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Variables That Impact The Implementation Of Project-Based Learning In High School Science

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VARIABLES THAT IMPACT THE IMPLEMENTATION OF PROJECT-BASED LEARNING IN HIGH SCHOOL SCIENCE

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DEDICATION

We all have dreams. But in order to make dreams come into reality, it takes an awful lot of determination, dedication, self-discipline and effort.

~Jesse Owens

My dissertation work is dedicated in memory of my beloved father, Hershal Clover who instilled in me the resolve to persevere during challenging times. Thank you daddy for teaching me to never give up and to fight for what I want. A special feeling of gratitude goes to my mother, Geraldine Clover for her love and support.

I also dedicate this dissertation to my children Darrayl, Courteney, Corey and Christian and my son-in-law and daughter-in law, Daniel and Andrea. You have supported and encouraged me throughout the dissertation process. I will always appreciate all you have done.

To my grandchildren Cheyenne, Makenzie, Zion, Zara, and Zen and my future grandchildren. I pray that my determination, zeal and enthusiasm for learning will be passed down to you and that one day you will walk in your grandmother's footsteps.

I dedicate this work and give special thanks to my many friends without whom none of my success would be possible. They have been my cheerleader, my confidante, and my shoulder to cry on. Thank you for believing in me and encouraging me throughout this journey.

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CHAPTER 1 INTRODUCTION

Background

In August 1981, the United States Secretary of Education created a committee to analyze the U.S. educational system. Eighteen months later, the National Commission on Excellence in Education published a report entitled *A Nation at Risk* declaring a "crisis" in American public education. The committee concluded:

> Our nation is at risk….the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our future as a nation and a people….If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war….Our society and its educational institutions seem to have lost sight of the basic purposes of schooling, and of the high expectations and disciplined effort needed to attain them. (The National Commission on Excellence in Education, 1983, p. 1)

Statistics collected by the Commission showed that U.S. students were not being adequately prepared for the current demands of society. Students were graduating from high school unprepared for work or college. *A Nation at Risk* provided suggestions on how the nation could improve education. Among the recommendations were an increase in high school and college graduation requirements and a requirement that students pass a test prior to the granting of a diploma or degree (National Commission on Excellence in Education, 1983).

The publication of *A Nation at Risk* sparked massive public interest in education across the country. Prior to the report, public education had not been a national focus (Goldberg & Harvey, 1983). The publication of *A Nation at Risk* spawned a movement to improve the academic achievement of U.S. students (Deboer, 2002). In response to the findings of the report, a number of states adopted more rigorous high school graduation requirements (Goldberg & Harvey, 1983; Smith, 2004; Wahlberg, 1986). States across the country increased the number of math and science courses students needed to take in order to graduate from high school. States also implemented state testing to increase school accountability. Moreover, states enacted standards-based reforms to ensure state tests were aligned to state standards (Smith, 2004).

According to Goldberg and Harvey (1983), student academic achievement had been subpar as a result of the "rising tide of mediocrity" discussed in *A Nation at* Risk (p.1). Even in the years after the publication of *A Nation at Risk,* student academic achievement remained stagnant. A study conducted by Bennett in 1998 showed that fifteen years after *A Nation at Risk*, very few improvements had been made in education. The study cited data from the Trends in International Mathematics and Science Study (TIMSS) assessment showing American twelfth grade students were performing below our international counterparts. Additionally, the data showed over 10 million twelfth grade students lacked rudimentary reading skills.

From a Nation at Risk to No Child Left Behind. In the years following the release of *A Nation at Risk*, very little progress was made in the quest for educational reform. Despite educational reform initiatives, many low performing schools continued to perform poorly (Lashay, 2003). In 2001, the federal government took the lead in educational reform with the reauthorization of the Elementary and Secondary Education Act (ESEA), also known as the No Child Left Behind Act (NCLB) (United States Department of Education [USDOE], 2013). The No Child Left Behind Act requires all students to show adequate yearly progress (AYP). The law holds schools responsible for closing the achievement gap amongst low and high performing students and economically disadvantaged and minority students. According to NCLB, if one of these subgroups does not make academic progress, then the school is labeled a low performing school. States identified standards for both schools and students to meet in order to make AYP. Schools that make AYP receive accolades and potential financial rewards. On the other hand, schools that do not make AYP for two consecutive years are identified as "in need of improvement" and are at risk of disciplinary consequences (Lashay, 2003; Simpson, LaCava, & Graner, 2004). When No Child Left Behind was reauthorized in 2011, all students were required to meet state specified standards by the 2012-2013 school year. However, in 2011, the federal government provided states with the opportunity to waive the requirements of the law as long as specific requirements were met. States were required to submit an ESEA waver application that outlined their adherence to the waiver requirements, in exchange the federal government granted the waiver through the 2013-2014 school year. However, states have the option of applying for waiver extensions beyond the 2013-2014 school year (USDOE, 2013).

According to Lashay (2003), low performing schools have customarily been defined as "bad" schools characterized by low expectations and low student achievement, a high number of dropouts, an absence of discipline, poor facilities, and low staff morale. He further claimed that the definition of low performing schools today has shifted and classifies schools that do not meet specific academic targets specified in NCLB as low performing. Based on this new definition, in 2002 close to 8,652 schools in the United States were labeled low performing. Research has identified student demographics, inadequate funding, and poor instructional strategies as explanations for the low performance in these schools (Lashay, 2003).

The evolution of science education. Science was introduced into the school curriculum in the 1800s by the scientific community. It was taught as an integral part of moral instruction. The belief at the time was that science could be used to develop moral character traits in children. By the mid-1800s, the focus of science education shifted from moral instruction to experiential learning. Experiential learning enabled students to learn through their own experiences (Atkins & Black, 2007).

In 1860, the faculty psychology learning theory emerged. This theory stated the mind has various faculties such as observation, memorization, generalization, and reasoning. This approach focused on developing these faculties of the mind in children 11 years of age and younger. The faculty psychology learning theory was translated in elementary schools to an instructional approach called Object Teaching. Object Teaching originated in England and was adopted by the United States. In this approach, children studied and described objects they brought to class. Object Teaching lost its popularity in the late 1800s because it expressed no relevance to the lives of students. Faculty psychology had a lesser influence at the secondary school level. Secondary school education tended to focus more on reading and memorization (Atkins & Black, 2003, 2007)

At the latter half of the 1800s, The Committee of Ten introduced a report that had a major impact on science education at the secondary level education. The report made recommendations about the age at which various subjects should be taught, the subjects that should be taught at the secondary level, the number of years it should be taught, how the subject should be weighed in college-bound admissions, and whether the subject should be taught differently for those who were college-bound versus those who were not. The committee also recommended that 25% of the curriculum be comprised of the study of sciences (Atkins & Black, 2007).

In the early 1900s, Nature Study was introduced at the elementary level as the science curriculum. Nature Study was developed by Cornell University to teach students an appreciation for nature. The goal of Nature Study was for students to develop an appreciation for rural life. This approach was created to minimize the amount of urbanization that was taking place at the time and to spotlight the importance of farmlands. Nature Study lost its appeal after about 10 years (Atkins & Black, 2003, 2007).

In the 1930s through 1940s, curriculum development was led by textbook publishers with the help of other experts in the field. Textbook publishers decided what was to be taught in the classroom. During this time period, a focus on application-based science began to emerge. The impetus to teach application-based science began at Columbia University's Teacher College and continued with the publication of the 31st Yearbook of the National Society for the Study of Education (NSSE) in 1932. The release of the 31st Yearbook put real-life application at the forefront of secondary education. The focus of science education was to promote inquiry and to stress the relevance of science in the everyday lives of students. Fifteen years later, the NSSE published the 46th Yearbook which expanded upon the 31st edition by stressing the importance of problem-solving and the scientific method (Atkins & Black, 2003, 2007).

The science reform efforts of the 1950s and 1960s took a turn from science in daily living towards goals identified by the scientific research community. The scientific research community had gained much influence in science curricula after their pivotal role in helping the US win World War II (Atkins & Black, 2007). Science education drew great attention after World War II when concerns arose about the nation's military defense capability and its ability to maintain its position as a superpower. Attention to the role of science in education continued after the launch of Sputnik in 1957. The 1950s to the 1970s, also referred to as the post-Sputnik period, was characterized by science curriculum reform efforts (DeBoer, 2000).

The National Science Foundation (NSF) was developed in 1950 with the expressed intent of science curriculum development. Scientists took the torch in developing science curriculum. Over a 10-year period, the NSF completed curriculum development projects in the areas of physical science, biological science, earth science and many other sciences (Atkins & Black, 2003).

In 1955, the University of Illinois Committee on School Mathematics (UICSM) began a science reform initiative to revise science and mathematics education goals. Physics was the first science course addressed by UICSM in 1956. A group of science researchers from various universities and organizations conferred to develop the curriculum for the physics course (Atkins & Black, 2003).

In 1960, the NSSE published its 59th Yearbook entitled *Rethinking Science Education* which focused on the role of science teachers in increasing students' scientific knowledge. It was during this time that scientific literacy emerged as one of the goals of science education (DeBoer, 2000).

The focus of science education took a slight shift in the 1970s. In addition to scientific literacy, developing individuals that could use science in daily decisions also became a goal of science education (DeBoer, 2000). By the mid-1970s, science reform efforts began to dwindle. Public perception of science took a negative turn. The scientific research community had lost its influence on science curriculum development. During this time, the US had been making advancements in scientific research and was no longer concerned with its ability to compete on the battlefield. In tandem with this time, the US noticed a huge increase in the number of students completing high school. With the growing number of students attending high school, there was a shift in science education to ensure all students were internationally competitive and to prepare them to enter the workforce (Atkins & Black, 2007).

In 1978, a study called Project Synthesis was conducted. Four goals of science education were concluded from this study. The four goals were organized as personal needs, societal needs, career awareness, and academic preparation (Yager, 2000).

In 1989, *Project 2061's Science for All Americans*, a report by the American Association for the Advancement of Science, was published. This report recommended specific goals for science education that would create scientifically literate students. Three years later, the National Academy of Science began work on the National Science Education Standards, which were released in 1996. The standards were created to guide the development of science curricula. Scientific inquiry was the guiding principle upon which the standards were based. Just as Science for All Americans, these standards focused on developing scientific literacy (DeBoer, 2000).

Educational reform in science education. Both *A Nation at Risk* and NCLB initiated a national movement to reform education. Not exempt to this movement has been a specific focus on science education. Bybee and Stage (2005) conducted a study in which they looked at the academic performance of students since the enactment of NCLB using the TIMSS (Third International Mathematics and Science Study) and PISA (Performance for International Student Assessment) assessments. The TIMSS measures students' basic skills in math and science in grades 4 and 8, while the PISA measures literacy in math, science, and reading of 15 year old students. The results of these studies showed that U.S. student performance in math and science on the TIMSS had remained stagnant since 1995 and performance on the PISA remained the same since 2000. The authors attributed the lack of improvement of student achievement in U.S. schools to lack of attention to higher order thinking, strategic reading, and logical thinking. According to Bybee and Stage (2005), the results of these studies indicated that the U.S. needed to move beyond teaching students at a basic knowledge level and instead provide instruction that develops students' higher order thinking skills. Contrarily, the most recent results from the TIMSS show that U.S. students' performance has been improving. U.S. students scored above the international average in both math and science on the 2007 TIMSS. However, on the 2009

PISA, U.S. students scored one point above the international average in science, but scored nine points below the average in math (International Association for the Evaluation of Educational Achievement, 2012). These results suggest middle schools are making progress in improving student achievement, while high schools are lagging behind.

The National Science Education Standards (NSES) were developed in response to the need to reform science education and were integrated into science curricula across the country (Deboer, 2002; VonSecker & Lissitz, 1999). The National Science Education Standards operate jointly with state and local reform efforts (National Research Council, 1996). The goal of the National Science Education Standards is to produce scientifically literate individuals; individuals that are able to use scientific knowledge to make informed decisions. According to the NSES (National Research Council, 1996), "Learning science is something students do, not something that is done to them" (p. 20). In spite of the development of the NSES, Bybee and Stage (2005) claimed the U.S. science curriculum still did not promote a deep understanding of science. They added, in U.S. schools, science is studied in breadth, not depth. Oddly, U.S. students are taught more science content than higher achieving students in other countries. Nonetheless, this superficial instruction of content does not promote an in-depth understanding of science concepts (Bybee & Stage, 2005). Reforming science education involves a long-term commitment from schools and teachers to create student-centered classrooms that address the needs of all students (VonSecker & Lissitz, 1999).

The pursuit to reform science education has recently been addressed with the development of the Next Generation of Science Standards (NGSS). The NGSS were created through the joint efforts of educational organizations and states across the country to ensure students are college and career ready and able to think critically. The NGSS were completed in April 2013 and have been adopted by a number of states (Achieve, Inc. 2014).

School reform and restructuring. The call to reform America's educational system is not an easy feat. However, the future success of our nation is predicated upon our commitment to a quality educational program (National Commission on Excellence in Education, 1983). Schools must continue to seek ways to bolster student achievement through effective reform strategies. Lee, Smith, and Croninger (1996) defined restructuring as the implementation of non-traditional reforms that include shared decision making. They identified two academic practices that promote restructuring: common academic instruction (all students take the same courses) and authentic instruction (students create their own understanding through inquiry). In their study of restructured high schools, Lee and colleagues (1996) found that students learned more in the core areas in restructured schools than in traditional schools. In another study of restructured high schools, Lee and others (1995) identified four important school characteristics that impact student learning, and thereby restructuring success, among which was authentic instruction. According to them, students' math and science achievement was positively correlated with the degree of authentic instruction practices.

The role of school districts is generally not taken into consideration when addressing school reform. Most school reform initiatives are targeted at the national/state level or the school/classroom level (Spillane, 1996). School instructional reform initiatives should address the whole school system; from the district level, to the building level, to the classroom.

Spillane and Thompson (1997) identified three factors that influence a district's capacity for instructional reform: human capital, social capital, and financial resources. Human capital involves individuals' attitudes towards new learning, the commitment individuals have to the reform initiatives, and the knowledge individuals have of the reform initiatives and how to teach them to others. Districts generally use their human capital to educate others across the district. Social capital entails the relationships between individuals. Two types of social capital exist within school districts: internal and external. Internal social capital builds upon the trust and collaboration between individuals with the school district. External capital is based upon the relationships a school district has with the organizations within the community. School districts increase their social capital by establishing relationships with local agencies and associations. These organizations offer opportunities for school districts to learn about new reform initiatives and provide a setting for collaboration with other educators. Financial resources is the third factor that influences a district's capacity for instructional reform. Reform initiatives can be hindered by insufficient financial resources allocated to staffing, time, and materials.

Not only is instructional reform impacted by a school district's capital, it is also impacted by the conceptions of district leaders of instructional reform initiatives. District leaders play an important role in communicating state level initiatives to the school and classroom levels. They control how state initiatives are communicated and implemented in schools (Spillane, 1996). If district leaders' have misconceptions of an initiative, then it will be inaccurately conveyed to school leaders and staff. In their study of nine school districts, Spillane and Thompson (1997) found that the reform initiatives implemented by these nine districts were incongruent with state and national initiatives. This was attributed to district leaders' misunderstanding of the initiatives. They learned that the district leaders' understanding and ability to communicate the state reform initiatives was subpar. It was also discovered that the district initiatives did not address the level of depth required by national reform initiatives. District initiatives only touched the surface of these reform initiatives. Therefore, it is imperative that district leaders have an accurate understanding of state and federal reform initiatives, otherwise teaching and learning will suffer.

District leaders create policies that support, impede, or ignore state initiatives (Spillane, 1996). Simply communicating a new policy is not sufficient. Policies may impact various entities within the school district. While all are expected to abide by the new policies, it is important for school leaders to understand that the construction of meaning of new policies is dependent upon the prior knowledge, beliefs, values, experiences and skills of the individuals enacting the policies. A teacher's failure to implement a new policy may be interpreted as blatant defiance or sabotage when in fact it may be due to a teacher's misunderstanding of the policy as it relates to their prior knowledge and experiences. Teachers must be provided with opportunities to assist them in developing an understanding of the policy and how it impacts their practice (Spillane, Reiser, & Reimer, 2002).

Teachers and administrators also play a key role system reform. Systemic reform requires high standards and a rigorous curriculum. According to Cohen (1995), the success of systemic reform in improving instruction depends upon teachers' knowledge, their attitudes and beliefs, and the support of social capital. Social capital support includes commitment from students, parents, and community in the educational process. Cohen argues that the U.S. educational system is weak in all three of these fundamentals and that the policies implemented to address these fundamentals are also weak.

Instructional reform is dependent upon school leaders' ability to learn new information and convey that information to staff (Spillane, 1996). Different understandings result in different interpretations in the classroom. Even if teachers develop an accurate interpretation of the reform idea, they may not have the skills or resources to implement the reform with fidelity (Spillane et al., 2002). The introduction of a new reform idea may not merely involve teaching the new idea but may require a paradigm shift for the learners (Spillane et al., 2002). Change of this nature requires a change in one's mindset (Spillane & Thompson, 1997).

Sometimes teachers view a new initiative as something they are already doing. When a new initiative is introduced, teachers may divert their attention to the information with which they are already familiar while disregarding the unfamiliar. Alternatively, teachers may merge the new reform idea with what they already know rather than perceiving it as a completely new idea; causing a loss of the original intent of the idea. New reform ideas may not be properly implemented when teachers focus more on the simple facets of the idea rather than those which require critical thinking (Spillane et al., 2002).

Reform initiatives may make teachers feel like their classroom instruction is inadequate and cause a decline in self-esteem. To "save face" teachers may discredit the initiative based upon their knowledge or skills or teachers may convince themselves the initiative is something they were already implementing in their classrooms (Spillane et al., 2002).

The organization of the public education system also has an influence in reform interpretation and implementation. There is state level, district level, school level and classroom level implementation. The interpretation of reform initiatives at these various levels can differ and even differ between individuals at the same levels thereby impacting reform implementation (Spillane et al., 2002).

Reforming education through effective instruction. Reform initiatives call for students to be active learners; learners who create their own understandings. Active learning is the process of creating meaning from life experiences (Newmann, Marks, & Gamoran, 1996). Active learning requires learning activities that demand higher-order thinking. Instruction and assessment that require demand learning and higher-order thinking is called authentic pedagogy. Authentic pedagogy consists of three criteria: construction of knowledge, disciplined inquiry (a deep understanding), and value beyond school (Newmann, Marks, & Gamoran, 1995). In a study of 24 restructured schools, Newmann and others (1995, 1996) found that authentic pedagogy improves student academic achievement.

Waxman, Padron, and Stringfield (1999) state the use of authentic and student-centered instruction can help teachers present content in a framework that students can understand. Student-centered teaching and scientific inquiry are related because they share common qualities. Student-centered teaching promotes student engagement. Inquiry teaching consists of students constructing their own meaning of phenomena. Inquiry teaching is synonymous with terms such as discovery learning, problem solving, and project-based instruction (Waxman, Padron, & Stringfield, 1999).

