selected, and the PBS curriculum was implemented in the selected schools. The control group consisted of the remainder of the schools not selected. Little is known about which science teaching method was being implemented in the control schools. In this dissertation study, both curricula will be clearly described so a comparison can be evaluated.

The evaluation will lend itself to understanding which method will best allow all students to achieve national and state science standards. It is critical for teachers to use the best method of teaching to enhance science knowledge.

Research Questions

The purpose of this study is to compare the effectiveness of PBS and TLS in a seventh grade middle school setting. The following research questions frame the study:

1. Are there differences in seventh grade student performance between those who experience project-based science or textbook/lecture science on a content test?
2. Are there differences in black student performance between those who experience project-based science or textbook/lecture science on a content test?
3. Are there differences in male and female student performance between those who experience project-based science or textbook/lecture science on a content test?
Hypothesis

All students receiving the project-based science curriculum will outperform students receiving the textbook/lecture curriculum on a multiple choice science content test.

Null Hypothesis

There is no statistical difference in students’ performances on a content test between those who experienced project-based science and those who experienced textbook/lecture science.

Significance of the Study

Limited empirical research has been done in educational classrooms comparing various methods of teaching science to PBS (Marx et al., 2004; Rivet & Krajcik, 2004; Thomas, 2000). Therefore, the results of this study provide data on the effectiveness of PBS and the understanding of science content knowledge by seventh grade students. The study will add to the literature on the relative effectiveness of PBS and TLS.

With this data, middle school teachers and administrators can make a more informed decision about what teaching method to employ for teaching science that will have the greatest impact on decreasing the race and gender gap that currently exists. This, in turn, should have an impact on students’ performance on standardized science tests.

Definitions

The concepts to be defined in this section include PBS and TLS. Other terms used in PBS that will be defined are “driving question,” “inquiry” and “artifact.”
Artifact: A product that addresses the driving question and shows what the student has learned using project-based science (Krajcik et al., 2003). An example of an artifact that students created in the disease unit was a pamphlet on a disease.

Driving question: A question or problem that is meaningful and important to the learner (Krajcik et al., 2003). An example of a driving question: “How can my friends make me sick?”

Inquiry:

[A] multi-faceted activity that involves making observations; poising questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze and interpret data; proposing answers, explanations, and prediction of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (National Research Council, 2005, p. 23)

Project-based science (PBS): A teaching approach that engages all learners in exploring important and meaningful questions through a process of investigation and collaboration. Throughout this process, students ask questions, make predictions, design experiments and investigations, collect and analyze data, and share ideas (Krajcik et al., 2003).

Textbook lecture science (TLS): A teaching approach that uses a science textbook and materials designed by the textbook company. Throughout this process students read, do worksheets, listen to lectures, and discuss the material presented in the books (Pine et al., 2005).

Methodology

A quantitative research design was used. More specifically, a quasi-experimental design with a random assignment of intact groups will be employed. A pretest, posttest and delayed posttest was given to the subjects to compare two different teaching methods. A repeated analysis of variance (ANOVA), a method that performs the analysis of variance, was used to analyze the data. An alpha level of .05 was used to compare the mean scores of the pretest,
posttest and delayed posttest when analyzing the data. All calculations were done with the use of SAS 9.2.

Organization of the Dissertation

This study is divided into five chapters. Chapter 1 includes the introduction, conceptual framework, purpose, research questions, and significance of the study. Chapter 2 presents the literature on PBS and TLS. Chapter 3 outlines the methods and rationale for data collection as well as data analysis. Chapter 4 shows the statistical analysis of the data. Finally, Chapter 5 explains the analysis, findings, and implications of the study.
CHAPTER 2

LITERATURE REVIEW

The No Child Left Behind (NCLB) legislation had increased pressure on all teachers to meet state goals so schools can receive state funding (Lee & Luykx, 2006). Science educators are no exception to feeling the need to teach to standardized tests (Anderson & Helms, 2001). The new Partnership for Assessment of Readiness for College and Careers (PARCC) is the current state assessment used to hold teachers accountable and in the future, it may become part of their evaluation, which would need to show students growth. Therefore, it is safe to say that both teachers and administrators are constantly searching for the best instructional methods that will help students pass these high stakes tests (Marx et al., 2004). This continued search for innovative and effective instructional techniques does not always translate into everyday classroom practices. There is often disconnect between theory and practice. While the NRC (2005, 2012) encourages learning science through investigation and inquiry, Weiss, Banilower, McMahon and Smith (2001) found the most common instructional activities in science classrooms were lecture and discussion. Because of this finding, more research needs to be done on science curricula to find research-driven methods that will meet the educational needs of students, improve learner outcomes, and decrease learning gaps.

The first part of this chapter will discuss the need for research in science education. The second part of the chapter will provide an understanding of project-based science (PBS). The
final part of the chapter will review studies conducted with urban populations comparing project-based science to textbook/lecture science (TLS).

Need for Research

According to the Glenn Reports (National Commission on Science and Mathematics Teaching for the 21st Century, 2000), U. S. students’ performance in science and mathematics is unacceptable and the United States is losing ground when compared to other nations. Additionally, the Program for International Student Assessment (PISA, 2012) shows a gender gap among 15 year old students. Out of 44 countries tested in science, only eight countries showed girls scoring higher than males on science problem solving skills. There is also a large gap among races in eighth grade science scores. A gap of 41 points exists between white and black students in Illinois (NAEP, 2011). White students score an average of 161 out of 300 possible points, whereas black students scored 120 points. However, the disparities in achievement scores are not set in stone, and according to Trends in International Mathematics and Science Study (TIMSS, 2011) researchers, the key to increasing math and science scores is to improve curriculum and instructional methods. It follows that educational reform needs to be based on research that produces persuasive evidence of great improvement in student achievement (Lynch et al., 2005).

The AAAS research from 2000 found that U.S. students’ performances lagged behind other countries in math and science, and the quality of the science textbooks and curriculum was sorely lacking. At the same time, science instruction in the U.S. was heavily dependent on textbooks. Fifty four percent of eighth grade science teachers reported that they rely primarily
on science texts (National Center for educational statistics, 2003). The statistics above warrant exploration of an alternative teaching method.

**Project-Based Science – Possible Solution**

When examining educational reform research, studies (e.g., Geier et al., 2008; Schneider et al., 2002) has found that on standardized tests students who are taught science through PBS outperform students taught by traditional TLS instruction. Research done by Wenglinsky (2000) found practices most closely associated with high achievement were hands-on learning activities with higher order thinking skills. However, other studies showed little evidence to suggest better learning outcomes for students using PBS over TLS (Colliver, 2000; Marx et al., 2004; Pine et al. 2006). Because of inconsistencies in the literature, more research is warranted.

Continued research is required to identify the effects of PBS instruction compared to traditional TLS instruction on learning outcomes of middle school science students. With further research, better science instructional methods may be found to close the gap among gender and ethnic groups.

**Understanding Project-Based Science**

Inquiry is an essential part of PBS. The National Research Council (2005) defines science inquiry as a

multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigation, reviewing what is already known in light of experimental evidence; using tools to gather, analyze and interpret data; proposing answers, explanations, and predictions; and communicating the results. (p. 23)
Project-based science is an approach to teaching and learning rooted in inquiry (Blumenfeld et al., 1991; Krajcik, Cxernaik, & Berger, 2003). Doing inquiry by designing investigations can help students learn how to approach and solve problems in both science and in everyday life (Fortus et al., 2006).

There are clear components of the PBS model. These components include the ability to engage students in investigating a real-life question or problem that drives activities and organizes concepts and principles (Krajeck, Blumenfeld, Marx, & Soloway, 1994). Another component results in students developing a series of artifacts or products that address the question or problem. A further component enables students to engage in investigation. There is a community component that involves students, teachers, and members of society in a community of inquiry as they collaborate about the problem. The final component of PBS is to promote students’ use of cognitive tools. All of these components help students construct an understanding of important science concepts as they inquire into real life problems (Schneider, Krajcik, Marx, & Soloway, 2002).

Conceptual Framework

John Dewey has shaped modern constructivist instruction. Dewey believed that a) the curriculum should spring from the genuine experiences of children, b) authentic problems should be identified within these experiences to serve as stimuli for thought, c) students should be allowed the freedom to gather the information necessary to deal with these problems, d) students should accept responsibility to develop solutions in an orderly way, e) and students should be given opportunities to test these ideas through application to make their meaning clear and test their validity (as cited in Joseph et al., 2000). Dewey’s philosophy has led to the three basic themes in today’s constructivist theory: centrality of the learner, integration of
subjects, and engagement of the learner. In a constructivist classroom, the learner must work to construct new knowledge. The students in a constructivist classroom must look at what they already know and then apply that knowledge to learn new concepts. Bruner (1996) suggests that learning is an active process in which the learner is the transformer of existing ideas and concepts. Students are not passive consumers but are capable of producing their own knowledge (Joseph et al., 2000). In PBS the students gather information about a topic they are interested in and then construct an artifact. Artifacts should address the driving question and show what students have learned (Krajcik, Czerniak, & Berger, 2003). The artifact must be personally meaningful and learner centered. For example, when doing a unit on disease, students in a PBS classroom may choose any disease that is of interest to them and construct a pamphlet about the disease. They construct knowledge about the disease by using the internet to gain information. The students then share their information with others as they present their pamphlets to the class. This first theme introduced in the constructivist theory is having students as the central part of learning and constructing knowledge. PBS students must construct knowledge by gathering information from multiple sources such as their books, internet websites, and community members. Reading comprehension is necessary for them to construct their knowledge and to produce an artifact to share with other members of the class. The integration of numerous subjects such as math, writing, and geography is also vital to PBS.

The next component of a constructivist classroom is the complexity of integrating the information and subject matter. Kilpatrick (1936) was a firm believer that projects are interdisciplinary and contribute a rich array of concepts and ideas. He felt that projects and inquiry provided excellent cognitive development for the learner (Kilpatrick, 1936). Not only does the creation of artifacts integrate information and subject matter, but inquiry also plays an
important role in the constructivist classroom and follows the second theme of complexity in the
cognitive development of the learner. Science classrooms should be rich with inquiry. Students
need to ask questions, form an hypothesis, design an experiment, perform and gather data on
their inquiry, analyze their data, and share this information with others, (NRC 1996; NGSS
2013).

Project-based science allows students to do science inquiry to construct knowledge. During a disease unit, students in a PBS classroom may use inquiry to set up an experiment to see where they would find bacteria in the school. Each cooperative group of three to four students design an experiment that will help them gain information about bacteria. One group of students may want to see if hand sanitizer is better than soap and water to kill bacteria. They will touch one agar plate with unwashed hands, one agar plate after washing with soap and the water, and one agar plate after washing with hand sanitizer. They will then record the amount of bacteria that grows on the agar plate. Students are using experimentation to construct knowledge and gain information about the world around them. The students will make a formal presentation of their research and share their experiment with the class. Students will use public speaking skills and writing skills to share their knowledge. They also use math and graphing skills while presenting their data.