The National Science Education Standards require educators to redefine the way in which science instruction is delivered and assessed (Marx et al., 2004). The learning of science requires a change from teacher-centered instruction to student-centered learning (National Research Council, 1996; VonSecker & Lissitz, 1999). "Inquiry is central to science learning" (National Research Council, 1996, p. 2) and defines good science teaching and learning (Anderson, 2002). Teaching through inquiry involves providing students with activities that strengthen their understanding of scientific concepts. Teachers assist students' in developing their inquiry skills by providing them with relevant scientific investigations (National Research Council, 1996).

VonSecker and Lissitz (1999) conducted a study to determine whether the instructional practices recommended by the National Education Standards have an impact on student achievement. The findings of their study showed that the instructional practices do impact student achievement; with laboratory inquiry having the greatest impact.

Johnson (2009) defined effective science instruction as standards-based instruction. Standards-based instruction, instruction based on the NSES, focuses on inquiry. Effective science instruction provides students with an in-depth understanding of concepts, thereby increasing students' knowledge retention and eliminating the need for re-teaching. A study conducted by Johnson (2009) showed that effective science instruction leads to higher student performance on science achievement tests and decreases the achievement gap between white and minority students.

Student interest and science achievement. Hulleman and Harackiewicz (2009) claim meaningful and relevant instructional activities can motivate students who are otherwise reluctant to learn due to their lack of belief in their academic abilities. When science is made relevant to students, it can promote student interest and influence their selection of future science course and science-related careers. They conducted a study of high school students comparing the academic performance and science related career interests of students involved in instructional activities relative to their lives versus a control group of students involved in activities with no relevance to their lives. The results of the study showed that students in the experimental group reported higher interest in science and earned higher course grades.

Statement of the Problem

Wagner and colleagues (2006) state the mediocrity of teaching and instructional leadership is the central problem that must be addressed if we are to improve student achievement. Educational reform efforts have been initiated to improve student performance and to hold teachers and school leaders accountable for student achievement or the lack thereof (Wagner et al., 2006).

Specifically, in the area of science, goals for improving student learning have led reformers to establish standards for what students should know and be able to do, as well as what instructional methods should be used. Key concepts and principles have been identified for student learning. Additionally, reformers recommend student-centered, inquiry-based practices that promote a deep understanding of how science is embedded in the everyday world. These new approaches to science education emphasize inquiry as an essential element for student learning (Schneider, Krajcik, Marx, & Soloway, 2002). Project-based learning (PBL) is an inquiry-based instructional approach that addresses these recommendations for science education.

Purpose of the Study

The objective of this research was to study the implementation of project-based learning (PBL) in an urban school undergoing reform efforts and identify the variables that positively or negatively impacted the PBL implementation process and its outcomes.

Research Questions

1. How was project-based learning conceptualized and implemented in high school science classrooms? How well did the implementation align with the major components of project-based learning?
2. What challenges and successes did science teachers experience as they implemented project-based learning? What other factors impacted (negatively or positively) the implementation of PBL?
3. What role did school administrators play in facilitating the implementation of project-based learning in the school?

Significance of the Study

Powell (1990) states math and science have been historically viewed as being difficult subjects and that often African American students attribute their poor performance in math and science to a lack of ability. African American students have internalized that they do not have the academic competence to perform well in math and science; consequently, they avoid pursuing careers in math and science. This self-defeated mindset is a result of a phenomenon called "learned helplessness" (Powell, 1990, p. 295). Repetitive course failures contribute to the learned helplessness of African American students. As a result, they develop a belief that they will never do well in math and science despite their concerted efforts. They attribute their failures to not being smart in math or science, therefore they avoid these subjects. This belief is one reason for the underrepresentation of African Americans in math and science related careers (Powell, 1990).

School reform in urban schools. In order to increase African American students' interest and success in science, schools have to change the way in which African American students are educated. According to Johnson (2009), the achievement gap between white and African American students still presents a problem for our educational system. Studies have shown there is a relationship between the achievement gap and low performing schools. The majority of students in danger of academic failure attend urban schools (Waxman, Padron, and Stringfield, 1999; Lashay, 2004). These at-risk students are commonly exposed to a skills-based curriculum; one based on the acquisition of basic skills. This type of curriculum does not promote higher order thinking skills (Johannessen, 2004).

Poor instruction is among the many problems present in urban schools (Lashay, 2004; Waxman et al., 1999). The focus of urban school reform is to raise educational expectations for urban students from a basic level of knowledge to a knowledge level that develops critical and creative thinkers (Haberman, 1991). Martin Haberman (1991) discovered what he calls the pedagogy of poverty in 1958. The pedagogy of poverty is characterized by 14 low-level, basic acts of teaching primarily performed by teachers in urban classrooms. The pedagogy of poverty is “certain ritualistic acts that have come to be conducted for their intrinsic value rather than to foster learning” (Haberman, 1991, p. 292). Haberman claims the pedagogy of poverty is ineffective because it does not allow students to develop to their full potential. Rather than using the pedagogy of poverty, Haberman states urban educators should perform specific acts that are associated with good teaching. Acts of good teaching include active student engagement in learning as well as relating content to students’ experiences.

Marx and colleagues (2004) conducted a study in the Detroit Public School system to determine whether an inquiry-based and technology infused curriculum would improve student learning of national science content standards. Results of science assessments showed that student achievement increased as a result of this instructional methodology.

The role of the school leader and school reform. School principals are accountable for student achievement no matter the characteristics of the school which they lead. Principals impact achievement by establishing a school culture that supports teaching and learning (Ross & Gray, 2006).

Leadership is central to school improvement. It entails empowering others with the resources and tools to foster continuous change (Spillane, Halverson & Diamond, 2004). Successful schools are dependent upon the principal’s ability to be an instructional leader. The actions taken by a principal impact student learning. Their daily decisions influence what occurs in the classroom. When the principal includes the staff in decision making, there is a greater chance that staff will be committed to the change. (Bossert, Dwyer, Rowan, & Lee, 1982).

Instructional leadership is not a task to be undertaken by the principal alone. Instructional leadership requires shared leadership (Hallinger, 2005). Shared leadership is the combined ability and skills of an individual leader and other school leaders and members (Spillane, Halverson & Diamond, 2001). Leadership can be divided amongst various individuals within a school; each sharing in the achievement of a final outcome. Instructional leadership is guided by the school leadership along with instructional instruments. Examples of instructional instruments include teacher evaluations, curriculum guides, and student assessments (Spillane, Diamond, & Jita, 2003).

In the case of school improvement, the principal's role as an instructional leader has garnered much attention. Hallinger (2005) identified three main responsibilities of an instructional leader: defining the school's mission, managing the instructional program, and promoting a positive learning climate. Similarly, Spillane and colleagues (2004) identified six key functions essential to instructional leadership:

- Constructing a vision
- Allocating resources
- Developing a collaborative school culture
- Supporting teacher growth and development
- Monitoring of instruction
- Creating a positive school climate

Leadership is a function of the principal's actions and those of all the leaders and followers within a school. The distributed leadership theory describes how leaders disseminate authority amongst various individuals in leadership roles within the organization. Based upon the theory of distributive leadership, school improvement efforts should not separate the leader from the leadership team. The two work hand-in-hand (Spillane, Halverson, & Diamond 2001).

Distributed leadership involves the allocation of leadership responsibilities among two or more individuals (Spillane, Halverson, & Diamond 2001). Distributive leadership includes the myriad individuals working with school staff to improve teaching and learning. These individuals include the principal, assistant principal, curriculum leaders, and lead teachers (Spillane et al., 2003). The collective activity of the leadership team creates a synergy where the outcomes produced by the team are greater than the outcomes produced by each team members working individually (Spillane, Halverson, & Diamond 2001). Instructional change requires distributive leadership. Each person has a different set of knowledge and skills that when combined with that of others create substantive change (Spillane, Diamond et al., 2001).

The implementation of school reform efforts is highly influenced by school leadership. The individual efforts of a school leader cannot improve instruction. It requires the energies of a leadership team (Spillane et al., 2003).

The introduction of a school reform initiative generally necessitates professional development. As an instructional leader, it is the responsibility of the school principal to ensure professional development is provided. According to Youngs and King (2002), in order to increase teacher competencies and student achievement, school leaders must provide professional development activities devoted to three factors: teacher knowledge, skills and attitudes, professional learning communities, and school program coherence.

Professional development assists in the growth of a school's organizational capacity. School organizational capacity is defined as the ability of staff as a whole to increase student achievement. A school's organizational capacity is influenced by five factors: (a) the knowledge, skills, and attitudes of the teachers, (b) the use of professional learning communities to increase teachers' competencies, (c) technical resources to provide high quality instruction, (d) school programs and initiatives that work in tandem for a common goal, and (e) effective leadership. A school's capacity can increase by providing opportunities for professional growth in house or through partnership with external organizations. The principal's participation in professional development activities can ensure that all current and future school initiatives are working together towards a common goal (Youngs & King, 2002).

This study responds to the need to change how science is taught by focusing on the implementation of project-based learning as an instructional approach to improve student achievement in science and identifying the role of both school leaders and teachers in the creation of a school environment that supports project-based learning.

CHAPTER 2 THEORETICAL FRAMEWORK AND REVIEW OF LITERATURE

Project-based learning (PBL) is a student-centered instructional strategy (Kubiatko & Vaculova, 2011). PBL promotes inquiry (Blumenfeld et al, 1991). It presents students with meaningful learning, defined as learning that is relevant to students and that addresses content standards (Kanter, 2010; Larmer & Mergendoller, 2010). However, there is no one universal definition or model of project-based learning (Thomas, 2000). Terms that are related to project-based learning include problem-based learning, problem or project-based instruction, and problem solving. Each term will be discussed respectively.

Project-Based Learning

A commonly held definition of project-based learning is that it begins with the introduction of a problem and concludes with the generation of a final project (Kubiatko & Vaculova, 2011). PBL consists of a driving question that guides student learning and learning activities that culminate with a final project. The final product embodies all a student has learning during a PBL unit. PBL promotes in-depth learning and increases student interest through relevant learning experiences (Blumfeld et al., 1991). Project-based learning (PBL) requires student collaboration to solve real-world problems (Schneider et al., 2002). Students are given autonomy over their own learning, while the teacher serves as a facilitator and guide throughout the learning process. At the end of the project, students present their findings to others. Project-based learning motivates students to learn because they understand the relevance of what they are learning (Solomon, 2003). Research has shown student motivation tends to increase when learning is linked to student's interests (Schwalm & Tylek, 2012). Student motivation is influenced by whether the project is interesting, whether they feel they are capable of doing what is requested by the project, and whether the project prompts students to focus on learning rather than the grade to be earned (Blumfeld et al., 1991).

According to Solomon (2003), there are six elements of a great PBL project:

- The project is aligned with content standards.
- Students make the decisions regarding all aspects of the project.
- Students learn the skills necessary to work in groups.
- The problem is authentic and relevant.
- The project is not time sensitive; it allows time for students to explore.
- There is continuous assessment of student learning throughout the PBL process.

Similarly, Larmer and Mergendoller (2010) identified seven essential elements of meaningful projects:

- A "need to know" - A project must present students with a rationale for learning. A "need to know" is usually presented by way of an entry event. The entry event draws students' interests to the topic being studied.
- A driving question - The driving question guides the students' learning throughout the PBL process. It is the question which is to be answered by the completion of the project. According to Cook, Buck, and Park Rogers (2012), the driving question is the core of project-based learning. It sets the stage for the project and should be structured in such a way to promote students' exploration of the topic. The driving question motivates students to learn because it is related to their own experiences (Schneider et al., 2002).
- Student voice and choice - Students may be given choice and voice in varying degrees. Students may be allowed to select a topic from a list of topics provided by the teacher

or they could be allowed to freely select their own topic of study. Students can also be given choice and voice in how they design a project or the resources they use for the research.

- 21st century skills - Project-based learning should provide students the opportunity to develop and utilize 21st century skills such as the use of technology, communication, collaboration, and problem solving.
- Inquiry and innovation - Students engage in researching the topic of study. With the newly acquired knowledge, students generate new ideas, questions, or a final product.
- Feedback and revision - Throughout the PBL process, students receive feedback which guides and informs their learning. The feedback can come from the teacher and/or other students.
- A publicly presented product - Students present their final product(s) to an audience beyond the teacher.

Furthermore, Krajcik, Blumfeld, Marx, and Soloway (1994) identified a model of PBL containing five essential features: (a) a driving question, (b) development of an artifact, (c) inquiry learning, (d) collaboration and (e) use of technology. Technology is used as a tool for students to conduct self-directed research (Cook, 2009).

Problem-Based Learning

Problem-based learning was developed by Howard Barrows (1998) as an instructional strategy used in medical schools. Medical school students were given real world problems to help them develop their diagnostic skills. Students gathered information and data related to the problem to assist them in creating a medical diagnosis. The instructor facilitated the process of problem-based learning by asking questions and providing guidance (Thomas, 2000).

Since the introduction of problem-based learning, Barrows (1998) noted that many variations of problem-based learning had arisen. Barrows felt it was necessary to develop a “true” definition of the instructional strategy. According to Barrows (1998), problem-based learning has three goals: a deep understanding; development of problem-solving skills, inquiry learning, and collaboration; and an excitement for learning.

Barrows (1998) also identified several key elements that are essential to problem-based learning:

- **Student-centered**: Students have control of their own learning. The teacher serves as a facilitator of knowledge. Students are not dependent on the teacher for their learning.
- **Problem-based**: The problems students are given are actual situations students may experience in their own lives.
- **Problem solving**: Problem-based learning requires students to be analytical thinkers.
- **Self-directed learning**: Problem-based learning allows students to determine and research the information they need to know to solve the problem.
- **Collaboration**: Students work with others and share ideas.
- **Integration**: The problems presented in problem-based learning cross multiple disciplines.
- **Reiteration**: Students take the new information learned and identify how it relates to the problem.
- **Reflection**: After identifying a possible solution to a problem, students discuss what they learned during the problem-solving process.
- **Peer and self-assessment**: Students get feedback from others and evaluate their own skills and behaviors during the process of problem-based learning.

- **Motivation**: Problem-based learning incites in students a passion for learning.
- **Authenticity**: The problems presented in problem-based learning are related to real-world experiences.
- **The tutor**: The teacher is a facilitator; asking probing questions and providing guidance as needed.
- **Student assessment in problem-based learning**: Problem-based learning assessments do not focus on knowledge gained, but of the application of the higher order skills learned through the process such as problem-solving, collaboration, and inquiry.

Similarly, Hmelo-Silver (2004) supports Barrow's notions regarding problem-based learning. She concurs that in addition to promoting the learning of new knowledge, problem-based learning promotes the acquisition of 21st century skills and is recognized for its ability to motivate students.

In problem-based learning, learning begins with the introduction of a real-world problem and students work in groups to the solve problem. The problem does not have a predetermined solution; therefore, the possibilities of solutions are not limited (Hmelo-Silver, 2004). Within problem-based learning, problems are structured to evoke student inquiry, while helping students take control of their own learning (Gallagher, 1997). According to Hmelo-Silver (2004), the problem-based learning cycle includes students identifying what they already know about the problem, formulating a hypothesis, identifying new information needed to solve the problem, researching the new information, applying the new information, and evaluating their conclusion. Students collaborate with one another to share ideas and obtain feedback. If necessary, students make modifications to their hypothesis and begin the process again. Hmelo-Silver (2004) called this process the problem-based learning tutorial process.

During problem-based learning, teachers act as facilitators of knowledge by asking probing questions. The role of the teacher is to promote metacognition through questioning and providing suggestions. The questions they ask help develop higher-order thinking and re-direct students as needed (Gallagher, 1997; Hmelo-Silver, 2004; Gallagher, Stepien, Sher & Workman, 1995). Additionally, the teacher ensures the problem is challenging, but still within the abilities of the students to ensure students' success (Gallagher, 1997).

Problem-based learning is a process. The skills students need to be successful in problem-based learning must be taught over a period of time (Savery, 2006).

Project-Based Instruction

Project-based instruction is typically used in the science classroom and follows the constructivist theory of learning (Krajcik et al., 1994). Colley (2008) states in order to effectively implement project-based instruction, there are a few conditions that need to be followed. The teacher must serve in the role of a facilitator and the student that of a researcher of knowledge. Both the student and teacher's roles are interchangeable; at times the teacher assumes the role of a student and the student that of a teacher and vice versa. Project-based instruction requires in-depth lesson planning and the delivery of instruction must be strategic. Finally, the lessons must be relevant to students (Colley, 2008).

Project-based instruction follows a cyclic process beginning with an introduction to project-based learning. The process continues with the introduction of the problem followed by the determination of the process to solve the problem. Students then carry out the process while collecting and analyzing data. At the conclusion of the project, students reflect on their findings and determine possible future actions (Colley, 2008).

Problem-Solving

According to Pizzini, Shepardson, and Abell (1989), in order for students to become problem solvers, instruction must be designed to teach problem-solving skills. Pizzini and colleagues developed the SSCS (Search, Solve, Create, and Share) model to teach science through problem-solving, which includes a 4-step cyclic progress:

- Search: students identify a researchable problem.
- Solve: students develop a plan to solve the problem.
- Create: students create a product that displays what they learned.
- Share: students present what they learned.

In this model, students are motivated to learn because they select their own problem to investigate. The teacher in this model serves as a facilitator.

Project-Based Learning vs. Problem-Based Learning

Project-based learning and problem-based learning are often used interchangeably. They are similar in that both focus on inquiry learning. They differ in that problem-based learning originated in medical schools whereas project-based learning originated as a response to educational reform. Additionally, in problem-based learning, students work to find a solution to a problem, while in project-based learning students create an actual product (Colley, 2008; Kubiatko & Vaculova, 2011).

Since there is no universally accepted definition of project-based learning, Thomas (2009) identified five criteria that a lesson should meet in order to be considered project-based learning. These five criteria will be the conceptual framework upon which this research study will be based.

The five criteria are: centrality, driving question, constructive investigations, autonomy, and realism.

- **Centrality**: Students learn the content through completing the project. The project is the starting point for learning. It is the curriculum.
- **Driving Question**: Projects begin with a question that motivates and directs students' learning.
- **Constructive Investigations**: Projects are inquiry based. If the project is not challenging or requires students to use information they already know, then the project would be considered an exercise, not PBL.
- **Autonomy**: Projects provide students with choice.
- **Realism**: Projects are relevant and real-world related.

For simplicity purposes, instructional models that meet the aforementioned criteria hereon will be considered and defined as project-based learning.

Characteristics of Project-Based Learning

Project-based learning (PBL) is a student-centered instructional strategy and it enables students to develop the problem-solving skills they will need to function in society (Gallagher et al., 1995; Kubiatko & Vaculova, 2010; Lam, Wing-Yi Cheng, & Choy, 2010). Students acquire new knowledge through the process of problem-solving (Goodnough & Cashion, 2006). Although PBL is student-centered, teachers can determine the extent to which PBL is student-centered based on the age of the students, the intellectual abilities, and the instructional goals (Gurses, Acikyildiz, Dogar, & Sozbilir, 2007). Teachers should create lessons focused on the learner to help develop students' ability to think critically, problem solve, collaborate and to communicate with others (Lam, Wing-Yi Cheng & Choy, 2010).

While the research on project based learning varies in regards to the essential elements of PBL, the identification of a problem, self-directed inquiry, and collaboration are commonalities identified in the research. Gallagher and others (1995) stated there are three components essential to project-based learning: (a) introduction of a problem, (b) a problem with no predetermined solution, and (c) the teacher serving as a coach. Project-based learning (PBL) presents students with the problem first in order to establish the relevance for learning the content. Unlike a PBL classroom, a typical classroom generally introduces a problem after instruction, which can mislead students to believe that problems only occur after all the information needed to solve the problem has been acquired. When the problem is presented after instruction, often students do not realize the relevance of their learning. They do not see the connection between the problem and their learning (Gallagher et al., 1995). In PBL, the problems presented to the students are different from problems commonly used in instruction in that students are not given enough information to solve the problem. Students are responsible for gathering the needed information. Additionally, there is no single right answer for the problem (Cook, 2009; Etmer & Simons, 2006; Gallagher et al., 1995). Students work in groups; sharing new ideas and knowledge (Cook, 2009; Goodnough & Cashion, 2006). Collaboration helps students persist in the project-based learning process. By conferring with their peers, they are able to get feedback, suggestions, and guidance (Meyer, Turner, & Spencer, 1997). As students gather information about the problem, the problem becomes more defined. PBL problems are generally multidisciplinary; enabling students to see the connection between subject areas. Finally, a sense of uncertainty will be present in PBL as information will be missing in order to come to a definitive solution (Gallagher et al., 1995).

The learning that occurs during the PBL process is represented by a "Need to Know" board which identifies the problem and the information needed, the analysis of the information gathered and the redefining of the problem based on the new information obtained (Gurses et al., 2007). PBL allows student choice. Choice can be given in what they work on, how their learning is attained, and the product produced. The learning tasks used in PBL should not be so demanding and complex that students focus more on completing the task than the learning (Blumfeld et al., 1991). The artifacts students construct through PBL demonstrate what they have learned. PBL artifacts promote in-depth understanding of the concept being studied (Blumfeld et al., 1994). Students construct artifacts to demonstrate what they have learned. Projects are typically eight-sixteen weeks in length (Schneider et al., 2002).

In PBL, the role of the teacher is to scaffold the content, provide guidance, manage student groups, continuously assess students' learning and provide opportunities for reflection (Tarmin & Grant, 2013). Scaffolding is an important process in project-based learning. Teachers have to carefully structure the learning activities to build upon each other; thereby gradually developing students' knowledge (Ngeow & Yoon-San, 2001). Teachers work with students to help them become self-directed learners which is done first by teacher modeling and then by allowing students to implement the skills on their own (Gallagher et al., 1995). Teachers act as facilitators of knowledge (Cook, 2009). Throughout the process, the teacher provides guidance and feedback (Etmer & Simons, 2006; Kubiatko & Vaculova, 2010). In project-based learning, students should receive feedback throughout the process in order to guide and monitor their learning (Ngeow & Yoon-San, 2001). Journal writing, self-evaluations, and reflections are useful ways to monitor student learning throughout the PBL process (Cook, 2009, Etmer & Simons, 2006). Reflection is an important step in project-based learning because it gets students to think about what they are learning or have learned (Ngeow & Yoon-San, 2001).

Implementation of Project-Based Learning in the Classroom

Project-based learning is an effective means of differentiating classroom instruction. It improves students' understanding of content and develops higher order thinking skills (Blumfeld et al., 1991; Schwalm & Tylek, 2012). PBL is not only a method to teach content, but also to expose students to the ways of thinking in various specialty areas (Gallagher, 1997). Proper implementation of project-based learning requires changes in curriculum and instruction (Gallagher, 1997). If used correctly, project-based learning will meet both state and national content standards (Colley, 2008).

Prior to implementing project-based learning, it is necessary to establish a learning environment in which students feel free to take risks (Solomon, 2003). Meyer, Turner and Spencer (1997) state project-based learning presents students with learning challenges. Some students welcome challenges, while others do not. The role of the teacher, therefore, is to create a learning environment where it is safe to make errors. Teachers must create an environment where students feel safe in learning by trial and error; an environment in which their learning is not stifled by a need to finish the project by a certain time or a need for 100% accuracy. By creating this type of learning environment, students will be more focused on the learning rather than just simply completing the project. Teachers should get to know their students so they will know how to structure projects to meet their students' learning preferences (Meyer et al., 1997).

Tarmin and Grant (2013) conducted a case study of the implementation of project-based learning. They found that teachers in the study used project-based learning in four different ways; to introduce a concept, for enrichment or extension of a concept, to reinforce a concept, or they used PBL based on the needs of students. Of the four, only one (use based on the needs of students) held true to the PBL criterion of the project being the center of student learning. They also found that in order to successfully implement project based learning, teachers must be motivated, open to change their instructional practice, and flexible. Furthermore, teachers need to be open to the concept of student-centered learning, and confident in their ability to use the strategy (Lam et al., 2010; Tarmin & Grant, 2013).

Successful implementation of PBL requires the support of both teachers and administrators. Teachers will need training through workshops or possibly an entire course devoted to learn the skills needed to properly implement PBL (Gallagher, 1997). Additionally, Goodnough and Cashion (2006) recommended that the implementation of project-based learning: (a) should not be used as a cookie-cutter approach, (b) provide teachers with proper preparation and training prior to engaging in PBL, (c) include professional learning communities to provide teachers the opportunity to collaborate, and (d) adapt PBL to meet the learning needs of students. According to Blumfeld, Krajcik, Marx & Soloway (1994), collaboration can increase teacher motivation and the sharing of ideas. Additionally, they state collaboration provides teacher encouragement.

Project-Based Learning in Science

Due to its inquiry nature, the majority of research on project-based learning has been conducted in the area of science. PBL can provide students with more opportunities to learn science content (Demirci, 2010). The goal of science education is to create scientifically literate students. In order to do so, schools must change the delivery of science instruction. According to Gallagher and colleagues (1995), PBL can be modified to fit the characteristics of scientific inquiry by utilizing a problem that is science related, allowing students to plan experiments, generate and test their hypotheses, gather and analyze data, and communicate their findings verbally or in written form. Kanter (2010) states a project-based science curriculum presents science content standards to students in a manner that helps students develop meaningful learning.

Project-Based Learning and Teacher Training

Teachers need professional development and resources to overcome the challenges associated with project-based learning (Tarmin & Grant, 2013). Professional development is a key element in improving the quality of instruction (Goodnough & Cashion, 2006).

Murray and Savin-Baden (2000) conducted a study of PBL staff development and found that modeling a PBL workshop in the form of the actual PBL process was helpful to teachers. They recommended that staff development begin at least a year prior to the implementation and that ongoing workshops be held throughout the year to support staff in the implementation of PBL. Furthermore, they stated all staff must buy into the concept of PBL and that leadership plays a crucial role in its successful implementation.

Training for the implementation of PBL can begin as early as teacher preparation programs. Cook and others (2012) made the following recommendations for teacher preparation programs to assist teachers in implementing project-based learning.

- Teachers should facilitate discussions which enable students to gain a clear understanding of the concept.
- Teachers should design lessons that gradually build upon students' knowledge and skills and that meet the learning objectives.
- Teachers need the skills to develop group activities so that students are focused on learning and not on the completion of the task.
- Teachers should develop summative assessments that require higher-order thinking skills.

- Teachers should administer assessments throughout the process to monitor student learning and to guide their instruction.

School support also plays an important role in the implementation of PBL. Lam and colleagues (2010), studied three types of school support: competence support, autonomy support, and collegial support. They found that the level of a school's support in these three areas can affect teachers' motivation. Their study investigated whether school support effected teacher motivation to implement project based learning. They found that teachers were highly motivated when they felt their school supported them in all three areas and therefore they were more willing to use and continue to implement PBL. Additionally, they found that teacher motivation depends on the level of support in all three areas. They concluded that motivation is essential in prompting teachers to make the necessary changes in their instruction to meet students' needs. When teachers' needs in the three areas of support are met, they are motivated to make changes.

Project-Based Learning versus Traditional Instruction

Comparison studies of the effectiveness of PBL versus traditional instruction showed that students in a PBL classroom retained knowledge longer and attained higher achievement scores than students in a traditional classroom. Moreover, PBL students demonstrated positive attitude towards the subject matter, were more engaged, had better collaboration and communication skills, and had higher levels of problem-solving skills (Alacapinar, 2008; Demirci, 2010; Drake & Long, 2009; Schneider et al., 2002; Wong & Day, 2008). These positive results were attributed to students being taught in a constructivist manner; constructing their own knowledge and understanding of the content, not just by memorizing facts (Wong & Day, 2008). The results, however, also showed that PBL may not be the best instructional approach for all teachers. According to Mergendoller, Maxwell, & Bellisimo (2006) some teachers may be more effective at using traditional instructional approaches. In their study, Mergendoller and colleagues (2006) compared the effectiveness of a group of five teachers using PBL to the same group of teachers using traditional instructional methods. The teachers taught one class using PBL and another class using traditional methods. The findings of the study showed that of the five teachers studied, one teacher was more effective using traditional instructional strategies than PBL.

Challenges and Benefits to the Implementation of Project-Based Learning

There are a number of challenges related to the implementation of PBL. One challenge is that students may not have the ability to develop questions on their own to fully engage in the PBL process. Therefore, it becomes the responsibility of the teacher to model metacognition. A good resource to use in this process is the "Need to Know" board. The "Need to Know" board identifies what students already know and what they need to know (Gallagher, 1997; Goodnough & Cashion, 2006). Another challenge to the implementation of PBL in K-12 classrooms is that the demands of teaching the required curriculum and preparing students for high-stakes tests do not leave sufficient time for teachers to engage students in problem-based learning (Savery, 2006). Teachers are therefore forced to make the choice between the curriculum or PBL. Most likely the curriculum will be selected over PBL.

Designing a PBL unit can also present challenges to teachers. Ngeow and Yoon-San (2001) identified three challenges to the implementation of project-based learning:

- Some students lack the ability to work in groups.
- Some students lack adequate problem-solving skills.
- Lack of timely teacher feedback to guide the learning process.

Kanter (2010) studied the development of a PBL unit and identified three challenges in designing a project-based curriculum and how to address these challenges.

- **Challenge one**: Establish a need to learn the content.
    - Strategy to address this challenge:

      a) Unpack the task: determine what information is needed to complete the project, b) Highlight an incongruity: generate discrepancies between what students know and what they believe to establish the desire to explore new possibilities through experimentation, and c) "Try to apply": encourage students to engage in the process of "trial and error"; in other words allow students to try possible solutions and learn from their failures.
- **Challenge two**: Applying all the content.
    - Strategy: Analyze the performance project to ensure it requires students to use all the content that is to be taught.
- **Challenge three**: Apply all the content in a timely fashion.
    - Strategy: Do not allow too much time to pass between the learning of the content and the application of the new knowledge to the project. Break the project into phases/stages, in order for students to apply new knowledge soon after it is acquired.

Etmer and Simons (2006) identified four challenges teachers are prone to encounter with the implementation of project-based learning and strategies to overcome them:

- **Creating a collaborative classroom culture**: use mini units to practice PBL skills; at the conclusion of a lesson, discuss the PBL process as an entire class.
- **Adjusting to changing roles**: The teacher has to adjust to the role of being a facilitator. He/she can do so by writing scripts and/or procedures to follow for certain activities. Teachers can also observe other teachers who use PBL.

- **Scaffolding student learning and performance**: teachers provide students with support as needed, and when necessary, pre-plan supports based on anticipated student struggles.

The transition to a project-based learning classroom can be difficult because both the teachers and students experience a shift in their roles (Solomon, 2003). In addition to the challenge of making the transition from the role of lecturer to that of a facilitator, Goodnough and Cashion (2006) mentioned the facilitation of group activities and using open versus closed questions as other challenges to the implementation of PBL. Furthermore, PBL presents teachers with the challenge of modifying and/or creating assessments that not only assess what students know, but also what they can do. Traditional assessments test what students are able to remember, not necessarily the problem-solving skills they have acquired (Wood, 1994).

Change in teacher and student comfort levels present another challenge in the implementation of PBL. In *The Problems of Problem-Based Learning*, E.J. Wood (1994) states that PBL may pose problems for students that are accustomed to traditional instructional strategies. The exploratory nature of PBL may be uncomfortable for students that are used to memorizing and recalling facts. Additionally, since teachers' roles shift to that of a facilitator, they may feel that students will not attain the same level and amount of knowledge they would normally attain with traditional lecture methods. PBL may be uncomfortable for teachers because they are no longer the holders of all knowledge. Just like students, they might not know the answer to the problem being investigated (Wood, 1994).

When teachers believe in the benefits of project-based learning, their belief empowers them to overcome the challenges associated with project-based learning (Tarmin & Grant, 2013).

Although there are challenges to the implementation of project-based learning, the benefits far outweigh the challenges. As a result of PBL, students learn presentation skills, how to work in groups and to be self-directed learners (Goodnough & Cashion, 2006). The use of PBL has also shown to improve student achievement on content area tests and students' problem solving skills (Gurses et al., 2007). Similarly, according to a study conducted by Pepper (2009), aspects of PBL that students enjoy include working in groups, working at their own pace, and sharing ideas. On the other hand, students identified lack of direction, group issues, and oral presentations as aspects of PBL they did not enjoy.

In a case study conducted by Tarmin and Grant (2013), teachers of PBL identified four benefits of project-based learning:

- Improvement in the quality of work produced by students, their use of 21st century skills and their performance on project tasks.
- Students are able to choose how they learn and how they demonstrate what they learned.
- Students are motivated and engaged.
- Students learn how to work effectively in groups.

Summary

The goal of science education is to create scientifically literate students. In order to do so, schools must change the delivery of science instruction. Project-based learning (PBL) is a student-centered, inquiry based instructional strategy that addresses the goal of science education. PBL begins with the introduction of a problem and ends with the creation of a final product. During PBL, students work collaboratively to solve a real-world problem. The problem does not have a pre-determined solution, so the possibility of solutions is limitless. Throughout the PBL process, teachers act as facilitators of learning and guide students through the process. Projects are typically eight to sixteen weeks. Other terms related to PBL include problem-based learning, problem or project-based instruction, and problem solving.

Project-based and problem-based learning are often used interchangeably. They are similar in that both involve inquiry learning. However, they differ in that in problem-based learning, students work to find a solution to a problem, where in project-based learning, students create an actual artifact.

Since there is no universally accepted definition of project-based learning, Thomas (2000) identified five criteria a lesson should meet to be considered PBL. The five criteria are centrality, a driving question, constructive investigations, autonomy, and realism.

There are a number of challenges related to the implementation of PBL. Students may not have the skills to engage in inquiry and problem solving. Teachers may not have the time to engage in PBL due to the pressure to cover content for high-stakes tests. Additionally, students and teachers are challenged with the shift in their roles; the teacher serving as a facilitator and the students taking control of their learning.

Among the benefits associated with PBL are an increase in student engagement and motivation, as well improvement in student achievement.

CHAPTER 3 METHODOLOGY

This research study examined the implementation of project-based learning (PBL) in an urban school undergoing reform efforts to identify the variables that positively or negatively impacted the PBL implementation process and its outcomes. A case study was the methodology utilized to conduct this study. According to Merrimam (1988), a case study is a research design that methodically examines a specific topic. It is a form of non-experimental research and is generally used when a researcher desires a deeper understanding of a topic. Furthermore, Merriman (1988) states the decision to select a non-experimental design such as a case study depends on the following:

- The research questions: Questions that seek to answer “how” and “why” are best answered through a case study.
- The amount of control: Experimental conditions which are difficult to control are best suited for a case study research design.
- The end product: Findings that are expressed as a description or interpretation of a phenomenon are best acquired through a case study research design.

Furthermore, according to Merrimam (1988), a case study that solely presents an in-depth explanation of the research findings, without forming any theories or hypotheses or making judgment, is considered a descriptive case study. Descriptive case studies provide a description and explanation of the topic of study. Hence, descriptive case studies are classified as qualitative research. Qualitative research has distinct characteristics. In qualitative research, the researcher (a) seeks to understand how phenomena operate, (b) is concerned with gaining an understanding of phenomena, (c) is the main tool for data collection, (d) engages in observations at the site of study, (e) presents the research findings in words or pictures, and (f) generates theories and hypotheses (Merriman, 1988).

Setting

The study took place in an urban school in the metropolitan Detroit area. The city in which the school was located had a population of approximately 701,475 citizens. The population consisted mainly of African-Americans, Hispanics, and Arab-Americans. The median home value was $59,700 and the median household income was $26,955. Over 77% of residents 25 years old and older were high school graduates; 12% of whom had a Bachelor's Degree. Major employers in the area included several automobile manufacturers and a financial lending institution (local news publication).

The school in which the study took place was part of a new state-wide public school system, established as a means to lead educational reform in the state's lowest performing schools. This new school district took over the operation of the 15 lowest performing schools in the city; nine elementary schools and six high schools, both public and charter, and was governed by an 11-member school board. The district did not operate using funds from local taxes but was funded by per pupil state aid and public and private donations.

The new educational reform model, by which this independent district operated, was based on the concept of student-centered learning. Students were provided with their own subject-specific learning plans and worked at their own pace to achieve the subject outcomes. Once a student achieved proficiency in a subject, the student was allowed to progress to the next subject.

The district's student-centered model was based on five pillars: (a) students are grouped by readiness, not grade level, (b) students have ownership of their own learning, (c) students work at their own pace, (d) students demonstrate proficiency through performance tasks and common assessments, and (e) frequent feedback is provided to all stakeholders (Sturgis, 2013). The district's schools followed a 7.5-hour school day for students and an 8-hour day for teachers and the school year was 210 days for students and 220 days for teachers (Sturgis, 2013).

The school in this study was a high-need, public school that educated students in grades 9-12. The student population was approximately 724 students. Ninety-seven percent of the student population was African-American and 2% Asian. Eighty-six percent of the students were eligible for free/reduced lunch, which was the reason why the school was eligible to operate a school-wide Title I program. Less than 5% of the students were proficient in any of the core content areas assessed on the 2013 state exam. The average ACT composite score was 13.8, and the school had a graduation rate of 54.2% and a drop-out rate of 21.1% (state school data website).

Participants

The study participants included three science teachers, an Instructional Coach, a Project-Based Learning Professional Development Facilitator, and the High School Principal. Participation in the study was voluntary and each participant's identity was fully protected by use of a pseudo name.

Data Collection

All data collection was done after the study had been approved by the Wayne State Human Investigations Committee. Data for the study was collected primarily through classroom observations, supplemented by interviews, a survey, and instructional artifacts. The data collection matrix displayed in Table 3.1 was used to help identify the data needed to address each research question and the method to be used for the data collection (LeCompte & Schensul, 1999).