The final component for a constructivist classroom is the engagement of students. Vygotsky (1979) theorized that learning occurs through social interactions, paralleling Dewey (1916) who contended that children must work together to make sense of the world around them. Marzano (2001) states that cooperative learning is one of the top nine strategies teachers can use to increase learning. Concepts develop and understanding happens when individuals enter into meaningful discussion with peers and teachers (Joseph et al., 2000).
When students participate in PBS, they are engaged in the learning process at the beginning of the unit. The students and teacher work together to develop a driving question. Students collaborate with other students when doing inquiry activities related to the driving question. They work together sharing ideas and concepts while completing their artifact. The teacher is a facilitator by helping student with resources that will enable them to construct knowledge. In a PBS classroom during a disease unit students come up with a driving question such as “How can my friends make me sick?” Inquiry activities are set up so students can gain information on bacteria and viruses. Students collaborate while setting up an experiment to test their hypothesis (Krajcik, et al., 2003)

Components of Project-Based Instruction

Inquiry is an essential part of PBS. According to the National Research Council (2005, 2012), science inquiry is a “multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigation, reviewing what is already known in light of experimental evidence; using tools to gather, analyze and interpret data; proposing answers, explanations, and predictions; and communicating the results” (p. 23). The NGSS (2013) require students to use eight science practices that are parts of science inquiry. Project-based science is an approach to teaching and learning that is rooted in inquiry and can meet the requirement (Blumenfeld et al., 1991: Krajcik et al., 2003).

Project-based science education requires active engagement of students’ effort over an extended period of time. This method of teaching is well received by the NRC (2005, 2012) and the NGSS (2013) and the call for fewer science concepts being presented in more depth.
Project-based instruction allows each student to work at his or her own pace while producing an artifact and answering a driving question. Finally, PBS promotes links among subject matter and disciplines as students work together using writing and communication skills to achieve their final project (Blumenfeld et al., 1991).

Technology also plays an important role in PBS instruction. In recent years, PBS instruction has been supported by computer technologies and contributed to fostering student-directed inquiry in real world settings (Barak & Dori, 2005). When constructing learning, students need to be equipped with hypermedia tools to explore knowledge and design artifacts within a learning community (Chen & McGrath, 2003). Appropriate experiences and opportunities to support their knowledge development and technological competencies are vital (Chanlin, 2008). Marx’s (2004) study showed that the lack of technology in a school can hinder the progress of students while participating in a project-based curriculum. Urban schools similar to the school in which this research will take place have similar limitations to technology.

Success of PBS in Urban Middle School Populations

Several studies based on science reform have been conducted by the University of Michigan in the Detroit, Michigan, school system (Geier et al., 2008; Marx et al., 2004; Rivet & Krajcik, 2004, 2008). The Detroit Public School system has a population of approximately 91 percent black, 5 percent Latino and 4 percent diverse ethnic mix. Over 69 percent of the students are eligible for federal free or reduced-priced lunch.
One of the studies conducted in the Detroit school reform was done by Rivet and Krajcik (2004). This was a longitudinal quantitative study using PBS curriculum to examine whether sixth grade students would demonstrate higher student achievement on a pre/posttest as support for teachers and the revision of the curriculum that occurred over the four years. The driving question of the project-based lessons used for the study was “How do machines help us build big things?” The project-based curriculum was created at Michigan University with National Science Foundation (NSF) grant money as part of a reform partnership with Michigan University and Detroit Public Schools.

Over the four years, approximately 2,500 students participated in this study. In this study, the number of students and teachers participating in the PBS curriculum was increased by 40 percent between the first year and second year and continued to increase during the third and fourth years to expand the breadth and scope of the study. This four-year study of sixth grade students showed significant overall improvement on the pre/post-test measure over the four years. A matched two-tailed t-test analysis was conducted to compare pre and posttest results after each year of the project enactment. Even as the study population increased and less support was being given to the new teachers in the study, significant gains were achieved consistently for all science goals. The goals or learning objectives for the students were to understand balanced and unbalanced forces, simple and complex machines, mechanical processes and inquiry processes. The greatest gains were seen in the understanding of mechanical advantages and the understanding of simple machines. The understanding of balance forces and inquiry skills showed the weakest gains.

Marx’s (2004) findings by were similar to Rivet and Krajack’s (2004). Marx found that as students and teachers were added to the study, the students consistently showed significant
gain in science pre and posttest. In this study, over 8,000 students participated from 14 different middle schools in the Detroit School System. Three years of data were collected. Project-based lessons were included for each of the three grades (sixth, seventh, and eighth). Pre and posttest were given on each of the project-based units for each grade. The test was multiple choice with some free response questions that were scored with a rubric. There was a rating on questions for low, medium, or high cognitive scores. For the multiple choice low content (recall) scores, students’ scores improved from a mean score of 62 percent to 83 percent over the course of three years and 64 percent to 77 percent on the medium content (applying). On the high cognitive (analyzing) items, the students’ posttest scores went from 68 percent in 1999 to 82 percent in 2001. A within subject t-test was used as the statistical analysis.

There were limitations to Marx’s (2004) study as well as Rivet and Krajcik’s (2004) research. Neither study had a random selection of schools or teachers. The principals chose the teachers. This sample was not random and the principal chose veteran teachers with PBS experience. This may have skewed the results. The schools were selected based on computer infrastructure so students would have access to technology. Not having a strong technology base could have been a limitation to students in the comparison group. However, it was reported in the findings that despite attention to maintenance of computer and network technologies, difficulties still persisted (Marx, 2004). Despite some limitations, the study remains important because it shows success under very real circumstances in urban schools.

In a similar study of the Detroit Public School System by Geier et al, (2008), junior high students participated in two seventh grade and/or one eighth grade project-based science curriculum unit. There were 37 teachers in 18 schools who participated in the study. The sample schools were selected based on adequate technology, supportive administration, and
equity among schools. The principals chose the teachers who would participate in the study. New schools, teachers, and students were added each year during the three year study. Students receiving the PBS curriculum were compared to students who did not receive the PBS curriculum. Students were compared based on the Michigan Educational Assessment Program (MEAP) the students take during January of their eighth grade year. The sample size for the first cohort group was 760 students compared to the other students in the Detroit Public Schools (DPS) that had a total of 8,900 students. After more students received PBS instruction, the second cohort grew to 1,043, and the DPS comparison had 8,662 students. In Cohort I, students who completed at least one PBS curriculum outperformed their DPS peers on overall MEAP, with a nineteen percent increase. Higher scores were received on all science content areas: earth, physical, and life science. Cohort II saw similar results, with a fourteen percent increase in the MEAP overall score. Girls outperformed boys by 17 points in 2000, but only 11 points in 2001. However after one PBS unit, there was an apparent reduction in gender differences. In Cohort II the gender gap had been narrowed, and the boys and girls showed no statistical difference in performance after participating in the PBS curriculum. This is a very positive finding because standard-based instruction that includes pervasive technology and project-based units appeared to engage at-risk urban male learners, narrowing and closing the gender gap in achievement with their female peers (Geier et al., 2008).

Rivet and Krajcik (2008) looked closely at students’ use of contextualizing – that is using students’ prior knowledge as a catalyst for understanding science concepts during a PBS unit. The study focused on two eighth grade classrooms with approximately 30 students per each class. Again this study showed convincing evidence that PBS instruction related to a gain in test scores between the pretest and posttest assessment. The pre and posttest assessments
were similar to Marx’s (2004) study because they had questions broken into force, velocity and impulse questions. Rivet and Krajcik wanted to see if contextualizing would increase test scores. The greatest increase in pre and posttest scores were found on the questions about force. Students in the two eighth grade classes were compared to other students in the Detroit Public Schools who were receiving the same PBS curriculum. The effect size for questions on force was .87 for the Detroit Public Schools and 1.48 and 1.20 for the two classes in this study. Cohen (1988) reported that an effect size above .88 was considered statistically high.

Not only a pre and posttest but also an assessment score was given for the artifact students made at the end of the unit on force and motion. Students made a helmet for their eggs and placed the egg in a cart to see if the egg was resistant to breaking when put under impact. The assessment was to answer four questions about their understanding of velocity and acceleration. The questions were scored 1 (low) to 3 (high). Some students showed great improvement between the pre and posttest multiple choice testing but may not have scored high on their egg assessment. The opposite results were true for the students in the two eighth grade classes. One eighth grader in the study showed a gain score of 13 out of 18 for his posttest score and then only 5 out of 12 for his artifact score. He did not show an understanding of force and velocity and had misconceptions that friction is the immediate force that stops an object. The pre/posttest was an individual assessment and the egg and helmet artifact was a group assessment, which may have accounted for the discrepancies among the scores. The artifact may not have been the reflection of each students’ understanding but the understanding of a dominant member of the group. However, Rivet and Krajcik (2008) agreed “both assessments were valuable and necessary to ascertain the extent and depth of students’ science learning (p. 94).
An intensive study took place in a large Maryland school district located in the Washington, DC metropolitan area. The school population was rapidly becoming more diverse, and science and math scores on state assessment test were slowly declining. Lynch, Kuipers, Pyke and Szcese (2005), from George Washington University, conducted a study to examine whether a science curriculum (receiving a high rating from Project 2061) could improve students’ outcomes in a diverse population with no ethnic majority. The ten most diverse middle schools in the district were identified for the study based on similar demographics. Five of the schools had eighth grade students receiving the highly rated project-based curriculum Chemistry That Applies (CTA). In the other five schools, eighth grade students were taught from a variety of approved chemistry textbook curricula. Pretests, posttests and delayed posttest were given to all students in the treatment groups and the comparison group. Both teachers in the CTA and comparison groups were asked to teach the same standards during the same quarter time period. The delayed posttest was given four months after the posttest.

Students in the treatment group scored significantly higher, with CTA students improving their mean score by 20 points on the posttest and the comparison group improving their mean score on the posttest by 11 points. However, ethnic gaps did not shrink among the CTA group form pretest to posttest, but even though the gaps did not shrink as hoped, the gaps also did not become wider except in the comparison group.

Importance of Urban Studies

The Detroit and Maryland studies are important because they examined results from a large number of participants conducted over an extended period of time using project-based science instruction with diverse urban populations. In addition, these studies are significant
because they looked at learner outcomes and achievement measured by standardized assessment tests with a multiple choice format, which is the way most students are tested by state assessments. While these results are significant, other teaching methods, curriculum, and assessments may also show similar findings.

Although the findings in the Michigan and Maryland studies showed significant improvement in students’ science knowledge when PBS curricula were used, it is hard to compare the results to the type of science instruction students were receiving in the remainder of the Michigan and Maryland schools. There is a lack of credible research on effective science curricula for diverse student populations (Lee & Luykx, 2004); therefore, more studies need to be conducted to give credibility to PBS, learner outcomes, and diverse populations. (Pine et al., 2006).