Table 1

Data Collection Matrix

Research Questions	Method of Data Collection
How was project-based learning conceptualized and implemented in high school science classrooms?	Survey, Interviews
How well did the implementation align with the major components of project-based learning?	Classroom observations, Interviews, Artifacts
What challenges and successes did science teachers experience as they implemented project-based learning? What other factors impacted (negatively or positively) the implementation of PBL?	Surveys, Interviews, Classroom observations
What role did the school administration play in facilitating the implementation of project-based learning?	Surveys, Interviews

Data gathering methods. Prior to the commencement of the study, an informal meeting was held with the research participants to discuss the nature of the study. At this meeting, teacher participants completed the consent to research form and scheduled a follow-up meeting date. The purpose of the follow-up meeting was to fill out the survey, to discuss the PBL unit to be observed, and to schedule the focus group interview and subsequent observation dates.

The researcher gathered data by means of a survey, interviews, and observations. The 5-point Likert-type scale from 1 (strongly disagree) to 5 (strongly agree) was used to assess teachers' beliefs about the usefulness of Problem-based Learning; how well prepared they felt to implement PBL; and the level of training and support they have received with PBL. The survey also included an open-ended question asking teachers to define PBL.

An individual interview was also conducted with the instructional coach, PBL professional development facilitator and the high school principal. These interviews followed an open-ended, exploratory format. The interviews took place at a mutually agreed time and place between the participants and the researcher. The interviews were tape-recorded based upon participant approval. The interviews were 50-60 minutes in length.

After each interview, the audiotapes were transcribed using the activity log technique. The activity log technique involves marking a segment on the audio tape that contains key information so that it can be easily located and creating a verbatim transcription of this segment. A general description of the contents of the tape segment is also included in the log (Schensul, LeCompte, Natasi, & Borgatti, 1999).

Classroom observations were for the full duration of a class period. The researcher took field notes during each observation, following the method of taking field notes as described by Merrimam (1988). The field notes recorded classroom occurrences during the PBL unit. The field notes contained important details related to the observation such as the time, place, and purpose of the observation. The field notes also indicated the number and types of people present (i.e. student, teacher, instructional coach). A diagram of the room-set up was included as well. The researcher made note of direct quotes or statements of major significance in the field notes. Any comments the researcher had regarding the observation were recorded in the margins of the field notes (Merrimam, 1988). A 15-minute debriefing session was held with each teacher after every observation.

Data Analysis

The data collected from the observations, interviews, and surveys were analyzed using ethnographic analysis as described by Spradley (1980).

Analysis of surveys. The data collected from the surveys was expressed in nominal scales of measurement. The responses to the survey questions were calculated into percentages related to the level of agreement or disagreement and comments were analyzed for patterns.

Analysis of classroom observation data. An observation protocol was developed based on the five criteria a lesson should meet in order to be considered project-based learning (Thomas, 2000). The five criteria identified by Thomas (2000) are: (a) centrality: the project must be the starting point for learning, (b) driving question: the project begins with a question that motivates learning, (c) constructive investigations: the projects are inquiry based, (d) autonomy: the project provides the students with choice, and (e) realism: the projects are relevant.

The classroom field notes were analyzed for domains (categories) that emerged as described by Spradley (1980). For each identified domain, a domain analysis worksheet was created to identify the three basic elements of each domain: the cover term, included terms, and semantic relationship. The included terms for each domain were divided into smaller subcategories based on similarities through the process of taxonomic analysis. A taxonomic diagram, such as a taxonomic tree, was created to illustrate the hierarchal categories of the domain. The ethnographic analysis continued with a componential analysis of each domain to identify contrasts (differences) among the included terms of the domain. A paradigm worksheet was constructed to illustrate and organize the contrasts that were identified (Spradley, 1980).

Analysis of interview data. Interviews were transcribed using the activity log technique. Interview responses were grouped question by question. Using the process of content analysis (Merrimam, 1988), the responses for each question were reviewed to identify categories into which the responses could be grouped. Each category was assigned an abbreviated code. Subcategories with corresponding codes were created as needed. Each response was labelled using the abbreviated codes. The responses were sorted by the abbreviated category codes and analyzed to identify patterns, themes, and relationships within and between categories.

Triangulation of Data

According to LeCompte & Schensul (1999), triangulation is the use of multiple sources of data to ensure the accuracy of the findings. Two types of triangulation were used in this study. Data triangulation involves obtaining and comparing data from different sources (Guion, Diehl, & McDonald, 2011). In this study data were obtained from the teachers, instructional coach, PBL professional development facilitator, and principal. The second type of triangulation, methodological triangulation, involves analyzing data collected by different methods (Guion et al., 2011). Interviews, observations, and surveys were the multiple methods of data collection in this study. The process of triangulation resulted in a rich and accurate account of the study's findings (Guion et al., 2011).

CHAPTER 4 RESULTS

The purpose of this study was to examine the implementation of project-based learning in an urban high school undergoing reform efforts and to identify the variables that positively or negatively influenced the implementation process and its outcomes. Results are based on quantitative and qualitative data addressing each of the research questions.

Conceptualization of Project-Based Learning

One of the research questions dealt with the process used to conceptualize the implementation of project-based learning in the school. Data were obtained from interviews with the school principal, science instructional coach, and the PBL workshop facilitator.

Principal's background and preparation. Steve, the school principal, was in his second year as principal at this high school. He began his teaching career as a secondary English teacher and spent the last 17 years as a principal at the elementary and high school levels. He also worked as a middle school assistant principal for three years. Steve had not received formal training on project-based learning. He was introduced to PBL as a classroom teacher and had collaborated with other teachers to create interdisciplinary PBL units. During his transition from classroom teacher to school administrator, Steve pursued his interest in project-based learning by establishing school-wide expectations of inquiry-based lessons and making a concerted effort to hire teachers with experience in PBL. During his work as an administrator at a previous school he could not afford the cost of PBL training for his staff and therefore conducted a book study on PBL with them.

According to the school's principal (Steve), he had a vision for STEAM (Science, Technology, Engineering, Art, and Math) which began at his former school, a PBL school. When he came to his current school, he wanted to continue that vision. Therefore, he included PBL as one of the school's improvement strategies and one of the first things he did when he arrived was to begin investing money in PBL. He and his staff consulted with companies that focused on PBL, such as the Buck Institute and Educurious. He was already familiar with the work that Educurious did with inner city schools.

In his efforts to implement PBL in the school, Steve involved the instructional coach, the Title I coordinator, and the school improvement grant coordinator in reviewing the PBL proposals and determining which company's program aligned best with the school's vision. The team selected Educurious because they felt the company had great sample lessons and a good teacher-training program. One of the things that stood out most to the team was the fact that Educurious' trainers were actually teachers.

When asked about his role in the implementation of project-based learning, he responded it was ensuring teachers had resources and support. As he pointed out:

> I think that for project-based learning to work, you have to have resources, especially in high poverty areas where the kids are not going to come with materials and supplies. The success of your project is going to be on what the kids have access to and the teacher. So we put tons of money into resources.

Steve realigned funds from the school improvement grant (SIG) and Title I funds to pay for the PBL resources the teachers needed. Some of these resources included teacher training and PBL units from Educurious. According to Steve, the teachers did not have the resources to do the things they were being asked to do. With the adoption of PBL, Steve allowed teachers to order the materials they needed based on the units they developed, creating teacher ownership of the PBL projects.

Many of the resources available to the teachers were through Educurious. By purchasing Educurious' services, teachers were provided with coaches, an online learning environment, and access to the Educurious website. Steve stated he also provided additional support to the teachers by reviewing and providing feedback in their PBL units. Steve spent over 1.5 million dollars on the school's PBL initiative, which included the installation of a STEAM lab that had a PBL focus. He mentioned the majority of the funds the school received came from grants, not the district. As he pointed out, "the district is strapped for funds so you just have to have a vision for it and just go. Money is out there because funding for inquiry-based science is supported through the National Science Foundation (NSF)."

Other forms of support included teacher observations and feedback. Steve stated that when he went into a PBL classroom, the outcome of the project was the first thing he checked. According to him, he expected to see constant teacher facilitation and students engaged either in small groups or working independently. He expected to see classrooms where the teacher was walking around and asking questions. He pointed out that he was aware that PBL could be a lot of work and that teachers needed constant support in implementing it. According to him, "you have to hang in there and make sure the teachers do not abandon the style because they will go to a style they are comfortable with. Good, bad, or indifferent, they will still go back to where they feel comfortable."

Educurious. Educurious provides training to equip teachers with the knowledge, skills, and tools to create relevant, project-based units. Components of the Educurious program include professional development, project-based units, and an expert network. The professional development is delivered through face-to-face, virtually, and coaching sessions. Once a school partners with Educurious, teachers have access to the Educurious online network through which they can share ideas and strategies. Upon completion of training, partner schools are provided with implementation and ongoing support. Educurious also provides leadership training to teach teachers and school leaders on how to facilitate the implementation of the PBL instructional approach. The company offers partner schools the option of purchasing pre-planned project-based units, including five courses in Biology and six in ELA and Humanities. The courses are aligned to the Common Core and Next Generation Science Standards. Schools can purchase full year courses (5 units in sequence) or single units that can be used at teachers' discretion. Field experts are available to provide feedback and answer questions as students and teachers work on projects.

PBL facilitator's background. Christy was employed by Educurious to train educators in the use of PBL. Prior to being hired by Educurious, Christy had over 20 years of project-based learning experience as a teacher. According to her, she began using PBL before she was even familiar with the concept. Her first experience with PBL took place when she taught a horticulture class in an inner city high school for students who had previously failed Biology. She had difficulty getting students to do any work and to garner their attention she used the students' interests to create lessons in which students researched and built artifacts. Christy described her first PBL experience with this group of students:

> I had this advanced horticulture class but I could not get those kids to do anything. So, finally, I was like, what do you guys want to do? The big bully guy was like, "I want to make a pond." I was, like, okay, what would that take? Pretty soon they were researching about how to make a pond. Then they were researching how to make a bio-filter, then they fundraised and we visited nurseries.

Christy believed PBL was a whole way of life. According to her, "project-based learning is not like looking up information in a book and doing a Power Point." Christy believed PBL looked differently in every classroom and did not believe PBL was a one size fits all approach. She felt teachers should not be required to use PBL as an instructional approach all the time.

School's science instructional coach background and preparation. The school's science instructional coach, Rick, had also been involved in the conceptualization of the PBL program. Prior to his role as a science instructional coach, Rick was a high school science teacher for six years during which he taught Biology, Anatomy, Physiology, Astronomy and Earth Science. His teaching experience included both charter and public schools.

To serve as a science instructional coach, Rick had to participate in a course called Coaching 101 offered through the State of Michigan. The course was one-week long and included free, ongoing training that he could attend at any time. This course was required for any school in the state with a high percentage of students from poverty and low academic performance. According to Rick, Coaching 101 specifically focused on how to communicate with teachers and taught participants to use questioning skills. Rick explained:

> The only way I can get through to teachers is to form relationships with them. If I do not have a relationship with them, then they are not going to listen. They are not going to think for themselves. They are not going to spill their guts.

The overall responsibilities of the science instructional coach included assisting teachers in using assessment data to inform classroom instruction. The data they used included state and district assessment data. Rick's role was to help teachers interpret the data and collaboratively decide which standards to target and assist teachers in developing strategies to increase student achievement. He also served as a mentor to teachers, observing their practice, modeling instructional strategies and co-teaching with them. Part of Rick's role as a science instructional coach was to plan the full-day professional development activities of the science department. Some of the workshops he presented focused on formative assessments and project-based learning.

Throughout the year, the school had identified professional learning community (PLC) time for teachers to participate in professional development opportunities and to work collaboratively as a department, focusing on teaching and learning. During this time Rick met with the science department teachers to facilitate professional development sessions and to examine classroom, district, and state assessment data. Rick felt the science PLCs were very good and that all the science teachers worked well together. Other activities included using instructional videos for discussion and helping teachers locate other professional development opportunities such as PD 360 and Edutopia. Rick mentioned he met individually with teachers, based on need, during their preparation periods to discuss individual student performance and to create intervention plans. Sometimes these meetings included members of the special education department to help teachers with strategies for modifications and interventions. Rick met with first and second year teachers at least once a week during their preparation period.

Although Rick was initially hired as a science instructional coach, he eventually took on the social studies and math departments as well. According to Rick, 25% of the teachers in the science department were not using the instructional strategies he had provided, whereas others were using them to a certain extent. Rick attributed the lack of implementation to the culture of the school. As he pointed out, "I think the culture in our building was very negative this year. I think the teachers were not motivated as a team. In our small groups, we worked well as a team, but as a whole we did not."

When asked about his experiences with PBL, Rick indicated that he had no prior experience or training on PBL when he began his teaching career, but had become familiar with PBL by reading books and watching videos during his fourth year of teaching. However, he felt he could contribute to the implementation of PBL because as he pointed out, "I have a large tool kit. I have a large bag of things that I can share with teachers because I have actually used these things. It is not stuff that was written in a book."

Rick participated with the teachers in the PBL training sessions that Educurious provided. During the training he gave the science teachers feedback and suggestions regarding the development of their units. Feedback comments included, "How does the final product answer the driving questions? Is the driving question something students can Google? Who will be the authentic audience for this project?" He also helped the teachers with the implementation of what they learned and assisting them in the development of their PBL units. According to him, he provided them with resources and additional information; gave them instructional strategies; and examined class assessment data to determine the best learning activities to be used in the unit. One of the units he helped teachers build was a unit on food consumption in Detroit; a unit that involved students in making a difference in their community. Rick explained:

> We talked a lot and built activities based on how to invest the kids in something that really relates to them personally. We also talked about how to actually do labs with our students. I am not a huge fan of traditional labs. Some of them are good, but when I look at traditional labs, they are not inquiry-based. Most of them are: follow these directions, here is the outcome, and if you do not accomplish the outcome we are going to move on any way. Some of the labs that happened this year were inquiry-based where students had to figure things out on their own. Some students actually had to design their own experiment. For example, two of the environmental teachers had students create their own water filter based on what they learned in class. It was not based on directions. Students had tons of different designs. Most of the students finished it and most of the designs were pretty cool. Students thought for themselves. It was their own plan, so that was neat.

Around the time the teachers began implementing the PBL units, Rick was given a new responsibility which consumed the majority of his time. As a result, he was unable to spend time in the classrooms to offer feedback regarding PBL implementation. However, he did make himself accessible to answer questions and provide guidance.

Teacher training in project-based learning. The school began the PBL training with the teachers in the science and social studies departments. The school's principal (Steve) believed these teachers needed some assistance. The English and math departments already had a consistent curriculum in place, whereas science and social studies did not. According to Steve, "there was no telling what you were going to get in those classrooms. So we wanted to unify, then have a consistent approach towards science and get back to the experiments and not just sitting and reading the text." Steve pointed out that in most of the classrooms he visited, students were engaged in passive reading activities. He explained that the lessons were not engaging, which consequently had an impact on classroom management. Other teachers selected to participate in the PBL training were chosen based on their skill set, classroom observations, and the content area they taught.

The instructional coach (Rick) was given the responsibility of coordinating the PBL training. He contacted Educurious and scheduled the PBL training, which took place over four days: two days in January and two days in March. Training sessions were seven hours in length and were held on a Friday and Saturday. The teachers were paid to attend the Saturday training sessions. Since PBL was one of the school improvement strategies for the science and social studies departments, teachers were strongly encouraged to attend. Teachers who did not attend the training were informed they would be responsible for obtaining the information. There were nine participants in the training: seven teachers and the instructional coaches.

Christy, the Educurious' PBL trainer, described her role as a facilitator like peeling back the layers of an onion. According to her, "the gradual process of creating a paradigm shift for teachers, includes peeling off one layer of the onion at a time." Her responsibility during the training was to teach teachers about and model the PBL process. She felt it was important to demonstrate the actual process for teachers. By the end of the training the teachers were expected to have developed one short unit using PBL. After the PBL training was completed, Christy was available to the teachers via online coaching as they worked through the PBL process.

Implementation of PBL in High School Science Classrooms

This study focused on three science teachers who participated in the PBL training. One of the teachers had been working at the school for two years. The other two teachers were first year teachers. Prior to classroom observations and teacher interviews, a survey was used to assess their understanding and beliefs about PBL.

Teachers' understanding of PBL. One of the questions on the survey asked participants to explain their understanding of project-based learning. The common theme that emerged from the teachers' responses was that project-based learning increased students' knowledge of subject matter and required students to apply the knowledge obtained to complete a project. According to the teachers, the type of project created through project-based learning varied. One of them gave the example of students building a cell model when studying the concept of cells. Two other teachers stated the projects created through project-based learning must be relevant and related to the real-world. One teacher compared project-based learning to an apprenticeship, in which a novice worked with an expert such as in the building of ships. As she pointed out, "the art of building ships is definitely a hands-on experience passed on by doing from expert to novice. In the classroom, a ship can be designed, built, and tested using the very same parameters and a carefully crafted project." Another teacher expanded her description of project-based learning by stating that all tasks and assignments throughout a PBL unit are designed to increase student knowledge related to the project, and that students must present their project to an authentic audience.

The remaining items on the survey asked teachers to rate their level of agreement (from strongly disagree to strongly agree) with statements related to PBL. The survey statements were developed around three themes: (a) teacher beliefs about PBL, (b) their perceived competency about implementing PBL, and (c) training and support they received related to PBL. Because of the small number of participants, the "strongly disagree" and "disagree" responses were collapsed into a single "Disagree" category, whereas the "strongly agree" and "agree" responses were grouped into one "agree" category.

Teacher beliefs about PBL. Table 2 (below) provides the percentage of teachers who agreed with each of the survey items (8-13, 23, 26-28), exploring their beliefs about PBL.

Table 2

Teacher Beliefs about PBL

Survey Items	SD/D %	Neutral %	A/SA %
8. I believe PBL is a great approach for teaching science.	0	0	100
9. I feel PBL will improve the academic performance of my students.	0	0	100
10. PBL can be used to address different learning styles of students.	0	0	100
11. All students can learn science using PBL.	33	0	67
12. I believe PBL can be used to increase student motivation for learning.	0	33	67
13 PBL takes away from teaching the content standards.	100	0	0
23. I think my students will enjoy learning science through PBL.	0	0	100
26. Project-based learning helps students develop problem-solving skills.	0	0	100
27. PBL helps students see the connection between science and their own experiences.	0	0	100
28. I believe PBL is an effective approach to teaching science.	0	0	100

As results in Table 2 indicate, all the teachers felt PBL was a good approach for teaching science and would address the diverse learning styles of students. They also believed that PBL would increase student achievement and motivation; would help students see the connection between science and their own experiences; and develop students' problem solving skills. However, not all the teachers agreed with statements 11 and 12. Only two of the three teachers

(67%) believed all students could learn using PBL (statement 11) and that PBL could increase student motivation for learning (statement 12).

Perceived competency about teaching using PBL. Table 3 (below) provides teachers' responses to survey items 14-17, which explored teachers' perceived competency in the use of PBL.

Table 3

Teachers' Perceived Competency about Using PBL

Survey Items	SD/D %	Neutral %	A/SA %
14. I feel comfortable about implementing PBL in my classes.	33	33	33
15. I'm excited about implementing PBL in my classes.	0	33	67
16. I feel I understand well how to implement PBL.	33	0	67
17. I feel well prepared for using PBL in my teaching.	33	0	67

Teachers' level of agreement with the statements related to their competency in the use of PBL varied among the three participants. Only one of the teachers agreed she felt comfortable about implementing PBL in her classes (statement 14), even though two of them (67%) felt excited about implementing PBL. Two of the teachers also felt they understood how to implement PBL (statement 16) and felt well prepared to use PBL in their teaching (statement 16). One of the teachers disagreed with both statements.

Training and support related to PBL. Table 4 (below) provides teachers' responses to survey items 18-21, 24, 25, 29, and 30, which explored their beliefs about the training and support they received related to PBL.

Table 4

Teachers' Beliefs about Training and Support Related to PBL

Survey Items	SD/D %	Neutral %	A/SA %
18. I have received sufficient training on how to use PBL.	33	0	67
19. I have the necessary materials to implement PBL in my classes.	67	33	0
20. I have sufficient support for implementing PBL.	33	33	33
21. I have sufficient planning time to use PBL in my classes.	100	0	0
24. My school district has provided the necessary resources for teaching science using PBL.	0	100	0
25. My school administration encourages science teachers to collaborate in the implementation of PBL.	0	0	100
29. I'm excited about working with other teachers in the implementation of PBL.	0	0	100
30. Besides training, I also have searched for other resources related to PBL.	0	0	100

As results in Table 4 indicate, two (67%) of the teachers felt they received sufficient training on how to implement PBL (statement 18). However, a similar number of them did not feel they had the necessary materials to implement PBL (statement 19) and all of them were neutral on whether they felt the school district provided the necessary resources for using PBL (statement 24). Furthermore, all the teachers disagreed they had sufficient planning time to use PBL in their classes (statement 21). Teachers' level of agreement with statements related to support for implementing PBL also differed among the three participants (statement 20). Only one of the teachers agreed she received sufficient support, but later on during an interview stated she did not know if she had sufficient support. However, all the teachers were excited about collaborating with other teachers in the use of PBL (statement 29) and felt the administration encouraged such collaboration (statement 25).

All the teachers agreed they had searched for other resources, related to PBL, to use in their classrooms (statement 30). Follow-up interviews with them revealed they conducted their own research on PBL. Two of the teachers stated they used the Buck Institute for Education (BIE) website as a resource for videos. As one of them pointed out:

> I have done a lot of research. I am really interested in PBL and how it works. I have done a lot of video searches. The Buck Institute has a lot of information on PBL. I read up a lot on that. I am just trying to find different people who are implementing PBL and find out how it works in their rooms. I want to try and get ideas on how we can improve it or start more of it here. I think that is very important.

Teacher implementation of PBL

For a period of three months, classroom observations of the three science teachers, followed by debriefing sessions, were used to examine the extent to which PBL was being implemented in the science classes. The science classes followed a block schedule and met three times a week. On Mondays classes met for 61 minutes, with classes on Tuesday/Wednesday and Thursday/Friday meeting for 110 minutes. The number of observations varied for the three teachers, depending on the length of the PBL unit they were implementing; teacher absences; and various school activities. Interviews were conducted with each teacher at the conclusion of the study.

Teacher participant 1. Kathy was a first year science teacher, who had been hired halfway into the school year. She had a teaching certificate in Biology and currently taught Biology to ninth grade students. The class had a total of 38 students enrolled; however the daily class attendance averaged 17 students. Kathy had the assistance of two paraprofessionals in her classroom, one for special education students and the other for general education students.

Kathy decided to develop a genetics PBL unit. She introduced the PBL unit by informing the students they were going to be learning about genetics and that they would be responsible for creating a Power Point presentation on a disease by the end of the unit. She gave the students an information sheet that explained the project expectations. Later, students received a rubric that explained how the project would be graded.

One of the key components when introducing a PBL activity to students, is the use of a "hook" to get students' attention and stimulate their interest. Kathy's PBL unit did not include a hook or entry event to the unit. She had planned to use a video as the "hook" for the project, but she was not sure how to create a hook. In-class sessions following the introduction of the project, Kathy conducted a series of lectures and class activities focused on genetics. Classroom activities included Power Point presentations, worksheets, and computer time for students to find background information on the topic using the Internet, which students and teacher referred to as "research." According to her, because she was hired at the school mid-year, she did not know how to integrate the school district's learning philosophy of student-centered learning with project-based learning.

In a debriefing session, Kathy said she thought students had mixed reactions to the PBL unit. Some students found it really interesting, while others indicated it was too difficult. Students either felt the information they were learning was too difficult or the actual process of researching was challenging. Kathy scaffolded the research process by providing the students with guiding questions to conduct their research. She also noted students struggled when she asked them additional probing questions. As she pointed out:

> For example, when I say who discovered it [the disease]? And who has done research on the disease? What is the current status of research on the disease? They are unable to answer the question. When they are trying to conduct research, they are putting in "what is the current status of research". You know what I am saying? Instead of trying to say what they have found out or what have they discovered or what more do they need to know to continue the research. Like those are the kinds of questions the students are not generating. So it [the guiding questions] helps them a little bit, because it is pointing them in the direction of some things, but they are not thinking outside of that.

However, field notes show that Kathy did not show students how to conduct their Internet research, except for telling them they could not use Wikipedia, Ask.com or Yahoo Answer. She informed the class to check with her to determine whether a resource was valid. She also provided them with sites they could use for their research.

Students were expected to conduct research on their own time; however Kathy gave the students four days throughout the unit to conduct research on their topics during class time. She also extended the due date for the project because of the Memorial Day holiday and school-wide testing that occurred. She noticed students did not use this time wisely. After a month into the project, some students were still doing research that should have been completed. Towards the final days of the project, Kathy gave students a day in class to finish their projects. Kathy was very disappointed because she had given the students eight hours of class time to conduct research when she thought only four hours were needed.

Students were required to present their research to the class. When students made their presentations to their peers, other students in the class were selected to give them feedback. The feedback was supposed to be positive and include suggestions for improvement. Although providing peer feedback was a component of the project, such feedback did not play a role in the students' grade on their presentation. Kathy wanted students to have the experience of listening attentively and learning how to evaluate a project. The evaluators received a peer evaluation grade worth 20 points.

Reflecting back on the experience, and based on the student presentations, Kathy felt the students had not learned what she intended for them to learn. The students were unable to make the connection between genetic diseases and mutations they studied in class. According to her, “the key component to this project was to get them to understand mutations and what the outcomes of certain types of mutations were. That is what was missing.” Kathy believed she should have established checkpoints and deadlines for the students to monitor their progress. Kathy also felt rushed to complete the unit. She knew the end of the semester was approaching and when the summer arrived student attendance would decline even more. As a result, she wanted to finish the unit prior to the summer.

Student attendance was an obstacle for Kathy. She established a website for students to access when they were absent, so they could find out what they missed. The website had open access so students did not need a password. When students returned from an absence, she would print a progress report and tell them what they missed. She also offered after school and lunch tutoring, however students seldom attended. If time allowed, she tried to assist students who were absent during class time.

When asked about the type of assistance with PBL she had received, Kathy pointed out the only time she received assistance from the science coach was during the initial planning that occurred during the Educurious training. She added she never asked for additional assistance either and pointed out the science coach never came to her classroom to observe her implementation of PBL and to provide feedback.

Teacher participant 2. Ashley was a seasoned teacher who had been teaching for 10 years. She was currently teaching an environmental science class consisting primarily of sophomores. Ashley believed the role of a teacher in the PBL process was that of a facilitator, ensuring students stayed on task and completed their project. She clarified by saying:

> The role of a teacher in project-based learning is primarily to facilitate learning -- to plan the curriculum and then to implement it through teaching the kids the skills that they need to understand and apply the curriculum. It is not so much giving it to them (the knowledge). It is more teaching them how to explore and understand their exploration, then teaching them what to do with their understandings.

She also believed the teacher should be a resource. As she pointed out, "when they get stuck, I am kind of like a librarian. I show them where something is, but they still have to do the work." Ashley believed the role of a student in PBL was to be an independent learner. She felt students have to learn how to access and process information. She added that the learning experiences that students have had over the years develop the characteristics and skills students need to be independent learners. Ashley described her ideal PBL lesson as one in which student learning is dictated by their current level of understanding. Students choose activities that are at their learning level, while the teacher serves as a resource for students when they have questions. According to her, such a learning environment would be very active and noisy, involving collaboration, as well as individual work.

As a result of last minute changes in the master schedule and school day, Ashley and another environmental science teacher, Courtney, co-taught a PBL unit titled "A Greener Detroit" (environmental issues in the city of Detroit) by combining both of their classes. Ashley's class was composed of approximately 65% special education students, some of whom were low performing in terms of cognitive ability. Due to the high number of special education students in her class, Ashley had the daily assistance of a paraprofessional. She felt PBL was beneficial to her special education students because it facilitated differentiated instruction. Prior to this unit, Ashley had completed another PBL unit on water filtration.

One of the district's expectations was for teachers and students to use the district's online learning platform, Horizons. Ashley integrated her PBL learning activities with Horizons to provide learning experiences that allowed for differentiated instruction for students with a variety of learning needs. Teachers created instructional units in Horizons that were broken down into modules based on the identified learning targets. Each module was organized into a Learn, Practice, and Apply format. Students learned the information or skill to be taught; practiced what was learned; and then applied their learning by completing some type of assessment. After a lecture or discussion, students worked through the Learn and Practice components that were self-directed activities. When students got to the "Apply" component, teachers rejoined the learning process. According to Ashley:

> It is not that we [the teachers] are gone, it is just that those [components] are more independent things. The Apply component requires more teacher direction or assistance. Some of those activities are of the highest level. Students are creating, they are evaluating, or whatever. They then start asking us [teachers] questions, and that is where we would put labs, in the Apply component. The directions for the lab might be in Horizons. The actual doing of the lab is in the lab itself. When students read the directions, there should be a pre-lab assessment to make sure they understand what they are supposed to be doing. The students then say they are ready to go. I look at their grade on the pre-lab assessment and say, yes you are, let us start. I would help them out in the lab if they needed it; help analyze their data, write their conclusion, things like that.

Ashley said this process was followed for every learning target. She added that not all teachers followed this process. She pointed out, "some teachers just hand them the computer and say 'watch the video.'" Throughout the PBL unit, Ashley monitored the class to determine who needed help by walking around and providing assistance. A feature in Horizons allowed the teacher to monitor students' moods; whether they were confused, bored, etc. Ashley did not use this feature because she thought she could get a better sense of students' moods by watching them. Sometimes the modules in Horizons required that students read articles, which presented problems for Ashley because students in her class were at four different reading levels. To accommodate her students' various reading levels, Ashley developed four different reading levels for each article by decreasing the number of pages to read and removing some of the vocabulary.

Students were not allowed to progress to the next learning target in Horizons until they demonstrated mastery. In Ashley's class, mastery level was set at achieving 80% or greater on a quiz. Based on a student's score, Horizons would redirect a student back to the segment of the unit the student had not mastered. The student then redid the segment to show mastery. After repeating the segment, the student retook the quiz incorporating different questions. Horizons had an extensive data bank of questions for some learning targets and students could take the quiz multiple times.

Ashley determined the success of a PBL unit by the culminating project. She was concerned that students should be able to apply what they had learned. She also indicated that she could determine the success by administering a test, assessment, or quiz. She added she could also listen to students' verbal explanations to other students as a means of assessing what they had learned. As students completed assignments in Horizons, Ashley graded them. She requested corrections be done immediately. Ashley explained:

> I give them a tentative grade on the side. If I were to grade this at this point, this is what you would get. If you do not make corrections and submit it again, this is the grade that you are going to get. It will be in my gradebook as that grade and when they resubmit it in, I re-grade it.

Teacher participant 3. Courtney was a first year environmental science teacher. She had 10 students enrolled in her class, two to four of whom she believed were receiving special education services. The class consisted mostly of seniors. Courtney had a paraprofessional assigned to her class as well. Courtney used her paraprofessional for small group instruction.

Courtney believed her role in PBL was to serve as a facilitator. She felt her role was to guide students through the learning process and to engage them in the process of collaboration. Courtney was able to get students to collaborate by having them work on group projects. Each group was composed of three to four students. She used a rubric to grade their work and assessed their collaboration skills. Courtney said some students continued to struggle with collaboration but by working in groups she wanted to show them the importance of collaboration. At times, Courtney worked with students in small groups. These groups consisted of students who were struggling; were behind on their work; or had demonstrated some type of misunderstanding of the project. Courtney believed the role of students in a PBL learning environment was to be teachers by working with and teaching their peers. She indicated that PBL placed students in charge of their own learning and that students must take charge of that ownership or they would not progress. The PBL approach to teaching provided little "hand holding" to which students often had become accustomed.

Courtney described her ideal PBL lesson as one in which students worked on investigative mini labs to understand a concept. Some students would be working independently doing research while the teacher helped various groups, possibly doing small pull-outs for mini lessons. In her ideal PBL unit, students would be working on different parts of a unit because they were able to choose their assignments based on their interests. She pointed out the goal of PBL is for students to work together collaboratively to solve a problem, using different approaches.

Courtney had limited experience with PBL. She had used PBL in pieces within units. She had developed lessons where the project came at the end of the unit, but it was not integrated throughout, which she realized was not the same as PBL and did not have the same outcome. She had never experienced the planning of a whole unit where every part of the unit built up to a single comprehensive project. Similar to Ashley, Courtney had completed the water filtration unit with her students. Courtney and Ashley had planned the unit together.

Courtney and Ashley planned together once or twice a week during their common prep hour. Courtney pointed out that planning a PBL unit takes time. She explained that a large amount of time was devoted to ensuring the project was connected to standards, developing scaffolds to facilitate student learning and engagement, and finding all the materials and resources needed. Not all of the units Courtney created were PBL units. She explained that "ideally they would all be PBL," but she had not begun PBL training until February.

Like Ashley, Courtney used the Horizons program in her class as well. She introduced her students to the Learn, Practice, and Apply components of Horizons at the start of the school year. For the "Learn" portion of the lesson she usually conducted mini lectures. Many of Courtney's students preferred to work individually once they got to the Practice section. As students worked through the sections of Horizons, she monitored student understanding and addressed misconceptions when they occurred. There were a few times when students' misconceptions were not identified until after they submitted assignments. When that happened, Courtney would give the assignment back to the students and review the material with them to ensure they understood the information. Students were given multiple chances to improve an assignment unless plagiarism was suspected.

Assignments were awarded different points depending on their difficulty and complexity levels. According to Courtney, she gave a couple of points for the "Learn" portion of the assignment because there were usually only a few application questions. As the level of application and depth of knowledge required increased, the value for the assignment increased. An "Apply" section could be worth three to four practice assignments, depending on the rigor of the Apply activity for environmental science. Courtney continuously monitored students as they worked through their PBL tasks. According to her:

> Well, I walk around a lot. I do not ever sit down in my room, which really gets kids frustrated because I am always moving. You can always tell if kids are not focused. I will walk around the room making sure they are working on assignments and asking them probing questions to make sure they understand.

Students in Courtney's class also completed quizzes and tests. There was generally an assessment for each learning target in Horizons; however, some targets did not have assessments. In such cases Courtney verbally assessed student understanding or administered a paper or virtual quiz.

Due to a last-minute change in the school's daily schedule, Ashley and Courtney had to cancel the PBL unit they had initially planned and instead adopted a project used at another high school in the district. The project was called "A Greener Detroit." Courtney stated she had to modify the unit to increase the level of rigor and to make the unit application-based. The final project for the unit required students to design a plan for the school's parking lot if it were torn up. The question she posed to the students was: "Should the parking lot be repaved or should it be converted into a garden or green space?"

As a result of the schedule change, Courtney did not begin the unit as she had done in the past. According to Courtney, she generally started a project with a hook to get students interested in the project. However, because of the short notice, Courtney did not have time to develop a hook for the project. Courtney stated she did not measure the success of the project quantitatively. Instead, she measured it qualitatively by noting how interested the students were in the project;

how much they were talking about it; and their level of engagement. Courtney felt the level of student engagement in a project was an indicator of a good PBL unit.

Alignment of the PBL Implementation Process with the Major Components of PBL

Classroom observations, debriefing sessions, and teacher interviews were conducted to determine how well the implementation of PBL aligned with Thomas' (2000) five criteria a lesson should have to be considered project-based learning.

Criteria 1 centrality: The project must be the starting point for learning. The PBL units developed by each teacher began with the introduction of the final project. Field notes from classroom observations indicate that all three teachers began their units by presenting the PBL project that would be the focus of their science unit. Kathy began by informing students they were going to be learning genetics and that they would be responsible for the presentation of a genetic disease at the end of the unit. She gave students a handout that provided the presentation details. When she introduced the topic of genetic mutations, she related genetic mutations to the genetic diseases that students were to research on the Internet. Ashley and Courtney opened their PBL unit by introducing the Greener Detroit project. According to field notes, they began with a discussion of the current environmental issues occurring in the City of Detroit, including land use. After the discussion, the teachers informed their students that in this unit they would be to designing a plan for the school's parking lot. Courtney introduced the project in the following manner:

> Say the school decides they want to rip up the parking lot, what should be done with this lot? Should it be repaved to make it nicer? Should they tear it up and make a garden and a green space? Should they put a big, huge garden that everyone can use? Your task for this unit is to decide what to do with the lot and explain why.

Field notes indicate the teachers did not provide students with a rubric or the details explaining the expectations for the project. The learning activities that occurred after the introduction of the project assisted students with gaining the knowledge needed to complete the final project. These activities included worksheets, lab activities, drawings, computer activities, and writing assignments. A description of these activities is provided in the discussion of Criteria 3.

Criteria 2 driving question: The project begins with a question that motivates learning. Kathy did not begin the project with a driving question. Instead, she provided an overview of the project to stimulate student interest. Ashley and Courtney began their PBL unit with an entry event and a driving question to motivate the students. As an entry to the project, Ashley and Courtney introduced the Greener Detroit project by discussing current environmental issues occurring in Detroit and the changes that have been proposed by local organizations to make the city more sustainable. Field notes show Courtney started the unit by discussing the Detroit Future City Framework. She told the students this framework provided ideas and innovations for revitalizing the city of Detroit. She informed students the document proposed possible changes that could be made in the city to make it more sustainable and suggested converting certain neighborhoods to farmlands or neighborhood forests. She continued by stating that some of the neighborhoods in the area were slated to become big farmlands or industrial areas. The discussion proceeded as follows:

Courtney: "If there is one house on a block, should that person have to move so they can make it a farmland?"

Michael: "Yes, because it is a waste of land."

Courtney: "Why do you say that?"

Michael: "It does not make sense to have one house on a block. That is stupid! It is not even a block anymore. Turning it into a farmland will make it easier for people in the neighborhood to get fresh fruits and vegetables."

Teacher: "Any other thoughts?"

Sarah: "And since it is so close (the farm), the fruits and vegetables might be cheaper."

Jennifer: "Also, it will help because we do not have a lot of "real" food stores in this area. Stores around here sell a lot of stuff that is not good for you like pop, chips, candy, and alcohol. Having a farm in the area would make it easier for people to eat healthier."

Teacher: "In the city of Chicago, there is a neighborhood where the land was converted to an urban farm. The farm is called the Wood Street urban farm. This farm has produced approximately 5,000 pounds of produce. What are your thoughts about this farm?"