Lack of Control in the Control Groups

One of the main problems with PBS research is the lack of control in the control group. Schneider, Krajcik, Marx and Soloway (2002) conducted a study on high school students using a PBS unit called Foundations of Science (FOS) to determine whether students participating in PBS curricula would perform as well on national achievement test items as students in general. Schneider et al.’s findings revealed a significant difference, with p<.001 between students in the PBS test group and the national sample group on a vast majority of test items. PBS students tested in the 70th percentile of the national sample. However, in the discussion the researchers noted that those students in the national sample may have completed only two years of science. The PBS sample group had at least three years of science. The researchers also said they had no way of knowing how many in the national sample may have had PBS instruction. Other
research done by Rivet and Krajcik (2004, 2008) and Marx (2004) compared students in the Detroit, Michigan, schools to select groups of students in the same school system, but little was known about the type of science curricula the control group of students received. Students do better on tests when they have covered the content regardless of the instructional method used (Walker & Schaffarzick, 1972). Therefore, to add credibility, it is important to know what science and instructional methods are being taught to the control groups.

Science Inquiry versus Textbook Program

Two studies compared hands-on science inquiry versus textbook-based science curricula (Davis, Raymond, Rowls, & Jordan, 1976; Pine et al., 2006). Since PBS is hands on as well as inquiry based, it is important to review these two studies. Pine et al. (2006) found no curricular effect between fifth grade students taught science through textbook methods compared to fifth grade students taught with the Full Option Science System (FOSS). In a similar study students in the first through sixth grades using the Science – A Process Approach (SAPA) were compared to students receiving standard textbook science instruction. Based on the results obtained in this study, students in SAPA did not differ in achievement scores obtained on the SRA achievement test in science, reading, and math (Davis, Raymond, Rawls & Jordan, 1976). Neither study showed that hands-on inquiry-based curricula increased students’ ability to perform inquiry-based activities or perform higher on standardized test. However, the studies also revealed that students were not at a disadvantage being taught science through inquiry instruction. The discrepancy in the research seems to suggest the need for additional research regarding inquiry-based teaching and learning (Pine et al.).
With an increasing emphasis on standardized testing, the trend is to move in the direction of traditional, teacher-directed instruction (Thomas, 2000). However, this form of instruction goes against many of the Next Generation Science Standards that state learning science is an active process involving science practices. There is a need for more research documenting evidence of the effectiveness of PBS in comparison to other methods of instruction (Thomas). It is vital to our schools to find the best methods that will teach students science not only for standardized tests but to prepare them to be scientifically literate members of society as well as critical thinkers. Continued research and science reform will allow science educators to find the best methods of instruction to prepare students not only to pass standardized tests but to have problem solving skills and compete in the modern job market (Barron & Darling-Hammond, 2008)
CHAPTER 3

METHODOLOGY

This study compared two methods of teaching science to middle school students in a middle school setting. The aim of this study was to see if one method of teaching project-based science (PBS) increases content learning over textbook/lecture science (TLS). The school where the research was conducted has not met AYP (adequate yearly progress) the past 5 years due to the black subgroup’s low scores in reading, math, and science (Illinois school report card, 2011). Males scored lower on science ISAT tests in this district than females which is a discrepancy from national norms (NAEP, 2011). Therefore, this study will place emphasis on gender and the black subgroups. This chapter will provide an overview of the research purpose, rationale for the research design, and methods and procedures used to collect and analyze the data.

Research Questions

The following questions guided this study:

1. Are there differences in 7th grade student performance between those who experience project-based science or textbook/lecture science between a content test?

2. Are there differences in black student performance between those who experience project-based science or textbook/lecture science on a content test?
3. Are there differences in male and female student performance between those who experience project-based science or textbook/lecture science on a content test?

Hypothesis

All students receiving the project-based science curriculum will outperform students receiving the textbook/lecture curriculum on a multiple choice science content test.

Null Hypothesis

There is no statistical difference in students’ performances on a content test between those who experienced project-based science and those who experienced textbook/lecture science.

Research Design

Various research designs have focused on students’ needs for academic success. Qualitative method designs have focused on student motivation when being taught by PBS (Blumenfeld et al., 1991; Pintrich, 2000). Mixed method designs have been used to study student achievement and attitude toward PBS (Baker & White, 2003; Lynch, Kuipers, Pyke & Szeeze, 2005). This study used a quantitative methodology to compare the two methods of teaching to see if students would perform better on content knowledge test. Lynch et al.’s research study of over 1500 eighth grade students found that students were more motivated when doing PBS. This motivation was seen across demographic groups. This study employed a repeated measure ANOVA to compare the mean scores on a multiple choice test of groups
taught using PBS and TLS. Because this study was done at a middle school, intact groups of subjects were used. The groups were randomly assigned to the two methods of teaching. Therefore, this study used a quantitative quasi-experimental design.

Sample

Demographics of the School

This study was conducted in the fall of 2011 in a school in Northwest Illinois. The district consists of two middle schools grades fifth through eighth; however, this study will focus on seventh grade students in only one of the middle schools. According to the Illinois School Report Card (ISBE, 2011), the school’s population consisted of 22% black, 63% white, 9% multiracial and 6% other. About 12% have an individual learning plan (IEP). Over 56% of the students qualify for free and reduced lunch. The middle school is divided into two teams of seventh grade students. There are approximately 90 students on each team. Both seventh grade teams participated in this research. This school was chosen because the researcher is a teacher in the district and knows the students and teachers in the school. However, the researcher did not have her students from her own middle school participate in this study to avoid bias.

Student Participants

Both male and female students from the ages of 11 and 15 were the sample for this study. A total of 172 students participated in this study. Of these 172 students 91 were white, 42 were black and 39 were other (multiracial and Hispanic). The students self-select to be in advanced or regular science. Once students have selected advanced or regular science the computer randomly
selects the team and schedules to accommodate each student. There are two seventh grade teams in this middle school. A team is a group of teachers who have the same students every day. The researcher has taught in this district for twelve years and has found the teams to have similar demographics reflecting the school’s population.

Teacher Participants

The two teachers who participated in the study had over eight years of teaching experience. Teacher A has been teaching seventh grade life science at the school where the research took place for eight years. Teacher A has a BS in Elementary Education and a MS in Elementary Education Science. Teacher B was a veterinarian before becoming a teacher. She has her BS in Health Science and a MS in Secondary Education. Teacher B had taught at another school before teaching four years as a seventh grade life science teacher at the school where the research took place. Both teachers are competent in teaching PBS as well as TLS. These two teachers were also chosen for this study because they possess the qualities that Tal, Krajcik, and Blumenfeld (2006) found important to teachers in urban schools to ensure students’ success in science. These three researchers found that the teachers needed to cover content, stay on task, have content knowledge, use technology, let students collaborate, and respect their students. Their competency can be attested to by their ability to use research and technology, understand content knowledge, and have a positive rapport with students. The researcher serves as an instructional leader and was a mentor to these teachers. The researcher noted these qualities while observing in their classrooms. The teachers in this study possess these qualities and will be referred to as Teacher A and Teacher B.
Consent/Assent

According to the approval of the Institutional Review Board Code of Federal regulations section 46.101b, paragraph 1, the subjects participating in this study are exempt from consent and assent forms (see appendix A). However, teachers participating in the study signed a letter of consent before giving the pretest to the students (see appendix B). Letters informing parents of the study were sent home prior to the pretest (see Appendix C).

Assessment Tool

Three multiple choice tests were given over the month-long study. The pretest/posttest/delayed test consisted of 25 multiple choice questions with 22 content questions from the textbook and three Illinois State Assessment Test (ISAT) questions. Test questions were rearranged as well as the choices for the answers. See appendix D to see all three tests. The grading scale for the test was 90 percent A, 80 percent B, 70 percent C, and 60 percent D.

In order to test for reliability, one class of 28 seventh grade students not participating in the pretest/posttest/delayed test design took the pretest on one day and then the same test on the second day. A Pearson correlation was used to check the reliability of the test with r .84. In order to check the face and content validity of the test, the researcher had a list of objectives for the unit on disease. The two seventh-grade teachers looked over the test items separately and circled the questions that they thought best met the objectives for the unit. The two teachers then met together to see which questions they had both selected. If both teachers had selected the same question and it met an objective it was placed on the test. The test questions came from a
question bank put out by the textbook company. This was the same text book that was used for the students taught with the TLS curriculum.

Below is an overview of both TLS curriculum and PBS curriculum. Both curriculum began with a multiple choice pretest and ended with a posttest see appendix D. Both curriculum lasted ten days. After the ten day unit students were given a delayed posttest ten days after the posttest.

TLS Curriculum

Lesson one for the TLS students began by having the students take the pretest. After the pretest students made a list of the various diseases they could think of and put the list on the board. During lesson two students watched a power point made by the textbook company and did a directed reading worksheet that went with the power point on disease. Lesson three students did a lab in the textbook called “Pass the Cold”. This was a similar activity that the PBS group did but students did not have to figure out who first had the disease. Lesson four students watched a power point on “Bacteria’s Role in the World” and filled out a directed reading worksheet that went with the power point. Students then looked at bacteria under a microscope. Lesson five students read about viruses and did a directed reading worksheet by themselves. Lesson six students did a lab showing how an apple peel keeps germs out of an apple similar to our skin. Students then watched a power point on “Your Body’s Defense”. For lesson eight students used their book to help draw the two ways the body can fight disease. On day nine the students watched Bill Nye on disease and wrote down ten facts they learned about disease. The last day of the unit students took the posttest and shared their drawings about how the immune system functions.
PBS Curriculum

With PBS curriculum students begin with a driving question. In this curriculum used by Teachers A and B the driving question for the unit on disease is “How can my friends make me sick?”. The first lesson had students come up with questions they had about disease. The questions were grouped and put on a board in the room. The students also brainstormed many diseases and made a list on the board. During lesson two, students were divided in three groups. Each group was given twenty cards with the name of a disease and short definitions of the disease. Students had to group the diseases by what they had in common and justify to the class why the disease were put in to various groups. Lesson three consisted of a simulation on how disease is spread. Students are given container and a pipet to exchange the fluid in the cup. They are ask to share fluid with three other members. After all students have completed the task they see if they were infected. Students then tried to determine who had the germ that was being passed. Lesson four has students think about where in the school they may find germs that could cause disease. Students design an experiment to inquire where they may find germs in the school. Lesson five allows students to carry out their experiment and gather data. Germs are collected on agar plates and allowed to grow for several days. Lesson six students look for answers to their driving question board by watching a power point presentation on “Your Body’s Defense”. Students will compare and contrast the two paths that the immune system use to destroy germs. During lesson seven students will act out the two paths that our immune system may use to help keep us from getting ill. Lesson eight and nine students will make their artifact and chose a disease that is of interest to them. Once they have chosen a disease, they do research and make a power point of brochure about the disease. Students will be given a rubric to help
them design the artifact. On day ten some students will share their artifact. Data from the petri dishes will be analyzed to see what areas of the school contains the most germs. The students will then take the posttest.

Quasi-Experimental Process

Research was carried out over a month-long period. All participants in Teacher A’s classes and Teacher B’s classes took the pretest. Teacher A taught two of her classes using the PBS curriculum and two of her classes using the TLS curriculum. Teacher B taught three of her classes using PBS and two of her classes using TLS. Teacher A only had one advanced science class; she flipped a coin and her advanced class received PBS. Then the teachers flipped a coin to see which regular science class would receive which method of teaching. The process was not completely random due to the fact that in order to avoid teacher bias, each teacher needed to teach PBS and TLS to the same number of classes and to approximately the same number of students. Teacher A had four classes of 84 students and Teacher B had 5 classes of 88 students. Therefore, the number of students taught were similar. Even though the chart below shows that one more class was taught using PBS the number of students taught with each method were very similar.