Michael: "It is just like I said. A farm can produce food for people in the community."

Teacher: "Is there anyone who believes the person should not have to move?"

Thomas: "What if the person does not have the money to move? Who is going to pay for it?"

Another student (Tracy) added: "A farm would make the surrounding neighborhoods smelly because of the animals. Then people would move out of the area and there would be more vacant houses."

Lisa: "Farms might bring diseases, like mad cow disease to the area. Then the area would not be safe for people to live."

Tracy: "The animals on the farm will make the area noisy; noise from cows mooing and chickens clucking."

Courtney mentioned to her students that according to some reports urban farms have shown to increase property value. She posed the question, "Do you still think an urban farm is a bad idea?" The students against the development of a farm harmoniously responded, "Yes". One student stated, "Property values may go up, but no one is going to be willing to buy the house." This discussion transitioned to the topic of land use. Ashley opened the discussion on land use by stating:

> There is a huge amount of unused and underused land that has developed in Detroit because of the declining population. The abandoned homes and vacant lots resulting from the population decline have become eye sores and breeding grounds for crime and pollution. In this unit, we are going to discuss land use and explore the question, how can we solve Detroit's environmental problems?

Courtney then proceeded with an introduction to the topic of land use. In a follow-up interview, she explained her rationale for the approach she used to introduce the topic:

> We decided to hook them in that way to talk about land use because land use is kind of boring. The term, land use. It seems really interesting since it is happening around you and especially on the east side where a lot of neighborhoods are slated to become big farmlands or industrial areas.

Criteria 3 Constructive investigations: **The projects are inquiry based**. Ashley and Courtney engaged students in activities to assist them in designing and creating a final project (a design plan for the school's parking lot). Throughout the unit, students participated in a variety of learning activities. The following is a description of the sequence of learning activities that occurred for one of the unit learning targets:

Courtney began with a PowerPoint presentation for the learning target: "I can compare the efficiency of different methods of food production." The PowerPoint consisted of 10 slides. The presentation discussed different types and methods of food production. Students were given a worksheet to use to take notes from the PowerPoint. Following the Power Point presentation, students were given a reading selection on methods of food production and answered questions related to the reading. Both the PowerPoint presentation and reading selection were regarded as "Learn" activities. After students finished the Learn activities, they preceded to the Practice activities. For the Practice component, students were given a choice of completing one of three activity options. The options included: (a) Farming Methods Slideshow: Students were provided a PowerPoint presentation which they viewed on a laptop computer. For each slide, students were to determine which farming method was more sustainable and explain why; (b) Venn Diagram: Students were given a Venn Diagram and were instructed to compare and contrast industrial and sustainable farming practices; and (c) Industrial/Sustainable Illustration: Students were instructed to draw illustrations of both industrial and sustainable farming. The illustrations were to show the different crops, required materials, how people farm the land, and the environmental problems caused by the type of farming. The Apply component for this learning target consisted of a quiz. The quiz was composed of definitions, matching, true/false and short answer questions. Other activities students completed during the PBL unit included completing concept maps, reading a map, creating illustrations, reading scientific articles, and writing activities such as writing letters and poems.

Data from observations suggest students looked forward to doing science. They appeared to demonstrate a desire to 1earn more. Students were observed collaborating and working cooperatively with their peers. Students asked questions of each other as well as the teachers. Mini-workshops were held to develop the knowledge and skills students needed to complete their inquiries. For example, during one of the lessons, students were having difficulty understanding the heat island effect and. Courtney took the students outside to conduct an "experiment" to help them understand the concept.

Although the final product of the project implied students would engage in inquiry activities throughout the PBL unit, careful review of the learning activities given to students throughout the unit suggests otherwise. According to Dr. Cornelia Brunner (2012), the process of inquiry is divided into four main parts: posing real questions, finding relevant resources, interpreting information and reporting findings. The learning activities provided did not engage students in these types of activities. Students were not required to develop their own questions or research information. Information was largely provided by the teachers. Teachers provided notes, identified key vocabulary and concepts, and gave detailed instructions on how to complete the activities. The learning activities did not create a demand to problem solve nor did they promote discovery. The activities placed students in the role of passive rather than active learners.

The project designed by Kathy did not involve problem solving or critical thinking. It simply required students to conduct background research on a genetic disease and create a Power Point presentation. Similar to Ashley and Courtney, after the introduction of the project, Kathy proceeded with a PowerPoint presentation on genetics. The following is the sequence of events that occurred during a lesson on Punnett squares:

Kathy reviewed genotypes and phenotypes with the students and then transitioned to a Power Point presentation on Punnett squares. She discussed each slide in the presentation and provided examples as needed. She reviewed relevant vocabulary as needed. Kathy demonstrated how to complete a Punnett square. After the PowerPoint presentation, she passed out a Punnett square worksheet to the students. She informed the students they had 20 minutes to complete the worksheet. The teacher circulated to assist students as they worked. Students completed the assignment individually. Based on the number of questions she received from students, Kathy announced, “Everyone seems to be struggling with number 4. Let us go over it together.” Kathy invited a student to the board to complete problem 4. Problem 4 stated: "SpongeBob SquarePants recently met SpongeSusie RoundPants at a dance. SpongeBob is heterozygous for his square shape, but SpongeSusie is round. Create a Punnett square to show the possibilities that would result if SpongeBob and SpongeSusie had children." The student misconceptions related to problem 4 included distinguishing between homozygous and heterozygous genotypes and how to set up and complete a Punnett square. After reviewing problem 4, Kathy reviewed the answers to questions 1-3. While reviewing the answers, Kathy encouraged students to use the correct terminology as they responded aloud. For instance, students couldn't say "2 Big Ts". They had to say "homozygous dominant." Field notes show that of all the students present, one female student was the primary respondent to the teacher's questions. After discussing the first 4 problems, Kathy instructed the students to complete the remainder of the worksheet. As students worked on the assignment, Kathy circulated to provide assistance to individual students. While Kathy assisted a female student with the completion of the assignment, the student was overheard saying, "I do not understand. I am lost." Field notes indicate students were not actively engaged in the lesson. Two students were observed out of their seats conversing with two students seated at another table. Students that finished the assignment early were given another Punnett square worksheet to complete. When the class ended, Kathy instructed students to place their worksheets in the assignment bin. In a debriefing session, Kathy admitted she did not allocate sufficient time for students to complete the assignment. Students were only given 20 minutes to complete the assignment when in actuality it took the remainder of the class period to complete. She had not anticipated the misconceptions that could arise when teaching students how to complete Punnett squares.

Learning activities provided throughout Kathy's PBL unit consisted of numerous worksheets and four days during the unit were dedicated to conducting Internet research on a genetic disease. The worksheets consisted of answering questions, filling in the blanks, and solving Punnett square problems. Field notes suggest students did not make productive use of the Internet research days. Five students were observed continuously talking and unfocused. There was no visual evidence that the students were conducting research. In a debriefing session, Kathy supported these observations. When asked whether she thought students used the research time productively, she responded, "Two boys, yes. The rest of them, no." She added students did not receive any type of training on how to conduct research; however, they were provided with a list of questions to guide their research.

Criteria 4 Autonomy: The project provides the students with choice. In Ashley and Courtney's class, students had autonomy in developing the design plan for the school's parking lot. Kathy's genetics project provided students with autonomy in selecting a genetic disorder they wanted to study. Ashley and Courtney's students were also given choices through the learning activities completed throughout the unit. Each learning target in a unit had various assignments at different levels of Bloom's taxonomy. Courtney described how students were given choices:

> Within stations, they could choose what to do, for instance, write a letter to a governor, make an illustration describing the problems of urbanization, or create a poem or rap to describe the problem. These options allowed the students to have some choice in the matter while still displaying content knowledge. It also allowed those students who might not necessarily feel as confident in their writing skills to practice other skills. There was always a reading too. So the kids will always have to read no matter what. The choices gave them chances to explain themselves in a different way. You really see the kids chose a variety of ways to do it.

Courtney developed the choices to offer students by sharing and discussing ideas with other teachers. She also used students' interests as a basis for the choices she gave them. If she knew students liked music, she offered them the option of writing a rap or poem. For students who liked to draw, she offered a choice for creating an illustration. Technology was also used as a choice. If a student preferred to watch a video to gain knowledge on a concept rather than to complete a station activity, s/he was given the choice to do so. One challenge Ashley experienced with choice was that the higher ability students often chose to do assignments of a lesser challenge. She rationalized the reason was that they were lazy and wanted to quickly complete the assignment to go back to playing their video games.

Criteria 5 Realism: The projects are relevant. The Greener Detroit project was grounded on the Detroit Future City framework; a compilation of suggested land usage suggestions for the city of Detroit. Statistics show the city of Detroit's population has been declining since 1950. Almost one-third of the city's area is vacant land. The recommendations in this document include repurposing areas of the city for various land projects. The areas identified for repurposing included the area where the school was located. These areas would be repurposed for the development of farms, forests, and artificial ponds and lakes. The framework also proposed relocating individuals from low populated areas to higher populated areas, thereby creating a more efficient use of city resources. Those areas with declining populations would no longer be targeted for future land development. The Greener Detroit project built on the Detroit Future City framework by requiring students to develop a plan for how to use the land of the school's parking lot. The relevance of Kathy's genetic disorder project was uncertain. The project may not have had any relevance for students unless the student or someone they knew had the disorder. Kathy commented:

> The students who picked sickle cell anemia did so because they knew somebody with it. I have a student in first hour that chose a disease that was not on the list. She chose Lupus. She chose Lupus because she knows someone who has Lupus and knew it was genetic. Diabetes is another one. The students who really wanted to research diabetes were those whose grandmothers had it. While some students studied more obscure diseases like Huntington and Tay Sachs, I was not able to

> make them relevant. I wish I could have because it could make the information that much more valuable to them, but I did not know connections to make for them.

Successes in the implementation of PBL

There were several successes noted regarding the implementation of PBL. These successes included improved student engagement, student achievement, staff motivation and commitment, and teacher collaboration.

Student engagement. Both Ashley and Courtney saw improvements in student engagement. According to them they did not have to beg and plead with students to pay attention once they became involved in the hands-on activities. Some students who had never worked on in-class assignments were actually participating in the activities. Ashley described an actual experience: "The best part was to see a really quiet student from Bangladesh totally come out of her shell and implement the ideas that she got because she had read that article about arsenic."

Courtney felt she saw more student engagement with students who had ADD or ADHD. These students found the hands-on projects more interesting than listening to lectures or doing worksheets. The performance tasks and assessments allowed students to demonstrate their knowledge and use their creativity. Notes from classroom observations indicate that students participated in classroom activities and interacted with each other. However, the class discussions were usually dominated by 2-3 students. Often students were observed asking one another questions to better understand the topic of discussion. They were seen working with other students on projects and assignments and appeared to be interested in the content. They made comments such as, "Hey, what did you do for this?", "I need help with my urbanization illustration, will you help me with it? and "I cannot draw a street sign, could you draw it for me?" I also observed students raising their hands and asking questions of the teacher. Similarly, Kathy indicated that students in her class were asking more questions and some students worked hard to complete their projects ahead of completion date.

Steve, the school principal, also noted a change in student engagement when he conducted a classroom observation. He explained that he had visited a teacher who had been experiencing behavior problems in her classroom. The behaviors were so disruptive that the teacher had threatened to walk out of the school. However, on the day Steve visited, he noticed her lesson was more engaging and the students were involved in the lesson and having fun.

Student achievement. Courtney said she saw some improvement in student academic performance on various classroom assessments. Courtney and Ashley also reported improvements in their students' ability to solve problems. Although field notes did not focus on student achievement, student interactions and engagement appeared to be present when the students were working on their science projects.

Teacher motivation and commitment. Courtney and Ashley were excited about implementing PBL. Kathy expressed a neutral attitude towards implementing PBL because she had limited PBL training. All three teachers felt PBL was an effective approach for teaching science. Classroom observations support these findings. The teachers appeared to enjoy teaching and did not see it as just a job. Despite the various challenges teachers encountered such as technology difficulties, class schedule changes, and declining class attendance, the teachers maintained a positive attitude. The teachers did not allow the challenges to cause them to give give up on PBL. On one occasion Courtney was observed teaching a class of seven students as if it were a class of thirty. She did not display a lackadaisical attitude. She was energetic and willing to assist students. Information gathered from debriefing sessions also indicated they used other motivated teachers to get ideas and encouragement. Courtney mentioned an instance in which she consulted an English teacher for ideas for her PBL project.

The teachers examined what happened in the classroom and questioned its value. They thought about different techniques they could use to improve student learning. In a debriefing session with Kathy, she confided, "I think I need to establish more check points and deadlines. I need to tell the students today your objective is to find this information and show me when it is done." The teachers demonstrated a willingness to try new things with their students. They analyzed what worked and what did not work and made the necessary adjustments in their teaching. For instance, in a debriefing session, Kathy stated poor behavior interfered with the progression of her lesson. Therefore, on the next day the class met, Kathy took action by discussing proper classroom behavior with the students. She discussed her classroom behavior expectations and provided specific examples of how students should behave. The teachers appeared to be interested in their students and wanted their students to be motivated. Kathy even allocated time after school and during lunch for students to get assistance with their project. Unfortunately, students did not take advantage of this opportunity.

Teacher collaboration. Teacher collaboration could not be observed as it occurred outside of the classroom visits. However, according to information shared during debriefing sessions, Courtney and Ashley found great benefits when they were able to plan together. Ashley stated Courtney had expertise at differentiating instruction, which was especially important for her special education students. She added Courtney would also notice things that escaped Ashley's attention. Courtney stated Ashley shared many resources and provided her with different ideas for her lessons. However, due to scheduling changes during the school year and being pulled from the classroom for professional development, shared planning time was not consistent. Moreover, Kathy was unable to collaborate with Courtney and Ashley because of a different planning time and working on a unit focusing on genetics.

Challenges in the Implementation of PBL

The challenges related to the implementation of PBL that emerged from interview data and classroom observations could be grouped into 15 themes.

Diverse student abilities. According to Courtney, the most difficult obstacle for her when using PBL was the various skill levels of her students and trying to develop lessons that were appropriate at these levels. She explained:

> Some kids did not understand the difference between fresh or salt water. Neither did they understand the difference in types of water and where water comes from. Whereas you might have a kid who already knows a lot about it and already knows about pollution issues. So trying to bridge the gap between those while filling in that critical basic understanding was very difficult.

She also stated students' lack of understanding and misconceptions made it difficult to manage students working at a number of different stations throughout the room. Units tended to take longer than planned because the students lacked the necessary background knowledge. In Kathy's class, concepts that were planned to be taught in one day often took one to two days longer than planned. For example, when Kathy planned her lesson on Punnett squares, she planned to teach the concept in one day; however, it took three days to teach the concept. She had not anticipated her students' comprehension difficulties such as vocabulary comprehension and the mathematical skills related to Punnett squares.

One of the challenges that Ashley experienced in her classroom was managing the needs of cognitively and emotionally impaired students. She stated that these students required one-on-one attention. Fortunately, she had the assistance of a paraprofessional who worked with these students in small group settings.

Field notes from observations support the teachers' claims that diverse student abilities presented a challenge to the implementation of PBL. All of the teachers had a population of learning impaired students in their classrooms. Students with severe cognitive impairments were not able to work independently on learning activities but consistently required the assistance of the teacher or paraprofessional. Although there was the aid of a paraprofessional, the amount of assistance these students needed surpassed the amount of support that could be provided. When the teacher or paraprofessional was not able to provide immediate assistance, these students put their head down on the desk, talked, or engaged in disruptive behavior. These students appeared to have difficulty with reading comprehension. They displayed difficulty with word recognition and decoding. One time Kathy had to read a passage aloud to a student and asked clarifying questions to assist the student in gaining an understanding of the information in the passage. On another occasion, Courtney was observed providing individualized assistance to an ELL student. The student was having difficulty understanding the vocabulary contained in a PowerPoint presentation. He appeared to be struggling with vocabulary comprehension. For instance, the student did not understand what the word "crime" meant, so Courtney worked with the student to make flashcards so that he could understand the words that were important to the learning target. In Kathy's classroom, field notes indicate advanced students tended to finish assignments earlier than the other students. Kathy did not plan additional activities for these students and these students were left with idle time. Sometimes she used these students to help other students who were struggling; however, this approach did not appear beneficial as they were observed talking and engaging in disruptive behavior with the other students.

There were also times when student questions were not addressed during the entire class hour. Specifically, in Kathy's class, some students would discontinue working on assignments when they needed help. These students displayed puzzled looks on their faces expressing discouragement and frustration. They put their head down or engaged in conversation with other students. Sometimes struggling students copied answers from students who had already finished the assignment.

Inability to work independently. Project-based learning requires students to act as independent learners while teachers facilitate learning. The teachers felt students relied heavily on the teacher to give them information. Notes from classroom observations indicate many students did not appear confident in their abilities and needed constant reassurance their work was correct. Students were observed on numerous occasions asking the teachers "Is this right?" Approximately 50% of teachers' time was dedicated to answering questions that had already been answered or questions students could have answered on their own. Also, without direct instruction from the teachers, students did not know what to do. One student was overheard asking Kathy, "How are we supposed to turn in the project?" Kathy harshly responded, "READ the assignment instructions." Without direct instruction, students were observed with their head down, talking with others, working on assignments from other classes, or playing with other students. The teachers were frequently overheard telling the students, "Get back to work!"

There was also a particular instance when Kathy expressed her discontentment with the students' lack of progress and misuse of research time as illustrated below when towards the end of the unit many students had not yet finished their work:

> Are you guys kidding me? You had a month! I have given you eight hours of class time to do this. It is something that should have taken an hour tops. You should already be done. What you should be doing now is checking it (the project) through the rubric and adding it to the channel.

During a debriefing session she elaborated further:

> Some of them, even though we have been working on it (the project) for a month, have not done anything. That is weird because when I had those research days, every single student was on a website looking at their disease. So I do not know what they are doing with their information. I mean I do not know. But it seemed like yesterday everyone was scrambling to start over. Or most of them.

On another occasion, Kathy found a student watching an irrelevant video on YouTube. She had to redirect the student to the appropriate site. She believed a lack of deadlines contributed to students' misuse of time. According to Kathy, her students preferred that she work one on one with them, however she did not have the time to do so. In a debriefing session, Kathy stated she felt her students were more focused during the lessons where she was actually teaching opposed to lessons requiring independent learning.

Poor student attendance. According to the teachers, poor student attendance prevented them from progressing through the PBL units. Some students never completed the final project because of their absences. Data from field notes indicate the average daily attendance for all the participating teachers' classes was less than 50%. The teachers felt some students may not have fully understood the PBL process because of their absenteeism. The teachers indicated that some students were indifferent about their poor attendance. Ashley felt some students thought it was okay to be absent because nothing major was happening in class when they were absent. She identified student attendance as the most difficult challenge she encountered when teaching through PBL. Some students had not been to Ashley's class in two months and it was common for students to come to class up to 40 minutes late. During one classroom observation, two students came to class who had not been to class in two weeks and another student came to class with only 15 minutes remaining in the class period. Field notes show that students who had chronic attendance problems struggled with completing learning activities. They were overheard asking the teacher and classmates numerous questions such as "How do I do this? Where can I find the answer to this? And "What does this mean?" They apparently did not have the knowledge needed to participate in the learning activities, therefore the teachers had to devote class time to bring these students up with the rest of the class.

Many students in Kathy's class were failing due to a high number of absences. She cited the average number of absences was 8 to 15 a semester. She added:

> It is not any one particular student. They all have problems with absences. The minority are the ones who are here all the time. I do not know what to do about that. Then with the block schedule, that makes it even more difficult, because of the way our school schedule is set up, you would think it would be ideal to have that big block of time to do PBL. It would have been, had the students come consistently, but they were not coming consistently.

Kathy mentioned students had 24-hour access to Horizons and could access it from home when they were absent. Unfortunately, the students did not take advantage of this resource. She also stated that she gave absent students the opportunity to receive help after school to catch up on what they missed; however, they rarely took advantage of the opportunity. She thought students did not understand they were responsible for the work they missed during an absence. According to Kathy, some students did not understand this concept until the last month of school.

Lack of research skills. In PBL students determine and research the information they need in order to solve a problem (Barrows, 1998). This usually means doing Internet searches to find information on the topic. Hannah Hudson (n.d.) identified the following essential skills students need and should be taught in order to conduct online research: (a) evaluating information found in sources for validity and relevance, (b) refining search queries to get better research results, (c) locating numerous resources to obtain greater depth of knowledge, (d) persistence in finding information despite challenges, and (e) respecting the intellectual property rights of others. Field notes from classroom observations show that students were not taught these skills prior to engaging in online research activities. As a result, students struggled in their research efforts. Students in Ashley and Courtney's class did not conduct independent research of any sort. When students were required to find information online, they were directed to a specific site to find the information. Students were not given the liberty to explore information on the Internet.

Kathy found that many of her students did not have the necessary research skills to complete the PBL project. They were unable to generate their own questions and determine what information they needed to gather related to their genetic disease. She elaborated:

> Even with me helping them, they are saying I cannot find this, I cannot find that. I am like, "Okay, you can say there has not been a lot of research on this." I think that they are trying to look for something that directly answers the questions on the guide.

Kathy's claim was also supported by the quality of presentations that students made. Students did not appear to know the content related to the genetic disorder they studied. Approximately 75% of the PowerPoint presentations consisted of students reading information that was copied from the Internet. It can be assumed that students viewed the process of researching as simply finding answers to the guiding questions Kathy provided and not actually learning or comprehending the information. The presentations primarily consisted of information related to the signs and symptoms of the genetic disease. Many of the guiding questions students were expected to answer were not included in the presentations. Questions students commonly did not address were: How is the disorder inherited? Is it sex linked? Is it caused by a mutation? Is it hereditary? Is it environmental? When Kathy asked students to address the unanswered questions, many of the students were unable to provide the answers. On one occasion, Kathy asked a student, "Do you even know anything about this?" The student replied, "I do not know any of this!"

Although Kathy provided students with a list of credible Internet resources, there were times when students were found using unreliable websites. During one of the class' research days, Kathy had to redirect a student who was not using a credible website to research his assigned disease. Kathy discovered the student was on the website while circulating through the classroom. Kathy explained to the student that information on the Internet is not necessarily factual and directed the student to a legitimate website.

Learning retention. Field notes indicate learning retention was a daily battle for all the teachers. It was common for teachers to have to reteach a previous concept prior to transitioning to the next concept. Kathy blamed the block schedule as a factor that negatively impacted students' learning retention in her class. Kathy explained:

> The day off, or like Thursday through Monday, they do not retain anything. I constantly say, "Remember when we did…? And the students responded, "No, I do not remember that at all." Where I think that if it (class) was every single day, even if the class period is shorter, retention would be better. It is that daily repetition. The block schedule is really hard to do. Like, for instance, what happened last week with the first hour testing. They missed a whole week of instruction.

I witnessed an incident when Kathy was challenged with learning retention. At the start of class, Kathy distributed a worksheet on protein synthesis. As she reviewed the instructions with students, students did not recall the information discussed during the previous lesson related to transcription and translation. Students had difficulty recalling the definition of an amino acid and determining base pair matching. Therefore, Kathy had to review the information with the students prior to continuing with the assignment.

Likewise, Ashley pointed out student retention was generally no longer than a day. She described her students as the "seven-minute generation." As she stated,

> You know you watch a television show and you have seven minutes of content and you have a minute and a half to two minutes of commercials. That is the format to

> which they are accustomed. They are used to flashes of information. Unless it is dramatic, they are not going to remember.

Student motivation. Kathy felt students did not retain what was taught because they did not care. She believed most of the students who came to school did not come to school to learn. She sensed they were there to fill up space because they had to go to school. Some students in both Ashley and Kathy's classes refused to do any work. Ashley stated she was persistent and kept pushing these students until they eventually gave up and did their work. As she pointed out:

> I just keep coming at them. You may have noticed there were some antagonistic things that were going on and that is why. If kids expect me to do the work for them, that is not going to happen. I will give them the skills and tools to do it, but I will not do it for them. So I keep pushing them, and they keep pushing back. Some students will just give up and say, "I am tired of arguing with you and I will just get it done." Then they will respond. Just give up, put the white flag up and surrender and we will be done with this. But then, I have had some die hard kids that just say no.

During one of the classes, Kathy threatened students who were not actively working. She reminded them that the project was worth 150 points and if they did not pass the class, they would have to repeat it in summer school. Fear of failing the class and having to attend summer school should have been a motivator for students to become engaged. However, many students chose to ignore the threat and remained unmotivated to complete their project.

Student engagement. Student engagement was identified as both a challenge and a success. Data from field notes indicate there were instances where student engagement was high and other instances where student engagement was low. Engagement decreased when students struggled with the content materials or when they had idle time. During these instances, students were observed with their heads down, talking, or engaging in disruptive behavior. Teachers generally administered a warning when students were discovered off-task. For example, when

Courtney observed a student off-task, she would administer a warning and threaten to take the computer away if the student could not stay focused.

Students tended to be more engaged when they were working independently or in groups opposed to whole class discussions. During class discussions, 2-3 students tended to dominate the discussions by volunteering or answering the teacher's questions. The rest of the students functioned as spectators. At times, the teachers would ask questions of the non-participative students to gain their involvement in the lesson. In a debriefing interview, Kathy rated the students' level of engagement of 3 on a scale of 1-5. She explained: "It is probably a 3 because they are definitely not totally disengaged, but they are also not really into it. So I would probably say a 3. There is just too much playing going on."

During one classroom observation Kathy addressed a female student who had her head down the majority of the class period. Kathy tried to engage the student and motivate her to complete her work, however, the student refused. Kathy called the student's parent immediately and then wrote a discipline referral and took the student to the office. Kathy stated the student even told the assistant principal she did not care. Although Kathy agreed to give this student additional time, the student still refused to do the work.

Poor student behavior and discipline issues. Courtney, Ashley, and Kathy had very different classroom management styles. Kathy and Courtney were first year teachers who had little experience and strategies to handle the students who were being disruptive to the class. Some of the problems in Kathy's class could have been from ninth grade students who were immature and not ready to learn. Ashley was better equipped to manage her classroom because of her teaching experience. However, they all had problems. For example, both Ashley and Kathy had issues with cell phone usage in the classroom. Ashley devoted much of her time asking students to put their cell phones away. Kathy admitted she had challenges with classroom management. She stated:

> I cannot get this class under control. I have too many groups of students that are loud and want to play. I mean, it is not even a matter of moving them, because wherever I move them, they find someone next to them to play with. It does not stop. I have tried with them. Like I said before, I have called parents. I have given them detentions. A couple of them I have put through for suspensions. It is like nothing changes. So that is my main issue; the playfulness instead of getting focused and serious. Maybe it is just because they are freshmen.

In two debriefing sessions, Kathy rated her lesson a 3 on a scale of 1-5 due to disciplinary issues. She stated the lesson could have progressed much faster if she did not have to deal with behavior issues. Field notes support Kathy's claim that discipline problems limited her ability to maintain the pace of the lesson.

Teachers sought the support of parents when dealing with behavior issues; however, many teachers did not receive the necessary support when contacting parents. Ashley explained her experience when contacting parents:

> I call home, and I usually do it during class. Whether they are acting up or there is an attendance issue, I call home right in class. Yes, it embarrasses them, but that is the point. The parents get mad and say, "You are disturbing me at work." My response is, "Your kid is disturbing me at work." I do that and it makes very little difference when I call home. They will improve for a very short period of time, then they go back to the disruptive behavior.

Classroom culture. PBL warrants a classroom environment very different from a traditional classroom environment. In a PBL classroom, students engage in inquiry learning. They participate in discovery activities and learn through trial and error. Students take responsibility for their own learning while the teacher serves as a facilitator. Students collaborate with their classmates to garner ideas, feedback and suggestions. If students do not possess the knowledge, attitude and skills to successfully participate in a PBL environment, PBL efforts will inevitably falter.

Teachers are responsible for creating a classroom culture suitable for PBL. The switch from a traditional to a PBL classroom is not a simple task. The skills to become self-directed learners are often not inherent in most students. Students must be taught these skills. Field notes indicate the teachers took minor actions to create a PBL culture. Ashley and Courtney attempted to incorporate collaboration into PBL activities by requiring students to work together on certain assignments. Nevertheless, field notes suggest students did not understand the concept of collaboration. Students were observed working independently on activities even though they were assigned to work collaboratively in groups. Furthermore, the physical classroom arrangement contributed to the lack of collaboration. Students sat at oblong, stationary lab tables with stools. The tables were approximately 15 feet in length and 4 feet wide. They accommodated roughly 6 students on each side. This seating arrangement made it difficult for students to gather into groups.

Ashley and Courtney also made an effort to create an environment which inhibited a fear of failure and allowed students to learn through trial and error. I observed an instance in Ashley's class where a student was resistant to taking a "wild" guess to answer a question. Ashley told the student to take a wild guess, but the student replied, "No, tell me." Ashley replied, "No, I want you to think about it. Tell me what you think. Nothing is right or wrong." The student eventually took a guess and he was correct. In a debriefing session, Ashley stated, "Getting them to guess is a challenge. They are not used to guessing. Getting them to take that step of possibly being right or wrong is challenging." She added, "Getting them to be curious like they were when they were little children is a tough one. That is why I have to make it comfortable to be wrong." Observations show Ashley and Courtney consistently gave students guidance and feedback on lesson activities and required students to revise assignments until they attained a mastery level of 80%. Although they stated they supported learning through trial and error, the activities they provided to students demonstrated otherwise. The activities they assigned required students to attain predetermined answers; not answers they discovered through the inquiry learning process.

One of the challenges that Courtney experienced as a classroom teacher was that students were not very receptive of the transition from a teacher-centered to a student-centered style of learning. She explained, "You are switching the rules on them. They do not like that. They have gotten used to a certain way of learning. It has been the same for ten years and now it is changing. It is more challenging." Courtney indicated that training students in PBL was difficult if it was not integrated in the curriculum across all courses. She stated, "One classroom might be getting a lecture worksheet done and then our class might be getting this giant project where they are given minimal information and not given things." She believed it was difficult for students to switch between the two styles of teaching.

Field notes show Kathy made no attempt to establish a PBL classroom culture. She assumed her students had the ability to work in a PBL environment. However, students' off-task behaviors observed throughout the PBL unit suggest they did not possess the skills to be self-directed learners. Kathy supported this observation with the comment, "it is nice in sciences if you have the culture where students can work efficiently in a two-hour lab period. But that is not the culture here."

District and school policies. As mentioned previously, the district required all teachers, regardless of subject matter taught, to use the Horizons program. Teachers were required to upload all lesson activities into Horizons for the students to access. Kathy did not use Horizons because she never received training. However, the teachers who did use Horizons identified challenges experienced with the program. Courtney described her experience with Horizons:

> There are a lot of bugs in the program and students do not know how to navigate the program effectively. Program features are getting changed all the time. Even

> teachers do not necessarily know how to navigate the program. It took me a good three months to really figure out how to copy resources, make sure they are visible to everyone, and how to embed HTML codes so you can embed videos. However, a lot of people do not know how to do that. Sometimes there are problems where if you attach a document, you cannot copy it to another class. Therefore, it is very time consuming. The idea is good. It is just not there yet, I think.

Ashley said she did not like Horizons because she is an auditory not visual learner. As a result, she used Horizons as a tool to augment her instruction and did not use the program to replace her classroom instruction.

Although the district paid approximately $20,000 for the purchase of two Educurious units, due to district requirements, teachers still had to modify the units. According to Rick, the units did not meet all the district's requirements. While the units met the students' academic needs, they did not provide student choice. Student choice was a district requirement. The district expected students to be given choice on how they learned and what they learned. Additionally, the units did not comply with the requirements of the Horizons program. As previously discussed, teachers had to organize lessons into Learn, Practice, and Apply modules. Since the Educurious projects were not developed according to these requirements, teachers had to modify the units to satisfy this requirement.

Resources. A lack of resources was mentioned by all three teachers in their interviews. They indicated that PBL requires specific materials for students if they were to complete the units successfully.

Teaching supplies. The lack of teaching supplies presented teachers with difficulties when implementing PBL. Courtney stated, "with our last unit, when the resources did not come in, that threw a wrench in the whole problem. We were trying to figure out how to implement PBL without the resources."

Courtney was not only dissatisfied with the lack of lab materials, but also with the resources she had on hand. She stated that she often did not have the materials she needed. Her classroom projector was broken. She felt her classroom set up was not ideal because she had large, long tables that were not conducive to creating small student clusters. She and Ashley had to buy the materials for the last unit they co-taught. Courtney added that the lack of supplies contributed to the discipline issues in her class.

The purchasing process for classroom supplies was overseen at both the school and district levels. The purchase process presented a challenge for teachers because it could take over a month to receive supplies. Rick provided further insight into the challenge of purchasing supplies. He explained:

> The purchase orders have to go through all these filters before it comes back around, but it should not have taken as long as it did. It took well over a month to get very few supplies. It was just a couple of hundred dollars for the stuff.

Ashley and Courtney stated they ordered supplies that either never came or arrived well after the date the supplies were needed. Even though they did not need to order any special supplies for the Greener Detroit PBL unit, they did state they had to use personal funds to purchase supplies for a previous PBL unit. Kathy's PBL project did not require the purchase of any supplies.

Support. Prior to implementing PBL, Courtney felt she had sufficient support from administration and other faculty, however after implementing PBL Courtney felt unsure. She believed the administration was at fault when she and Ashley did not receive the supplies they needed for their PBL unit. Ashley stated:

> Just because they [the orders] were put in does not mean the orders were placed. So having some accountability when you are placing this order would help us out so that we would know whether we are going to do the activity or not. You know what I mean? That is pretty simple. That is a huge part of it. It is huge.

Courtney also stated that although the administration encouraged teacher collaboration, they did not support it. She and Ashley lost a lot of planning and collaboration time because they were asked to cover a class or participate in other school activities and initiatives.

Lack of external resources. During her interview, Christy (the PBL facilitator from Educurius) mentioned that one of the essential components of PBL was an authentic learning experience. She stated that often teachers did not have access to connect students with authentic audiences or clients. There was a single occurrence where Kathy connected her students with an authentic client. She invited her mother to speak to students about a genetic disorder she carried. But other than this occurrence, field notes indicate the PBL units had no links to an authentic audience. Ashley and Courtney tried to link their project to an external audience by having students write letters to their senators regarding the Greener Detroit project. Sadly, the letters were never mailed, resulting in the students feeling the project was an exercise in futility and not a genuine learning experience on contacting relevant people about solving a problem.

Lack of time. Planning time and the school schedule presented additional challenges for the teachers. Courtney thought PBL required a large time commitment and collaboration among teachers to make it effective. She indicated that she felt constantly rushed for time when planning the PBL unit. She believed that if she had more time, the PBL lessons could have been more effective. Courtney also said more time to collaborate could have reduced the time she needed for planning because resources could have been shared by working with other teachers, instead of everyone having to find them on their own.

Rick also felt that collaboration was a missing component in the school. As he pointed out in an interview:

> One of the reasons we did not have this component is because the professional development schedule is set up for individuals or small groups to go away from the building and do their collaborative group work. There was not whole school building professional development where teachers worked together. We were not a team. This building was very segregated. I have been to places where the entire faculty was a team, with great things happening in the school. I think that was the biggest problem, in that no one felt like they were a part of a team. I only know that because I spoke to all those teachers. They said, this is the one thing I need. I need to work with the team. I feel alone. There are a lot of islands in the building this year.

The loss of collaborative planning time consequently had a negative impact on the lessons that were developed. Ashley explained:

> If you plan a lesson that is supposed to start on Monday but you are not done planning until Friday and you know you need plants, you obviously know that they are not going to get here in time for Monday's lesson.

Ashley and Courtney were frequently pulled from their classrooms to attend professional development. Ashley explained that "it is kind of an oxymoron. You see a teacher who may be having some success and what tends to happen in this education system is the teacher is pulled out of the classroom!" Ashley stated she was even pulled out of the classroom for things such as district initiatives that were unrelated to classroom instruction. She felt teachers needed dedicated, uninterrupted planning time, as well as consistent presence in the classroom when starting or completing a unit.

Courtney stated she had been pulled out of the classroom for three consecutive weeks, which slowed down her class' progress. As a result, her students did not progress as far as she had anticipated. Students needed more time to master the material. The students had great ideas, but absenteeism made it difficult to follow through on their ideas. Courtney added that she and Ashley were involved in many other activities, which limited the amount of time to plan after school. As a result, they had to meet and plan on weekends. They spent more than 20 hours planning lessons for the unit; had to upload assignments in Horizons; and find resources and create rubrics, which took a long time, especially with the technology difficulties they experienced. Ashley emphasized the need for teacher collaboration to make PBL successful. She stated that some schools where she had previously worked granted a two-hour late start for students one morning each week for teacher collaboration. This time was used for teachers to meet and co-plan.

Rick's schedule was also changed midyear. He was drawn from his coaching responsibilities to work on district initiatives which reduced the amount of time he was able to devote to working with the teachers. Although he still met with the teachers to give them strategies, answer questions, and examine data, he was unable to spend time in the classroom to observe the implementation of the feedback he had provided.

Scheduling. Towards the end of the school year, the school district decided to change the school schedule. The school adopted a flex schedule (students had shortened classes for ½ of the school day, with students involved in credit recovery classes for the remainder of the school day). With the flex schedule, Ashley and Courtney's classes were combined into one class. Ashley felt that the change in the school schedule and classroom location negatively influenced her students' progress in the unit. The teachers noticed that with the change in schedule, fewer students were coming to school. This change also affected the length of each class. Whereas before the schedule change, students were in class for approximately two hours, with the flex schedule students were in class less than one hour. As a result of the schedule change, there was insufficient time available to complete the Greener Detroit PBL unit.

The school calendar presented yet another challenge for teachers. The school year did not end until August. Teachers believed summer was a problem because student attendance decreased substantially. They stated students were hot and burned out, and that no one was functioning at their best. In addition, there were a number of school related events that interrupted class time:

movie days, a school assembly, and building fires. As Ashley pointed out, “if it is a normal day, it is abnormal.”