Once the teachers, classes, and methods had been assigned, a ten-lesson unit on disease was taught to the classes for approximately 10 days. Table 1 shows which teacher taught PBS and which teacher taught TLS.
Table 1
Teachers Classes and Methods

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<td>Teacher B</td>
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Some of the lessons that the students participated in with the TLS unit were a PowerPoint presentation, worksheets, and audio CDs all designed by the textbook company (see appendix E). Lessons taught using PBS included conducting an experiment about bacteria, acting out how the immune system works, and designing a pamphlet on disease (see appendix F). After the students completed 10 days of the disease unit a posttest was given to all participants.

If participants missed more than three days while the unit was taught, they were excluded from the research. If students were absent the days of testing they were allowed to test at another time. At the end of the 10-day unit, participants took a posttest. Once the posttest was completed, students took the delayed posttest 10 days later. A total of 161 of the 172 students who participated in the study met the above criteria.

Teachers A and B kept all test scores for all participants on Skyward, the school grading program. Attendance was checked to see if any participant missed more than three days of the unit. If more than three days of instruction was missed, the scores were not included in the study.

Teacher A and Teacher B also were asked to keep a daily log of information that may have caused a change in their daily instruction. However, little information was useful from the logs that were turned in from the two participating teachers.
Data Analysis: Descriptive Statistics & Inferential Statistics

Data were analyzed quantitatively. Mean and standard deviations were calculated using SAS software. A repeated analysis of variance (ANOVA) was used in SAS software to analyze the difference between the various groups’ scores. An alpha level of .05 (Mertens, 2005) was utilized to determine significance for all statistical analyses.

Limitations

To control for teacher bias the researcher did not use her students in the research study. Also, both Teacher A and Teacher B taught both PBS and TLS. Both teachers also taught advanced and regular science classes with both methods of teaching. Teacher A had only one advanced class and Teacher B had two advanced classes, which was a limitation in the study.

Another limitation to this study may have been the length of the unit on disease. Ten days may not have been long enough to allow for the students understanding of the content. NGSS (2013) requires more time spent so students understand the content and concepts.

The final limitation was the use of a pre/post/delayed test design. The questions were scrambled to avoid students becoming test wise. However, one of the subgroups for PBS performed higher on the posttest, which may have been because they remembered the questions from the previous tests. The PBS group also had one more advanced class than the TLS group which could have caused an academic difference in the groups.

Conclusion

In this study 172 students and two teachers from a school in Northwest Illinois were asked to participate in this study. A quasi-experimental quantitative study was used to compare
PBS and TLS instruction. The students were given three similar multiple choice tests based on content and skills. Data were collected and analyzed using SAS. An ANOVA was used to determine if differences occurred between the two methods of teaching in the various groups. This quantitative data analysis resulted in information which will inform educators as well as administrators on instructional methods that may lead to better methods of teaching science. Thoughtful analysis of the research may lead to further studies on best methods for teaching science to schools with similar populations.
CHAPTER 4
RESULTS OF DATA ANALYSIS

Introduction

This chapter reports the results of the study of 172 seventh grade students in an urban setting who were taught a unit on disease. One group was taught using textbook/lecture science and the other group was taught using project-based learning. The aim of the study was to see if one method of teaching increased content learning and retention of the knowledge. The research questions are reviewed and answered.

Data Analysis by Research Question

Descriptive statistics, a repeated analysis of variance (ANOVA), was used in SAS software to analyze the data. An alpha level of .05 was utilized to determine significance for all statistical analyses (Mertens, 2005)

Research Question 1
Are there differences in seventh grade student performance on those who experience project-based science (PBS) or textbook/lecture science (TLS) on a content test?

Table 1 summarizes the average scores of all students on a pre, post, and delayed multiple choice test that the students took in conjunction with a unit taught on disease. The possible range of scores was 1 to 25 points. Information in Table 1 shows the scores of students who were taught
using TLS compared to the students taught using PBS. The mean and standard deviations have been rounded to the second digit.

Table 2

Overall Student Mean Scores on a Multiple Choice Test

<table>
<thead>
<tr>
<th>Method of Instruction</th>
<th>Tests</th>
<th>Standard Deviation</th>
<th>Mean</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbook/Lecture</td>
<td>PRE</td>
<td>3.58</td>
<td>9.92</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>POST</td>
<td>4.73</td>
<td>14.91</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>Delayed Post</td>
<td>4.94</td>
<td>13.42</td>
<td>79</td>
</tr>
<tr>
<td>Project-based</td>
<td>PRE</td>
<td>4.02</td>
<td>12.20</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>POST</td>
<td>3.83</td>
<td>16.61</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>Delayed Post</td>
<td>4.24</td>
<td>15.90</td>
<td>82</td>
</tr>
</tbody>
</table>

The mean scores for the multiple choice test on disease are lower for the pre, post, and delayed posttests for students being taught using TLS. The mean scores for the PBS were higher in the pre, post and delayed posttests. The mean score for the pretest shows that the TLS group had a lower mean score than the PBS group.

Table 3 shows the mean score of the pre, post and delayed posttests for students in TLS and PBS. The data were analyzed using the greater linear model (GLM) procedure (a tool used to test for analysis of variance by testing least square regression to fit a linear model) in SAS software.
Table 3

Mean Scores for Pre, Post, and Delayed Tests for Both TLS and PBS

| Method of Instruction | Mean   | Std. Error | DF   | t Value | Pr > |t|
|-----------------------|--------|------------|------|---------|------|
| TLS                   | 12.4207| 0.3768     | 164  | 32.96   | <.0001|
| PBS                   | 14.3742| 0.4105     | 164  | 35.01   | <.0001|

Table 3 shows the combined mean score for all three tests per teaching methods. A statistically significant difference from zero was found between the two teaching methods. The PBS group had the highest combined mean score. However the PBS group had higher pretest scores. Table 4 shows a more accurate comparison by looking at the differences in the scores.

Table 4 summaries the difference in scores between the pre and posttests and between the post and delayed posttests for all students. The data compare the TLS and PBS groups. Table 4 represents the difference of pretest to posttest scores for all students in the study. The p value was .3340 > .05, so there was not a significant difference in the students’ scores between TLS and PBS. There was more of a difference in the post to delayed posttest scores; however, the p value of .7096 was not significant with p > .05.

Table 4

Difference of All Students’ Scores Comparing TLS to PBS

<table>
<thead>
<tr>
<th></th>
<th>TLS Differences in scores</th>
<th>PBS Differences in scores</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>DF</th>
<th>t Value</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All students pre to post TLS compared to PBS</td>
<td>4.99</td>
<td>4.41</td>
<td>0.7349</td>
<td>0.7583</td>
<td>164</td>
<td>0.97</td>
<td>0.3340</td>
</tr>
<tr>
<td>All Students post to delayed TLS compared to PBS</td>
<td>1.49</td>
<td>0.71</td>
<td>-0.2797</td>
<td>0.7497</td>
<td>153</td>
<td>-0.37</td>
<td>0.7096</td>
</tr>
</tbody>
</table>
Research Question 2
Are there differences in black student’s performance between those who experience project-based science or textbook/lecture science on a content test?

Table 5 shows the pre, post, and delayed posttest of students broken down according to race. Students who are racially mixed are not included in the black population and are listed under “other.” The mean and standard deviations have been rounded to the second digit.

Table 6 shows a graph of the mean scores for pre, post, and posttest comparing the various races. It is interesting to note that the white population had better retention when taught using PBS, and the black population had better retention when using TLS.

The mean scores for pre, post and delayed posttest were higher for all three tests in PBS as opposed to TLS. When averaging all three tests together, the mean score for TLS was 11.39, but for PBS, the mean score for all three tests was 13.14. The black population showed a higher mean score for all three tests being taught using PBS.

Table 7 shows the differences in mean scores between the TLS and PBS. The top rows show the difference in mean scores from pre to posttest and the second row show the differences in mean scores from post to delayed posttest for both TLS and PBS.
Table 5

Racial Difference in Mean Scores on a Multiple Choice Test

<table>
<thead>
<tr>
<th>Instructional Method</th>
<th>RACE</th>
<th>Tests</th>
<th>Standard Deviation</th>
<th>Mean</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbook/Lecture</td>
<td>Black</td>
<td>PRE</td>
<td>2.21</td>
<td>8.66</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>POST</td>
<td>4.50</td>
<td>12.80</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DPOST</td>
<td>3.64</td>
<td>12.75</td>
<td>16</td>
</tr>
<tr>
<td>Other</td>
<td>PRE</td>
<td>3.91</td>
<td></td>
<td>10.04</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>POST</td>
<td>5.11</td>
<td></td>
<td>14.84</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>DPOST</td>
<td>4.97</td>
<td></td>
<td>12.57</td>
<td>23</td>
</tr>
<tr>
<td>White</td>
<td>PRE</td>
<td>3.81</td>
<td></td>
<td>10.45</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>POST</td>
<td>4.37</td>
<td></td>
<td>15.95</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>DPOST</td>
<td>5.35</td>
<td></td>
<td>14.18</td>
<td>40</td>
</tr>
<tr>
<td>Project-based</td>
<td>Black</td>
<td>PRE</td>
<td>3.66</td>
<td>10.50</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>POST</td>
<td>3.67</td>
<td>16.05</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DPOST</td>
<td>4.27</td>
<td>13.32</td>
<td>22</td>
</tr>
<tr>
<td>Other</td>
<td>PRE</td>
<td>4.55</td>
<td></td>
<td>12.29</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>POST</td>
<td>3.45</td>
<td></td>
<td>14.29</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>DPOST</td>
<td>3.80</td>
<td></td>
<td>15.38</td>
<td>13</td>
</tr>
<tr>
<td>White</td>
<td>PRE</td>
<td>3.86</td>
<td></td>
<td>12.94</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>POST</td>
<td>3.74</td>
<td></td>
<td>17.53</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>DPOST</td>
<td>3.79</td>
<td></td>
<td>17.26</td>
<td>47</td>
</tr>
</tbody>
</table>
Table 6

Pre Post and Delayed Mean Scores Comparing Various Groups and Teaching Methods

![Bar chart](chart.png)

Table 7

Differences in Black Students’ Scores Comparing TLS to PBS

<table>
<thead>
<tr>
<th></th>
<th>TLS difference in scores</th>
<th>PBS difference in scores</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>DF</th>
<th>tValue</th>
<th>pValue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black students pre to post TLS compared to PBS</td>
<td>4.14</td>
<td>5.55</td>
<td>-1.378</td>
<td>1.4030</td>
<td>164</td>
<td>-0.98</td>
<td>0.3274</td>
</tr>
<tr>
<td>Black students post to delayed TLS compared to PBS</td>
<td>.05</td>
<td>2.73</td>
<td>3.1170</td>
<td>1.4136</td>
<td>153</td>
<td>2.21</td>
<td>0.0289</td>
</tr>
</tbody>
</table>
When analyzing the data on the black students between the pretest and the posttest, the black students scored higher being taught by PBS. However, the improvement in the scores was not significant with p value at .3274. When comparing the difference in scores for post and delayed posttest, the p value was .03, which is < .05; therefore, a significant difference occurred between the two testing methods among black students, with the retention being greater using TLS.

**Research Question 3**
Are there differences in male and female student performance between those who experience project-based science or textbook/lecture science on a content test?

Table 8 show the gender comparison of the mean scores for both TLS and PBS. The mean and standard deviations have been rounded to the second digit.

**Table 8**

<table>
<thead>
<tr>
<th>Instructional Method</th>
<th>Gender</th>
<th>Variable</th>
<th>Std Dev</th>
<th>Mean</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbook/Lecture</td>
<td>Female</td>
<td>PRE</td>
<td>3.33</td>
<td>9.73</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>POST</td>
<td>3.92</td>
<td>14.27</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>DPOST</td>
<td>4.10</td>
<td>13.63</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>PRE</td>
<td>3.81</td>
<td>10.09</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>POST</td>
<td>5.34</td>
<td>15.48</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>DPOST</td>
<td>5.66</td>
<td>13.22</td>
<td>41</td>
</tr>
<tr>
<td>Project-based</td>
<td>Female</td>
<td>PRE</td>
<td>3.71</td>
<td>12.60</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>POST</td>
<td>3.21</td>
<td>17.38</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>DPOST</td>
<td>4.37</td>
<td>16.31</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>POST</td>
<td>4.34</td>
<td>11.75</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>POST</td>
<td>4.31</td>
<td>15.75</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Male</td>
<td>DPOST</td>
<td>4.07</td>
<td>15.41</td>
<td>37</td>
</tr>
</tbody>
</table>
Table 9

Graph of Gender Differences in Mean Scores on a Multiple Choice Test

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th></th>
<th>Male</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DPOST</td>
<td>POST</td>
<td>DPOST</td>
<td>POST</td>
</tr>
<tr>
<td>Mean score</td>
<td>13.63</td>
<td>14.27</td>
<td>15.41</td>
<td>15.75</td>
</tr>
<tr>
<td></td>
<td>12.6</td>
<td>13.22</td>
<td>15.41</td>
<td>15.48</td>
</tr>
<tr>
<td></td>
<td>9.73</td>
<td>11.75</td>
<td>10.9</td>
<td>11.75</td>
</tr>
</tbody>
</table>

Table 9 shows the mean scores of the males and females for TLS and PBS for their pre, post, and delayed posttest scores. Females’ mean scores on their unit tests were higher for the pre, post and delayed posttest than the males’ scores for the same tests and instructional method. However, the male mean test scores on pre and posttest were higher with the TLS instructional method over the females’ scores for the same tests. The delayed posttest mean scores for the females were better with the TLS instruction than the males’ scores.

Table 10 compares the differences in mean scores for males using TLS and PBS. The first row shows the differences for males mean scores from pre to posttest. The second row shows the differences of the mean scores for males post to delayed posttest.
Table 10

Differences in Male Scores Comparing TLS to PBS

<table>
<thead>
<tr>
<th></th>
<th>TLS difference in scores</th>
<th>PBS difference in scores</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>DF</th>
<th>tValue</th>
<th>pValue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male pre to post TLS</td>
<td>5.39</td>
<td>4.0</td>
<td>1.2727</td>
<td>1.0044</td>
<td>164</td>
<td>1.27</td>
<td>0.2069</td>
</tr>
<tr>
<td>compared to PBS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male post to delayed TLS</td>
<td>2.26</td>
<td>.34</td>
<td>-1.0992</td>
<td>1.0049</td>
<td>153</td>
<td>-1.09</td>
<td>0.2758</td>
</tr>
<tr>
<td>compared to PBS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Males taught using TLS improved their scores by 5.39 questions from pretest to posttest, whereas males taught by PBS only improved their scores by 4 questions. The p value of .2069 did not show a significant difference at the > .05 level for content knowledge gain.

When comparing retention of scores, males being taught with TLS showed less retention with a difference in their average test scores showing a lower test score of 2.26 questions, whereas PBS showed that students retained knowledge better with less than one question loss of knowledge. The p value was .2758, which did not show significance with p > .05.

Table 11 exhibits the differences in mean scores for females using TLS and PBS. The first row shows the differences in mean scores for females pre to posttest. The second row shows the differences of mean scores for females for post to delayed posttest.
Table 11
Difference in Female Scores Comparing TLS to PBS

<table>
<thead>
<tr>
<th></th>
<th>TLS difference in scores</th>
<th>PBS difference in scores</th>
<th>Estimate</th>
<th>Std Err</th>
<th>DF</th>
<th>tValue</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female difference in avg. score pre to post TLS compared to PBS</td>
<td>4.54</td>
<td>4.78</td>
<td>0.1970</td>
<td>1.0699</td>
<td>164</td>
<td>0.18</td>
<td>0.8541</td>
</tr>
<tr>
<td>Female difference in avg. score posttest to delayed posttest TLS compared to PBS</td>
<td>.69</td>
<td>1.07</td>
<td>0.5398</td>
<td>1.0389</td>
<td>153</td>
<td>0.52</td>
<td>0.6041</td>
</tr>
</tbody>
</table>

There was not enough difference in the pre to posttest scores of the female subgroup to show a statistical significance $p=.8541$. The difference of the females’ post to delayed posttest showed that they were able to retain information slightly better with TLS. However, with the $p=.6041$ there was not a significant difference at the $p>.05$ level for post to delayed posttest for either method of teaching science.

Linearity Assumptions

The important assumptions behind this analysis are that the two groups are normally distributed and the graphs show the groups were similar at the beginning of the study. Tables 11 and 12 show the normal distributions and are independent with constant variance.

Here are the linearity assumptions of the models built (Institute for Digital Research – UCLA, 2015):
- Linearity - the relationships between the explanatory variables and the response variable should be linear.
- Normality - the errors should be normally distributed.
- Homogeneity of variance (homoscedasticity) - the error variance should be constant.
- Independence - the errors associated with one observation are not correlated with the errors of any other observation.
- Errors in variables - predictor variables are measured without error.

Tables 12 and 13 show the histogram of the residuals (or error) and residuals vs. predicted values plot (a graphical technique used to check the validity of a homogeneity).

Table 12

<table>
<thead>
<tr>
<th>Histogram of the Residuals</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Histogram of Residuals" /></td>
</tr>
</tbody>
</table>

This table shows that there is a normal distribution among the tests scores for both groups and the groups were similar at the beginning of the study.
This table shows a scatter plot to show that the PBS and TLS groups predicted mean scores are homogenous. The groups are similar.

Summary

Chapter 4 provided the results of the analysis and a presentation of the data. A repeated ANOVA and General Linear Model (GLM) were used in SAS software to analyze the data. The software was used to identify significant differences in the TLS and PBS when all students’ pre, post and delayed posttests were combined. This analysis of data showed that the students’ test scores for PBS are higher than the students’ test scores for TLS. A significant difference was also found that black students retained the information better using the TLS method of instruction. However, male students exhibited better retention when taught using PBS. Students taught using PBS and students taught using TLS made similar gains of knowledge between pretest and posttest.
Explanation for the Findings

When looking at all students in the study, the average test scores of PBS are overall higher than TLS. However, when analyzing the pre to posttest and posttest to delayed posttests there are no statistically significant differences among the groups.

When comparing the two methods of teaching among black students, there is a significant difference between the pre to posttest, with project based learning showing an increase in the content knowledge gained. However, the statistical data did not support the retention of information by the black students. TLS showed an increase in retention by almost 3 points on the delayed posttest.

The females showed no difference in learning the content with either method of teaching. But females seemed to be able to retain the content better with TLS as opposed to PBS. Males saw a slight increase in learning with TLS over PBS. However, male students retained the information better with PBS.

When analyzing the black students, there was not a breakdown between males and females. The assumption that may be drawn from the above information is that black students gain knowledge better by the use of PBS and males seem to retain information better from PBS. Females retained knowledge better when they were taught using TLS. The drop in retention among blacks using PBS may be due to the fact that there were more black females who took the posttest. Therefore, black males may gain knowledge and retain knowledge better with PBS. However, this study did not single out black males because the researcher did not feel the sample size was large enough. Further research needs to be done to see if black males will retain information better with PBS.
CHAPTER 5

CONCLUSION

The purpose of this study was to compare two methods of teaching science to seventh grade students. The aim was to see if using project-based science would increase content learning over textbook/lecture science. The school in which the research was conducted has not met AYP for the last several years due to the black subgroup’s low scores in reading, math, and science. There is an achievement gap of 37 percent difference in the black and white population (2011 Illinois School Report card). Therefore, an emphasis in this study was placed on the black subgroup. The study also compared male to female students because approximately four percent fewer males met or exceeded standards on the science ISAT scores than females (2011 Illinois School Report Card).

In this study 172 students from a school in Northwestern Illinois received either PBS or TLS instruction over a 10 day period. There were 3 advanced PBS classes and 2 advanced TLS classes as well as 3 regular PBS classes and 3 regular TLS classes. At the beginning and at the end of the 10 day lesson students from both the PBS and TLS groups were given a multiple choice test on disease, the targeted unit. Ten days later the students were given a delayed posttest to determine whether they had retained information learned from the disease unit.
Analysis and Discussion of Findings

Research Question 1 Interpretation

The first research question investigated the performance on a multiple choice content test of all seventh grade students who experienced PBS and TLS. Overall scores for the pre, post, and delayed posttest were averaged. The findings showed that the students taught using the PBS method had a higher mean score than the students taught using TLS. The significant difference on the overall scores of the students taught using PBS may have resulted from the fact that the PBS group’s mean pretest started higher than the TLS group’s. The discrepancy between the PBS and TLS mean scores may have been because there were two advanced classes being taught using PBS and only one advanced class being taught using TLS so there would be a similar number of students receiving each method of teaching. The students in the advanced classes self-select. They are usually students with a higher grade point average and who excel in science. Therefore, teacher B’s students scored higher on the pretest and continued to score higher on post and delayed posttest.

It should be noted that students were given test questions designed and written by individuals from the textbook company. The terminology on the test was similar to what was used in many of the lessons and worksheets. This may have been an advantage for the students taught through TLS and one of the reasons more gain was not seen by students being taught using PBS. This is supported by Walker and Schaffazic (1972), who stated students do better if content and vocabulary are covered regardless of the method of teaching. The fact that the PBS group scored just as well or higher on the textbook test may suggest that it is a better method of teaching.
The researcher also analyzed the difference between the mean scores of the pre to posttest and the posttest to delayed posttest to identify knowledge gained and retained by both methods of teaching. When the pre to posttests were analyzed, there was not a statistically significant difference between the PBS and TLS methods. The TLS group improved its average score by 5 points, whereas the PBS group improved its test score by 4.4 points. The fact that the PBS group started with a higher pretest may have influenced the lower gain in test scores from the pre to posttest. These findings were similar to Davis’s (1976) and Pine et al.’s (2006), who found that students in hands-on curriculum had similar scores to the TLS group.

In the Davis (1976) and Pine et al. (2006) studies students were participating in science practices and hands-on learning, but they were not totally immersed in a PBS curriculum. The researchers also felt that teachers may have lacked training in science practices and hands-on learning and may have taught the lessons more like TLS than PBS (Pine et al., 2006). In the constructivist theory complex inquiry is required to gain science concepts (Joseph et al., 2000). If inquiry is not being taught so student have to design experiments, form hypotheses, gather and analyze data then the hands-on curriculum is not going to show students growth in knowledge (Joseph et al., 2000). Blumenfeld (1991) also found that PBS poses difficulties for teachers. Teachers may need training with implementation and questioning to guide students to gain understanding of concepts. The lack of fidelity using a PBS curriculum may have had an effect on students’ lack of learning during hands-on curriculum.

When analyzing the post to delayed posttests, there was not a significant difference between the PBS group and the TLS group. The PBS group’s scores dropped 0.71, which is less than one question, whereas the TLS group dropped 1.49 points. This suggests only a slightly better retention rate for the PBS group. When PBS was used in Rivet and Krajcik’s (2004, 2008)
and Lynch et al.’s (2005) studies, the PBS unit was 10 weeks long. The disease PBS unit used in the current study was only 10 days long. This may not have been enough time for students to construct and gain content knowledge. Vygotsky (1979) contends that students need time to process the knowledge. Students need to construct knowledge to learn a concept. The ten days of PBS may not have been enough time to obtain a clear understanding of disease and how the body fights diseases.

Research Question 2 Interpretation

Differences were found in the black students’ performances between those who experienced PBS and those who experienced TLS on a content test. Black students made higher gains between the pre to posttests when taught using PBS. However, black students had better retention of knowledge when taught using TLS. It should be noted that 16 black students took the delayed posttest in the TLS group and 22 black students took the delayed posttest in the PBS group. The small sample sizes for each group may have had an impact on the data outcome.

The study done by Geier (2008) showed black students improved science scores on the MEAP standardized tests by over 20 percent compared to students not taught with PBS. The Detroit schools where Geier’s research took place had 91 percent black students. The number of students who participated in PBS was approximately 2,000, and they were compared to over 8,000 other students who did not receive PBS. This large subgroup (2,000) seemed to show that PBS could have an adverse effect on black students’ learning of science content.

When analyzing the difference in performance between the black subgroup who participated in the current study, it was found that the black population had an increase in test scores by 5.55 points after being taught with PBS as opposed to an increase of 4.14 questions
with the TLS method of teaching. This seems to suggest that black students gained content knowledge better by being taught by PBS. However, this increase was not enough to be statistically significant. Rivet and Krajcik (2004) found black students’ pretest and posttest scores increased as PBS was introduced into the curriculum. A similar study done in Michigan found that at-risk males scored higher on the NAEP after being taught using PBS (Schneider et al., 2002). Therefore, the current study lends some support to the Michigan findings.

When analyzing the post to delayed post scores of black students, there was only a .05 decrease in test scores for the TLS method of teaching as opposed to the PBS scores. Black students retained the information better when taught using TLS. The only study that used a posttest design was the Maryland study (Lynch et al., 2005), which found that black students improved their understanding of a concept better than the white population in the study after using the highly rated CTA science program, which has inquiry and hands on learning found in PBS. The delayed test scores for black students fell by 2.73 points when students were taught by PBS. This is a contradiction from the overall population scores, which showed a slightly better retention using PBS. This is also a contradiction, which showed that males retained information better when using PBS. Therefore it may be assumed that there were more female black students at the end of the study that took the delayed posttest. This study did not single out black males and females because the researcher did not feel there would be enough population in these subgroups. In this study the black population did not retain content knowledge better using PBS.

**Research Question 3 Interpretation**

Research question 3 shows the results of the male and female students’ scores on the pre, post, and delayed posttests. There were no statistical differences between male and female
performance on the pre, post, and delayed posttests when taught using TLS and PBS. However, the females’ scores were slightly lower for the TLS. The overall combined mean score for pre, post and delayed posttest TLS scores for females was 12.54 and 12.72 for males. The PBS mean scores were higher, with a female combined mean score of 15.48 and a male combined mean score of 14.30.

It is interesting to note that the male mean score for TLS was slightly higher than the females’ mean score. However, the female mean score was higher than male score in PBS. The females started out knowing approximately one question more than the males in PBS, and in TLS, the males started out knowing approximately one question more than the females, which shows the similarity between the groups. Grier (2008) found that there was little gender gap in scores between male and females in Cohort II after they participated in PBS. This was a significant finding because there had been large gaps between black males’ and females’ scores in science, and in this Detroit study the population was predominately black.

In the current study, males also showed no statistically significant difference in PBS and TLS. Their increase from pre to posttest was 5.39 points when taught by TLS compared to a 4.00 increase in test scores when taught by PBS. In the study done in the Detroit schools, girls outperformed boys when using PBS (Schneider et al., 2002). Therefore, the results of the current study differ slightly from the findings in Michigan.

The interesting finding in the current study is that there was a difference in females and males in retention of knowledge when taught by the two methods. The males’ test scores dropped by 2.26 points when taught by TLS and the PBS male students’ scores only fell by .34 points, which shows the males had very little loss of knowledge when taught using PBS. The female scores showed just the opposite effect.
In contrast, the female students seemed to retain the information better with the TLS than the PBS method. The female test scores fell only .64 points for TLS and 1.07 points with PBS. This was not a statistically significant difference but should be noted because a couple of points can change the grade and percent on a test. This may also explain why the black population retained more when taught using TLS. The assumption was that more black females than males took the delayed posttest.

Support for Project Based Science

Other research (Geier et al., 2008; Schneider et al., 2002) showed that on standardized testing, students taught by PBS outperformed students who were taught using TLS. The 2011 National Assessment of Education Progress (NAEP) investigated how many times a week students did hands-on projects during science. Students who reported doing hands-on projects and collaborating with peers more than three times a week showed higher science test scores on standardized testing. The students in the current study taught using PBS were doing hands-on projects and peer collaboration eight out of the ten lessons. The students in this study through TLS used inquiry and collaboration only three out of the ten days. Students at the school where the research was collected did score higher on their seventh grade ISAT science test in 2012. In 2011, the students’ mean score was 64.5 out of 100; the science scores improved to 67.6 in 2012 (Illinois School Report Card, 2012). There is no way of knowing if this improvement in standardized testing was due to the hands-on learning the students received in both TLS and PBS, but the improvement of standardized science test scores increased similar to findings by Geier (2008) and Schneider (2002).
Leaders in science education research, such as Krajcik and Reiser (2003), were instrumental in writing the Next Generation Science Standards (NGSS, 2013) using many of the components of project-based science. PBS and NGSS encourage using a driving question or phenomenon that students will explore. Another component of NGSS and PBS is the use of science practices such as questioning, setting up experiments, and gathering and analyzing data. Students are encouraged to make artifacts or models to explain the phenomena or science concepts. Students are led through a story line that helps them construct knowledge to understand a concept.

These same principles of PBS are the three themes of the constructivist theory: the learning should be child centered, the subjects should be integrated, and the learner should be engaged (Joseph et. al., 2000). The learner needs to construct meaning and be engaged in learning (Bruner, 1996). PBS has students asking questions, solving problems, using multiple subjects, and participating in cooperative group learning. Dewey (1916), Bruner (1996), and Piaget (1970) contended that children need to be allowed to make sense of the world around them. PBS allows students to complete tasks and make realistic products (Thomas, 2000).

The methods teachers use to instruct students are very important to help students master concepts and content knowledge. Many school districts encourage teachers to use the practices advocated by Marzano (2001). His research based strategies and best practices help teachers plan their lessons to improve student learning. PBS has many of Marzano’s practices built into the curriculum, including collaborative group work and generating and testing hypotheses. School districts need to continually look at statistical data to help them make changes and improve their science curriculum. The data collected in this research should encourage teachers to use a project-based approach when working with all students.
Other research suggests that students enjoy hands-on science, and if students enjoy learning they will be more likely to learn (Blumenfeld, et al., 1991; Lynch et al., 2005; Pintrich, 2000). The 2011 NAEP reported that students scored higher on standardized testing when teachers did hands-on projects and collaborative learning in the classroom. A study by Wilson, et al. (2010) found that when inquiry was used over traditional classroom science, there were no gaps among subgroups. Science teachers and administrators are looking for ways to close the gaps so all students learn science. The current study suggests that science taught using inquiry may appeal to a wider group of students and offers useful information when selecting curriculum for students.

Recommendations for Practice

Findings from this study show that male students retained the information better when taught using PBS and female students retained information better using TLS. This research can be helpful to teachers and administrators. Teachers could have the female students do the textbook review from the back of the science book and have the males do a project to review before a test. For example, the male students could make a pamphlet on a disease they were interested in. This practice has been implemented in the school in which the research was conducted, and the gap on science ISAT scores has narrowed between males and females. In 2013, the males outperformed the females for the first time in five years (Illinois School Report Card, 2013).

Based on Kilpatrick’s (1936) contention that projects should incorporate all subjects and contribute to cognitive development, teachers should design projects or have students design artifacts to prepare for tests and help them learn the concepts. The black students in this study
performed almost two questions better when taught using PBS as opposed to being taught using TLS. Rivet and Krajcik’s (2004) study also found that PBS improved test scores in their target population, which was 91 percent black, from pre to posttest compared to other science curriculum. This information can be useful when choosing science curriculum. Most current textbooks could be used in conjunction with a PBS curriculum. Teachers could have students refer to their texts when doing projects and look up information so they become used to the science terminology. This may help the black students learn the content and retain the information.

A statistically significant difference between PBS and TLS was found when all three means for all three tests are combined. Supporting the ideas of Marzano (2001) and Wenglinsky (2000), the current study’s findings should encourage teachers to have students actively engaged in science. The teacher and the students need to identify a question or a phenomenon they want to explore. They then need to explore these questions by developing and using models; planning and carrying out investigations; analyzing data; using math; constructing explanations; engaging in argument from evidence; and obtaining, evaluating, and communicating information (Framework for K-12 Science Education, 2013). These practices are supported by the constructivist framework that learning needs to be child centered with authentic problems. Projects should be used to integrate the subjects and help students apply the information they are taught in their classes. The learners must work to construct knowledge by doing hands on activities and discussing information with other students. This is the new wave of science. NGSS (2013) wants teachers to have a story line as they teach to help students build concepts to better understand science.
Further Research

The future of science seems to be moving away from content knowledge to focusing on concept knowledge (NGSS, 2013). The NGSS are designed to be taught using many aspects of PBS. Driving questions help students construct knowledge about real world phenomenon. Scientific practices are used to gather and analyze data. Crosscutting concepts are used to look for patterns and similarities and differences. All of the three dimensional learnings of NGSS are part of PBS and the constructivist theory of learning. Therefore, current research should look at various subgroups to see if NGSS will address the needs of those subgroups.

With NGSS, teachers will need to have professional development. Pine et al. (2006) suggest that without improvements in teacher preparation, it seems unlikely that changing to hands-on inquiry will result in science learning gains. PBS curricula created by the University of Michigan and used in Rivet and Krajcik’s (2004, 2008) studies have tried to address the needs of teachers by designing teaching materials to help teachers learn pedagogical skills and better understand the inquiry-based approach. The lessons are very specific with science principles and concept understanding built in to the lessons. This may be why students’ science scores increased in Rivet and Krajcik’s (2004, 2008) studies; the teachers were more prepared to teach PBS.

Because the demographics of many schools are becoming diverse, there are many achievement gaps among various subgroups (ethnicity, economic status, gender). Research needs to be done to see how these gaps can be narrowed. Some future research areas could focus on black males, low income students, and gender inequities. Other areas of study could include looking at the best method to teach concepts as opposed to merely content.
There is a 25 percent gap in ISAT science scores between black and white students across the state (ISBE Report Card, 2013). There was a two point test gap in the posttest scores between black and white students in this study. The black students showed higher scores on their tests when taught using PBS; however, those being taught using TLS showed a statistical significance in retention. Without the breakdown of the gender in this group, it is difficult to see if the black males would have retained information better with PBS. Therefore, more research needs to be done with black male subgroups.

There is a 22 percent academic gap in the state on the science ISAT scores between low (those students who qualify for free and reduced lunch) and high income students (ISBE Report Card, 2013). According to the Common Core data report, 48 percent of the United States students were eligible for free or reduced lunch in 2010-2011 (NGSS, 2013, p. 35). With such a high number of students in this subgroup, researchers need to focus on low income students to determine if low income learners increase their understanding of science concepts when taught using three dimensional learning (crosscutting concepts, science practices and core ideas) which are similar components in NGSS and PBS?

Finally there needs to be research based on the gap in gender. The gap in this state has narrowed over the years, but when you look at the differences in males who exceed state standards and females who exceed state standards, there is a five percent gap (ISBE, 2011). More males exceed state standards in science than females. NGSS is trying to increase the rigor in the science curriculum and more engineering practices are being incorporated in the standards to encourage higher order thinking. Research needs to be conducted to see if females taught using NGSS guidelines, which are aligned with PBS, will start excelling in science reasoning skills and move to the exceeds column on standardized testing.
Conclusion

With the implementation of NGSS and the new assessments for science, there is always a need for teachers to know the best way to help their students understand concepts, gain content knowledge, and prepare for the future. Comparing PBS and TLS and looking at various subgroups in this Northwest Illinois school was a way for the researcher to see if students would gain and retain knowledge better with one method of instruction compared to the other. The findings demonstrate that the overall scores were higher for PBS than TLS. The PBS students performed as well or better in almost all of the comparisons in this study. However, there was a significant difference with delayed posttest results, showing that the black students in this study retained information better when taught with TLS. For content knowledge, students may want to use the textbook to look up information and gain vocabulary to help them pass content knowledge tests. If teachers use components of PBS such as engaging students in real life problems, enabling students to do inquiry, and having students collaborate with each other, this should allow students to create an understanding of science concepts. To understand science concepts, students need to have the problem solving skills and analytical reasoning that will allow them to have a deeper understanding of the world around them. A combination of both TLS and PBS may be needed to meet the needs of all students to ensure that science content and concept knowledge are achieved.
REFERENCES


Lee, O., & Luykx, A. (2004). *Science education and student diversity: Synthesis and research agenda*. A monograph supported by the center for Research on Educational Diversity and Excellence CREDE at the University of California at Santa Cruz and the National Center for Improving Students’ Learning and Achievement (NCISLA) in Mathematics and Science University of Wisconsin in Madison.


APPENDIX A

INSTITUTIONAL REVIEW BOARD LETTER FOR FEDERAL CODE (45 CFR 46)
May 31, 2011

MEMORANDUM

TO: Sindy Sue Main  
Department of Teaching & Learning  
2991 West Forest Rd.  
Freeport, IL  61032

FR: David Henningsen, Chair  
Institutional Review Board #1

RE: Graduate student research involving human subjects for the project titled "Project-based learning versus textbook/lecture learning in middle school science"

This is to inform you that your request for approval of modifications to the above-named project has been received by the Office of Research Compliance. Because your research project was originally approved on May 12, 2011 by the Institutional Review Board (IRB) as exempt from the Code of Federal Regulations, (45 CFR 46) for the protection of human subjects, and because the modifications you propose do not change that categorization, you do not need any further review of this project.

The IRB has adopted this strategy for exempt projects only. Further review is required only if proposed modifications would necessitate Subcommittee or Full Board Review.

Thank you for your attention to the NIU policy on the use of human subjects in research, and best wishes for success in your research endeavors.

DH/ska

cc:  M. Henning  
ORC #HS11-0171
APPENDIX B

TEACHER PARTICIPATION AGREEMENT
Dear Teacher

I am asking for your participation in my doctoral research study entitled, *Project-based Learning versus Textbook/lecture Learning*. The purpose of this study is to compare textbook/lecture learning to project-based learning to determine how children learn science content more effectively. Your participation in this study will last ten school days. You will be responsible for giving a multiple choice pretest, posttest and delayed posttest as well as teaching the two different curriculums on disease. You will also be responsible for putting the scores of the tests in the school computer program so the scores may be analyzed at the end of the study.

Through this research I hope to learn which method of teaching science content is most effective. But I want you to know that any scores collected from the students will be kept strictly confidential.

Participation in this study is voluntary. I hope that you will sign below so you can be part of this research study. But, your decision whether or not to participate in the study will not affect you in any way. You will be free to withdraw from participation at any time without penalty or prejudice.

If you have questions about the study, please feel free to contact me at [email protected] or Dr. Henning my committee chairperson at any time. Both contacts are listed below.

| Mrs. Sindy Main |
| Science Instructional Leader |

| Mary Beth Henning Ph.D. |
| Assistant Professor at NIU |
| Department of Teaching and Learning |
| Northern Illinois University |
| DeKalb, IL 60115 |
| Telephone: 815-753-8591 |
| Email: mhenning@niu.edu |

If you wish further information regarding your rights as a research participant, you may contact the Office of Research Compliance at Northern Illinois University at 815-753-8588.

*I agree to participate in this research study and acknowledge that I have received a copy of this consent form.*

__________
Signature of Teacher  (Please return to Researcher Sindy Main. Thank you)
APPENDIX C

LETTER SENT HOME TO PARENTS ABOUT RESEARCH
Dear Parents/Guardians

I am currently working on my dissertation at Northern Illinois University in Science, Social Studies and Environmental Education. Mrs. [REDACTED] and Ms. [REDACTED] classes will be participating in a study after spring break that will be using two different types of curriculum to teach a unit on disease. Half of the students will participate in project-based learning and the other half of the students will participate in textbook/lecture learning. Each student will take a multiple choice pretest, posttest, and delayed posttest to see if there is a difference in the content knowledge and retention between these two types of curriculum. The students will be randomly assigned to the curriculum.

If you have any questions please contact:

Mrs. Sindy Main

Email: sindy.main@fsd145.org, Cell Phone: [REDACTED]
APPENDIX D

PRE/POST/DELAYED POSTTESTS
Chapter 27 Disease Pretest

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

1. Which of the following helps people resist or recover from infectious diseases?
   a. a high-fat diet
   b. genetic testing
   c. immunity
   d. ultraviolet radiation

2. What does an antibiotic do?
   a. It treats bacterial and fungal infections.
   b. It treats viral infections.
   c. It provides immunity to smallpox.
   d. It makes milk safer to drink.

3. Which of these is the unregulated growth of cells?
   a. cancer
   b. an allergy
   c. an infectious disease
   d. a noninfectious disease

4. When your normal body processes are disrupted, you have a(n)
   a. immunity
   b. pathogen
   c. enzyme
   d. disease

5. A substance that can kill bacteria is a(n)
   a. antiviral
   b. pasteurization
   c. pathogen
   d. antibiotic

6. What kind of disease is spread from one person to another?
   a. a noninfectious disease
   b. an infectious disease
   c. a pathogenic disease
   d. a contamination disease

7. Most pathogens do not infect skin because
   a. they do not attack skin
   b. the skin is immune to them
   c. you can see them
   d. dead skin cells carry them away

8. What do platelets do?
   a. split to make antibodies
   b. cling to viruses
   c. seal open wounds
   d. activate killer T cells

9. Two examples of pathogens are
   a. poor diet and no exercise
   b. smoking and heredity
   c. clothing and heart problems
   d. viruses and bacteria

10. What normally destroys unregulated cells?
    a. antibiotics
    b. helper T cells
    c. memory B cells
    d. killer T cells

11. Which of these is NOT a possible way to spread disease?
    a. shaking hands
    b. playing with a dog
    c. boiling water
    d. sneezing
12. Why do people with AIDS often die of other causes?
   a. the cardiovascular system fails
   b. AIDS causes HIV to occur
   c. the immune system cannot fight pathogens
   d. cancer spreads faster than AIDS

13. One example of a pathogen is
   a. uncooked meat.
   b. a helper T cell.
   c. boiled water.
   d. Streptococcus bacteria.

14. Which of the following is NOT true about the immune system?
   a. It sends signals to the brain.
   b. It fights allergies.
   c. It consists of cells, tissues, and organs.
   d. It destroys infected cells.

15. Helper T cells are activated by
   a. memory B cells.
   b. viral antigens.
   c. killer T cells.
   d. pathogens.

16. Pathogens that are carried to the stomach by mucus
   a. always cause stomach infections.
   b. infect the mucus.
   c. are usually digested.
   d. get into the blood system.

17. People with AIDS have very few
   a. cells.
   b. pathogens.
   c. helper T cells.
   d. memory B cells.

18. What is one way people get noninfectious diseases?
   a. dirty hands
   b. a genetic disorder
   c. being around sick people
   d. being sneezed on

19. What is mucus?
   a. a first line of defense
   b. a pathogen
   c. a helper cell
   d. an antigen

20. What is the system that attacks pathogens called?
   a. antibiotic system
   b. attack system
   c. vaccine system
   d. immune system

21. Sometimes the immune system tries to fight antigens that are not bad. What is this called?
   a. an allergy
   b. a disease
   c. an antigen
   d. an antibiotic

22. When modern disease controlling medicines and practices are introduced in developing countries, the major change is that
   a. life spans increase
   b. birthrates increase
   c. the population decreases
   d. the water supply increases
These graphs show the rate at which four different disease-producing bacteria grow. Which bacterium would produce a disease in the shortest amount of time?

A. Bacterium 1  
B. Bacterium 2  
C. Bacterium 3  
D. Bacterium 4

New studies on a drug that regulates blood pressure show that it can cause harmful side effects if used for many years. What should the manufacturer do?

A. Inform the public and remove the drug from the market immediately.  
B. Ignore the new studies because all drugs have harmful long-term side effects.  
C. Market the drug under a new name to avoid bad publicity.  
D. Destroy the new results.

A student wants to perform an experiment to test how much water bean plants need for good growth. Which factor should be changed?

A. The temperature  
B. The amount of light  
C. The amount of water  
D. The amount of soil
Chapter 27 Disease Posttest

Multiple Choice.
Identify the letter of the choice that best completes the statement or answers the question.

1. What normally destroys unregulated cells?
   a. memory B cells  
   b. antibiotics  
   c. killer T cells  
   d. helper T cells

2. Two examples of pathogens are
   a. poor diet and no exercise.  
   b. smoking and heredity.  
   c. clotting and heart problems.  
   d. viruses and bacteria.

3. What kind of disease is spread from one person to another?
   a. a pathogenic disease  
   b. an infectious disease  
   c. a contamination disease  
   d. a noninfectious disease

4. Why do people with AIDS often die of other causes?
   a. the cardiovascular system fails  
   b. cancer spreads faster than AIDS  
   c. the immune system cannot fight pathogens  
   d. AIDS causes HIV to occur

5. Which of these is the unregulated growth of cells?
   a. an allergy  
   b. an infectious disease  
   c. a noninfectious disease  
   d. cancer

6. What is the system that attacks pathogens called?
   a. attack system  
   b. vaccine system  
   c. immune system  
   d. antibiotic system

7. Pathogens that are carried to the stomach by mucus
   a. get into the blood system.  
   b. always cause stomach infections.  
   c. are usually digested.  
   d. infect the mucus

8. One example of a pathogen is
   a. uncooked meat.  
   b. boiled water.  
   c. Streptococcus bacteria.  
   d. a helper T cell.

9. What is one way people get noninfectious diseases?
   a. being around sick people  
   b. dirty hands  
   c. being sneezed or  
   d. a genetic disorder

10. A substance that can kill bacteria is a(n)
    a. pathogen.  
    b. antiviral.  
    c. pasteurization.  
    d. antibiotic.

11. Which of the following is NOT true about the immune system?
    a. It fights allergies.  
    b. It consists of cells, tissues, and organs.  
    c. It destroys infected cells.  
    d. It sends signals to the brain.
Name: ____________________________

12. People with AIDS have very few
   a. pathogens.
   b. cells.
   c. memory B cells.
   d. helper T cells.

13. When your normal body processes are disrupted, you have a(n)
   a. enzyme.
   b. pathogen.
   c. immunity.
   d. disease.

14. What does an antibiotic do?
   a. It makes milk safer to drink.
   b. It provides immunity to smallpox.
   c. It treats bacterial and fungal infections.
   d. It treats viral infections.

15. Which of the following helps people resist or recover from infectious diseases?
   a. ultraviolet radiation
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   c. immunity
   d. genetic testing

16. What do platelets do?
   a. cling to viruses
   b. split to make antibodies
   c. seal open wounds
   d. activate killer T cells

17. What is mucus?
   a. a helper cell
   b. a pathogen
   c. a first line of defense
   d. an antigen

18. Sometimes the immune system tries to fight antigens that are not bad. What is this called?
   a. an antigen
   b. an antibody
   c. a disease
   d. an allergy

19. Which of these is NOT a possible way to spread disease?
   a. playing with a dog
   b. boiling water
   c. shaking hands
   d. sneezing

20. Helper T cells are activated by
   a. viral antigens.
   b. killer T cells.
   c. pathogens.
   d. memory B cells.

21. When modern disease controlling medicines and practices are introduced in developing countries, the major change is that
   a. life spans increase
   b. birthrates increase
   c. the population decreases
   d. the water supply increases

22. Most pathogens do not infect skin because
   a. dead skin cells carry them away.
   b. you can see them.
   c. the skin is immune to them.
   d. they do not attack skin.
These graphs show the rate at which four different disease-producing bacteria grow. Which bacterium would produce a disease in the shortest amount of time?

A. Bacterium 1  
B. Bacterium 2  
C. Bacterium 3  
D. Bacterium 4

New studies on a drug that regulates blood pressure show that it can cause harmful side effects if used for many years. What should the manufacturer do?

A. Inform the public and remove the drug from the market immediately.  
B. Ignore the new studies because all drugs have harmful long-term side effects.  
C. Market the drug under a new name to avoid bad publicity.  
D. Destroy the new results.

A student wants to perform an experiment to test how much water bean plants need for good growth. Which factor should be changed?

A. The temperature  
B. The amount of light  
C. The amount of water  
D. The amount of soil
Chapter 27 Delayed Fossiez

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

1. Helper T cells are activated by
   a. killer T cells.
   b. viral antigens.
   c. pathogens.
   d. memory B cells.

2. One example of a pathogen is
   a. Staphylococcus bacteria.
   b. a helper T cell.
   c. boiled water.
   d. uncooked meat.

3. When your normal body processes are disrupted, you have a(n)
   a. enzyme.
   b. disease.
   c. immunity.
   d. pathogens.

4. Which of these is NOT a possible way to spread disease?
   a. shaking hands
   b. playing with a dog
   c. boiling water
   d. sneezing

5. Which of these is the unregulated growth of cells?
   a. a noninfectious disease
   b. cancer
   c. an infectious disease
   d. an allergy

6. Two examples of pathogens are
   a. viruses and bacteria.
   b. clothing and heart problems.
   c. smoking and heredity.
   d. poor diet and no exercise.

7. What is anacous?
   a. a first line of defense
   b. a pathogen
   c. a helper cell
   d. an antigen

8. A substance that can kill bacteria is a(n)
   a. antibiotic.
   b. pathogen.
   c. pasteurization.
   d. antiviral.

9. Which of the following helps people resist or recover from infectious diseases?
   a. genetic testing
   b. ultraviolet radiation
   c. immunity
   d. a high-fat diet

10. People with AIDS have very few
    a. memory B cells.
    b. cells.
    c. pathogens.
    d. helper T cells.

11. Sometimes the immune system tries to fight antigens that are not bad. What is this called?
    a. a disease
    b. an antigen
    c. an antibiotic
    d. an allergy
Name: ____________________________  ID: A

12. What kind of disease is spread from one person to another?
   a. a pathogenic disease  c. a noninfectious disease
   b. an infectious disease  d. a contamination disease

13. What does an antibiotic do?
   a. It treats viral infections.  c. It makes milk safer to drink.
   b. It provides immunity to smallpox.  d. It treats bacterial and fungal infections.

14. What is the system that attacks pathogens called?
   a. attack system  c. antibiotic system
   b. vaccine system  d. immune system

15. Pathogens that are carried to the stomach by mucus
   a. are usually digested.  c. infect the mucus.
   b. get into the blood system.  d. always cause stomach infections.

16. Which of the following is NOT true about the immune system?
   a. It fights all organelles.  c. It sends signals to the brain.
   b. It consists of cells, tissues, and organs.  d. It destroys infected cells.

17. What do platelets do?
   a. cling to viruses  c. activate killer T cells
   b. split to make antibodies  d. seal open wounds

18. Most pathogens do not infect skin because
   a. dead skin cells carry them away.  c. they do not attack skin.
   b. you can see them.  d. the skin is immune to them.

19. What normally destroys unregulated cells?
   a. helper T cells  c. killer T cells
   b. memory B cells  d. antibiotics

20. When modern disease controlling medicines and practices are introduced in developing countries, the major
    change is that
    a. the water supply increases  c. birthrates increase
    b. life spans increase  d. the population decreases

21. Why do people with AIDS often die of other causes?
    a. the immune system cannot fight pathogens
    b. AIDS causes HIV to occur
    c. cancer spreads faster than AIDS
    d. the cardiovascular system fails

22. What is one way people get noninfectious diseases?
    a. being around sick people  c. a genetic disorder
    b. dirty hands  d. being sneezed on
These graphs show the rate at which four different disease-producing bacteria grow. Which bacterium would produce a disease in the shortest amount of time?

A. Bacterium 1  
B. Bacterium 2  
C. Bacterium 3  
D. Bacterium 4

New studies on a drug that regulates blood pressure show that it can cause harmful side effects if used for many years. What should the manufacturer do?

A. Inform the public and remove the drug from the market immediately.  
B. Ignore the new studies because all drugs have harmful long-term side effects.  
C. Market the drug under a new name to avoid bad publicity.  
D. Destroy the new results.

A student wants to perform an experiment to test how much water bean plants need for good growth. Which factor should be changed?

A. The temperature  
B. The amount of light  
C. The amount of water  
D. The amount of soil
APPENDIX E

TEXTBOOK/LECTURE LESSONS
Textbook/Lecture Lesson Plan Outline:

Day 1
Give pretest
Have students make a list of the various diseases they can think of and post list somewhere in the room.

Day 2
Chapter 27 (section 1) power point and directed reading worksheet on disease.

Day 3
Page 722 book experiment “Pass the Cold”

Day 4
Chapter 10 (section 2) “Bacteria’s Role in the World” power point and directed reading worksheet
Look at bacteria slides under the microscopes.

Day 5
Chapter 10 (section 3) “Viruses”
Students will read about viruses and do a directed reading worksheet (work alone)

Day 6
Do book experiment (quick lab pg. 55) “Only Skin Deep”. Discuss experiment and begin power point Chapter 27 (section 2) “Your Body’s Defense”.

Day 7
Finish power point Chapter 27(section 2) “Your Body’s Defense”.
Do worksheet “Immunity Teamwork”.

Day 8

Have students draw and explain how the immune system works using all the parts from “Immune Teamwork” worksheet.

Day 9

Video: Bill Nye on Disease.
Students will write down 10 facts they learned from the video

Day 10

Give Posttest on disease unit.
Students share and explain pictures they drew explaining the immune system.
APPENDIX F

PROJECT-BASED LESSONS
Project-Based Lesson Plan Outline:

Day 1

Give pretest
Have students list all the diseases that they can think of and write the diseases on the board.

Now have students come up with questions that they have about disease. Narrow down or combine the questions so you have 2 or 3 questions. These are the driving questions that the students will try and answer over the course of the unit.

Day 2

The teacher will divide students into 3 groups. Each group will be given a separate disease to read about. The students will answer questions about the diseases and share the information with the rest of the class.

In the same groups, students will get a packet of cards containing diseases with short definitions about the disease. Students will group the diseases according to their similarities. Once all groups have finished the task, each group will share how and why they grouped the diseases.

Day 3

How disease is spread simulation.

Day 4

Inquiry

Students will design an experiment to see where bacteria are found.

Day 5

Students will perform and gather data using the experiment they designed. This may take several days to gather data and allow bacteria time to grow.

Day 6

Show power point Chapter 27 (section 2) “Your body’s defense”. Students will look for answers to the driving questions on the board. Students will compare and contrast the two paths that the immune system uses to destroy a pathogen.
Day 7

Students will use information from the power point to act out the immune system. Each group will get a packet on two paths the immune system goes through to destroy a pathogen. Assign one student as the leader to cast parts. Each group will perform for the other group. Students will compare and contrast the two ways pathogens are destroyed by the body.

Explain the artifact students will be making to help them learn more about disease.

Day 8 and 9

Students will spend the next two days in the computer lab researching a disease that is of interest to them. They will have a rubric to follow. Each student will make a brochure or power point giving information about the disease they researched.

Day 10

Give posttest on disease unit.
Have students share their brochure or PowerPoint.