Courtney liked the one-hour classes in comparison to the two-hour classes. She thought two-hour classes were too long, especially for students who were used to moving around in the classroom. However, she did mention that she felt more time was needed to do hands-on lab activities. Conversely, Ashley was not a proponent of the flex schedule. She felt she was unable to teach science concepts in depth.

Kathy expressed a dislike for block scheduling. She felt her students needed constant repetition. Students’ retention of information was inhibited by not having class daily. Her class had recently lost a whole week of instruction due to standardized testing. An additional challenge for Kathy was that she started teaching at the school mid-year. She believed that due to her late start and the students’ lack of prior knowledge about the unit, she was unable to teach the unit effectively. Kathy stated:

> I have talked about this before. With the block schedule, I have two days a week to teach this information. I am not teaching genetics the way I normally would teach genetics. When I taught at another school, pretty much second semester was genetics and evolution. That was it. And, I do not have the time for it here. I cannot even give them the background knowledge needed. It is just bits and pieces. It is like okay, you need to know this to get here. So let us focus on this instead of what the standards say you need to know.

Technology problems. Teachers felt technology was an integral part of PBL; however, technology problems made it difficult to implement PBL. All three teachers recounted their negative experiences with technology. As Courtney pointed out:

> There are a lot of technology issues, which sometimes slowed the learning down and frustrated the students. It is very hard for the teacher. Not so much in the summer, but it is hard for the teacher when you have 38 students in the classroom and 20 of the computers are not working or when you are trying to run a mini-lab in the back with 15 students or something like that.

There were a couple of days when Courtney pulled out her computer cart only to find two of 30 computers were working for her class of 38 students. When instances such as this occurred, Courtney used her paraprofessional to work in small groups with students. She asked students who were finished with their assignments to act as leaders for that day. She even began printing assignments in the event she experienced technology issues. Ashley explained how she dealt with technology issues.

> There are NetBook issues individually. There are network issues around the building. Then there are the software issues. That is what makes me angry because we do not know if it is programming or networking issues. Either one is out of our control. We almost have to anticipate that and have everything copied from the Horizon program. So it is redundant.

Kathy did not experience technical issues to the same degree as Courtney and Ashley. However, during one of the observations the Internet was not working. Therefore, she had to give the students a worksheet as an alternative assignment. According to Kathy, her main technology issue was Internet Explorer, which did not work well. As a result, she asked students to use Google Chrome as their search engine.

A school policy that interfered with the implementation of PBL was the classroom computer use policy. When teachers were absent, students could not use the computers. Without the use of computers, students could not use the Horizons program to access the PBL tasks neither could they conduct Internet research. Teachers had to provide students with filler activities while they were absent and these filler activities might not have been related to the current topic of study.

Inadequate professional development. Science teachers, along with Social Studies teachers, participated in four days of professional development training on PBL. Nine teachers attended the training; four of which were science teachers. The science and English instructional coaches were in attendance as well. The school principal did not attend the training.

The following is a description of the events that took place during the professional development training.

The Educurious facilitator began the training with a self-introduction. Afterward, she questioned participants of their knowledge and previous experience with PBL. Participants' responses indicated teachers possessed a basic awareness of PBL. One teacher defined PBL as "an instructional method which uses projects to demonstrate student learning." Another teacher asked the difference between project and problem-based learning. The facilitator responded, "These methods are more similar than different, but there are two main differences: problem-based learning focuses on solving a problem, not a final product and problem-based learning generally does not require the same amount of time investment as project-based learning." Over half of the participants had no prior experience with PBL. None of the participants had any formal PBL training. The facilitator proceeded with a PowerPoint presentation consisting of an overview of Educurious and an introduction to the Educurious model of PBL. Field notes indicate teachers were attentive and intellectually engaged in the presentation. Teachers responded to questions posed by the facilitator. Teachers were actively listening, taking notes and asking questions. Some of the questions posed by teachers included "What is the best way to establish and manage student groups?", "How long is a typical PBL unit?", and "How often is formative assessment used and how do I use it in a unit?" Teachers were regularly observed interacting with each other in response to the facilitator's request to confer with a partner or complete various activities.

The facilitator discussed eleven Educurious learning design principles that should be present in PBL projects. Teachers indicated they needed more information regarding those principles not generally utilized in a traditional classroom such as digital citizenship and the use of discipline experts. The presentation continued with the introduction of the PBL planning process. The remaining three training days were devoted to the PBL planning process. The planning process was divided into two phases, unit development and unit revision. The unit development phase consisted of brainstorming possible project ideas, identifying applicable content standards, goals and objectives relevant to the project idea, developing “need to know” questions, and identifying a possible project/product. The facilitator had teachers work through the steps of the development phase by participating in mind mapping activities. Teachers were given large poster paper and Post-It notes to map out their ideas. The majority of teachers worked individually on the activity while Ashley and Courtney worked collaboratively on their project. Both the facilitator and science instructional coach circulated to provide assistance, give feedback, and answer questions. Feedback comments included, “How does the final product answer the driving questions?” “Is the driving question something students can “Google”? “Who will be the authentic audience for this project?” Teachers appeared to be excited and motivated by the future use of PBL in their classrooms. Teachers were overhead making comments such as “I am hoping they will be as excited as I am!” and “Wow, I never thought of it like that!”

By the end of day two training, teachers had developed a draft of their PBL unit, which they shared with their peers. Teachers were instructed to email a copy of their draft to the PBL facilitator who would provide additional feedback and identify a discipline expert for the project. The final two days of training were dedicated to phase 2 of the PBL planning process; unit revision. Teachers continued to revise their PBL units utilizing the feedback of the facilitator, coaches, and colleagues.

On the last day of PBL training, teachers shared their final unit plans with their colleagues. Feedback and suggestions were provided. At the end of the day, time was allotted for teachers to summarize their PBL experience and to express any problems or concerns. Field notes indicate teachers were optimistic regarding their PBL training and units. Teachers commented they felt the training was beneficial. One teacher stated "The training was very effective for me. I knew very little about PBL, but this training brought more clarity. Another said, "I thoroughly enjoyed the training. The information was clear and the hands-on activities helped to understand the PBL process." Some teachers were concerned about their ability to cover all the content standards while using PBL. The facilitator responded teachers should ensure the standards are the focus of the project. In that way, the standards drive the project. Another concern was the time needed to plan units. The facilitator acknowledged PBL would require a great deal of planning time initially. She suggested using the Educurious units or finding online projects. She stated once a unit is planned, it will not require as much time the next time it is used. Kathy posed the question, "Looking at the demographics of my students, how I design an appropriate activity that they can access?" The facilitator gave a vague response. She stated, "Well, they will just get it." One teacher commented she would have liked to have seen videos showing a teacher actually implementing the PBL process.

In the course of the 8 weeks following the initial training, teachers were expected to continue with the revisions of their PBL units. The science instructional coach informed the science teachers he would be conducting meetings with them to assist in the development of their PBL units. Unfortunately, these meetings never occurred.

After the PBL training, teachers were left with the challenge of integrating the district's instructional model with the implementation of PBL in their classrooms. The training did not address how to incorporate PBL into the district's instructional model of Learn, Practice, and Apply. The teachers indicated they invested their best efforts in aligning PBL implementation to the model. However, they expressed they were uncertain whether their efforts met both PBL and district expectations.

During the PBL training, Kathy began planning her genetics unit with the help of the Educurious facilitator and science instructional coach; however, she did not like Educurious' approach. She stated Educurious wanted her to begin the unit with the character from X-Men, Wolverine, as an introduction. She indicated that this type of introduction was not relevant to her students. Therefore, she decided to begin the unit with the introduction of genetic diseases. Kathy also believed the resources provided by Educurious were not relevant to students. After the genetics unit, Kathy planned to begin an Educurious unit on evolution. The project for the unit focused on Orca whales. She believed the topic of evolution would be of interest to students; however, she was concerned that students most likely would not care about Orcas.

Ashley felt that the PBL professional development was not offered at an appropriate time. Teachers did not begin training on PBL until February. She thought that starting the training at the end of the previous school year would have been more effective and would have given teachers time over the summer to plan and write curriculum for the upcoming school year.

Rick believed the training was good at explaining how to build PBL units, but was lacking on how to implement the units. He stated:

> I also think that more training needs to happen in terms of how to implement the practice. Not just hiring someone to come in. I think there needs to be more time to sit down and discuss the implementation together as a group.

CHAPTER 5 DISCUSSION, CONCLUSION, AND IMPLICATIONS

This chapter discusses the results presented in the previous chapter. The discussion is framed around major areas related to the study.

Implementation of PBL in High School Science Classrooms

The focus of this study was the implementation of PBL in the classrooms of three science teachers. The teachers had secondary certification in either Biology, General Science, or both. Two of the teachers were first year teachers; one had previous teaching experience as a science substitute teacher and the other was a teacher obtained from the organization, Teach for America. The third teacher had seven years of teaching experience. The veteran and the Teach for America teachers co-taught an environmental science class while the other teacher taught a Biology class. The environmental science teachers shared a common planning period and were therefore able to collaborate in lesson planning. The Biology teacher had a separate planning period and had to plan independently.

Project-based learning is commonly defined as an instructional approach that begins with the presentation of a problem and ends with the generation of a final project (Kubiatko & Vaculova, 2011). Survey results indicated that only two of the three teachers had an understanding of PBL aligned with this definition. The other teacher believed PBL was the completion of an artifact at the end of the unit. She referred to students building a cell model as an example of PBL. Her limited view of PBL may have been the result of only attending two of the four PBL training sessions. She was hired in February and therefore missed the initial PBL training. The shortcomings in her understanding were in turn reflected in how she implemented PBL in her classroom.

Research states that in order to successfully implement PBL, teachers must be motivated, open to change, flexible, and confident in their ability to use a new strategy (Tarmin & Grant, 2013). Classroom observations and survey results indicate that although the teachers were excited about implementing PBL, only one of them rated her confidence level on the approach as high. However, all of the teachers appeared open to change and viewed it as a means to increase student engagement and achievement. Unanticipated changes in the school's schedule and various classroom interruptions required teachers to be flexible and they attempted to adapt their lessons accordingly.

A study conducted by Tarmin and Grant (2013), identified four different ways a teacher may use PBL: to introduce a concept, to reinforce a concept, for enrichment of a concept, or use it based on the needs of the students. In this study, all teacher participants used PBL to introduce a concept. According to research, the role of the teacher in PBL is to scaffold the content, provide guidance, manage student groups, continuously assess student learning, and provide opportunities for reflection (Kubiatko & Vaculova, 2010; Tarmin & Grant, 2013; Etmer & Simons, 2006; Cook, 2009). Classroom observations provided evidence of some of these teacher actions. All the teachers showed evidence of scaffolding content in various ways. Teachers provided guided practice and demonstrations to clarify concepts. They used graphic organizers and pictures to aid in student learning. Teachers also used class discussions to introduce new ideas and promote conversations about the content, and used open-ended questions to engage students in inquiry thinking. During the lesson debriefing sessions the teachers mentioned that scaffolding was necessary due to the diverse learning abilities of their students. Ngeow and Yoon-San (2001) noted scaffolding is an important process and teachers have to carefully structure learning activities to build upon each other, thereby gradually developing students' knowledge. The teachers in this study continually provided guidance while students worked independently or in groups. Guidance included answering questions, working with students in small groups, and providing individual assistance. The environmental science teachers emphasized group work and students were encouraged, and sometimes required, to work in groups to complete classroom assignments as well as the final project.

Student learning was assessed throughout the PBL unit, but was done to varying degrees by each of the teachers. The teachers who co-taught the PBL unit assessed student learning on a daily basis through the questioning of students and student performance on class assignments. This approach in turn allowed the teachers to provide students with immediate feedback. Students were even required to correct their work based on the teacher's feedback so that they could attain mastery. In contrast, the Biology teacher assessed student learning sporadically. Her approach to assessment and feedback was not done daily and/or consistently. Assignments were submitted to the teacher, graded, and returned to the students. In addition, none of the teachers provided students with the opportunity to reflect on their learning. Reflection is an important step in PBL because it allows students to think about what they have learned and allows teachers to monitor student learning throughout the PBL process (Colley, 2008; Cook, 2009). Reflection was also not emphasized as an important component of PBL during the PBL training the teachers received. This could explain why none of the teachers utilized reflection.

According to the literature on PBL, the problems presented to students in PBL should be ill-structured and open-ended (Nelson, 2010). In PBL the problem should have a number of possible solutions and is constantly evolving as students discover new information through inquiry learning (Akçay, 2009). As students gather additional information, they must consider other variables and possible solutions not previously considered. As a result, the PBL process provides a degree of uncertainty in the learning process to which most students are often unaccustomed (Gallagher et al., 1995). These important aspects of PBL were not evident in all the classrooms observed in this study. The problem associated with the Greener Detroit PBL project was an ill-structured problem and students had to search for information to reach a proposed solution to the problem. Students proposed various solutions to the problem; supporting the claim that PBL problems have no definitive solution. In a follow-up interview, the environmental science teachers also mentioned a water filtration project they had completed for a previous PBL unit. The teachers mentioned how the students had to design and create their own water filtration system and present their final product to the class. This approach supports Gallagher and other's (1995) claim that PBL can promote scientific inquiry by requiring students to generate and tests hypotheses, plan experiments, gather and analyze data, and present their findings to a group of peers. On the other hand, the students in the Biology class were not provided with a problem. Instead, they were asked to use the Internet to locate background information on a genetic disease of their choice. Classroom observations suggest the Biology teacher had misconceptions about PBL. She held to the traditional approach that projects are completed after the content has been taught. She did not appear to understand that the project should be guided by a problem the students needed to solve.

Collaboration is also an essential component of PBL. Collaboration allows students to get feedback, suggestions, and guidance from their peers (Meyer, Turner, & Spencer, 1997). Evidence of collaboration was observed in the environmental science classes. Students were frequently observed working in pairs or in larger groups. One of the teachers felt so strongly about the need for collaboration that she assessed students' collaboration skills and their ability to work in a group. Some of the collaboration attributes she assessed included the students' ability to cooperate, the distribution of the work among the group members, and the students' ability to stay on task.

Collaboration was not observed in the Biology class. Students were regularly observed working independently to complete assignments and perform tasks. Debriefing interviews and classroom observations indicate classroom behavior was problematic for the Biology teacher, who might have avoided group work in order to minimize classroom management issues.

Alignment of PBL Implementation with the Major Components of PBL

Thomas (2000) identified five criteria that a lesson should meet in order to be considered project-based learning. The five criteria are: centrality, a driving question, constructive investigations, autonomy, and realism. Data obtained from classroom observations, debriefing sessions, and follow-up interviews were used to identify these criteria in the science teachers' implementation of PBL.

Criteria 1 Centrality: The project must be the starting point for learning. When planning a PBL unit, teachers' must begin with the end in mind. PBL lesson planning should follow a backwards design process similar to that developed by Tighe and Wiggins (2005) in which the teacher begins with the lesson outcomes and plans corresponding lesson activities that foster the learning needed to achieve the outcomes. The projects created in PBL should be aligned to the desired learning outcomes and should provide the evidence that the learning outcomes have been met. Therefore, the project in PBL drives classroom instruction and all associated learning activities (Larmer, Ross, & Mergendoller, 2009).

The results of this study indicate the project was the starting point for the learning in each teacher's class. It provided the purpose for student learning. However, even though the teachers began the PBL units with the introduction of the project, classroom observations suggest the project lost its focus as the unit progressed. Students performed daily tasks and assignments but the teachers often did not link these tasks and assignments back to the PBL project. The daily activities appeared to be isolated and unrelated to the project. For example, students in the environmental science class were given a concept map to complete. They were provided with a word bank to use in the concept map. The relevance of the concept map to the final project was not evident. Similarly, in the Biology class, students completed worksheets on genetic mutations to reinforce their learning. However, when the time came for student presentations, students were unable to make the connection between genetic mutations and the genetic diseases discussed in their projects. Teachers can establish the relationship between daily classroom activities and the final project by creating a "need to know" list. A "need to know" list is created by students at the introduction of the project in which they identify the information they need to know to solve the problem (Savery, 2006). The "need to know" list then guides student learning thereafter. Data from this study suggest the teachers themselves created the "need to know" list for the project and developed the lessons and classroom activities based upon this list. This in turn prevented the students from ever taking ownership of their learning and final project.

Criteria 2 Driving question: The project begins with a question that motivates learning. Larmer and Mergendoller (2010) state that an important part of the PBL process includes a driving question to be answered by the completion of the project. The driving question is an open-ended question that centers on a real-world problem and is designed to promote the learning of content standards. The driving question motivates students to learn because it is related to their own experiences (Schneider et al., 2002; Larmer, et al., 2009). According to Larmer and colleagues (2009), a driving question has three characteristics: 1) provocative or challenging -- the question is relevant and interesting, 2) open-ended and/or complex -- there are numerous solutions to the driving question and the solution requires the use of critical thinking skills, and 3) linked to the core of what students are to learn -- the driving question steers students in the direction of acquiring the knowledge and skills intended for the students to learn. Krajcik and Blumfeld (2006) mention two additional characteristics of a driving question: the driving question should be realistic, meaning it can be actually answered by the students and the question should be ethical -- it should not cause harm to the objects of study.

The environmental science teachers began the Greener Detroit project with the driving question: "How can we solve Detroit's environmental problems?" The final project for students to accomplish was to design a plan for the school's parking lot if it were torn up. The question further asked: should the parking lot be repaved or should it be converted into a garden or green space? This project directly related to the driving question of the unit. Throughout the unit, students learned about urbanization and urban sprawl and the final project addressed one of the environmental problems of urban sprawl in the Detroit area. On the contrary, the Biology teacher did not begin the PBL unit with a driving question. She began the PBL unit by informing students they were going to be learning about genetics and that they would be responsible for the presentation of a genetic disease at the end of the unit. She gave students a handout that provided the presentation details and reviewed the project expectations with the students.

Criteria 3 Constructive Investigations: **The projects are inquiry-based.** The goal of science is to spark inquiry. PBL is an inquiry approach to science (Chin & Chia, 2006). The National Science Education Standards (NSES p. 23) define scientific inquiry as:

> The diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.

Therefore, inquiry describes the teaching and actual process of doing of science (Colburn, 2000). It is an on-going investigative process that continues until a solution is found (Larmer, Mergendoller, & Boss, 2015). Inquiry is important because it engages students in the practices of science and promotes a deep understanding of science concepts. With the newly acquired knowledge, students construct new ideas, questions, or a final product (Larmer & Mergendoller, 2010). Through inquiry students develop scientific skills such as asking questions, testing hypotheses, analyzing data, and drawing conclusions (Chia & Chin, 2005).

In an inquiry-based science classroom students create and answer their own questions and students' generation of new ideas and questions guide teacher instruction and directs student learning (Chia & Chin, 2005). Students engage in two methods of inquiry learning; general inquiry and scientific inquiry. General inquiry is unrestricted inquiry. Students are allowed to investigate anything they choose. In scientific inquiry students investigate science-related concepts. With scientific inquiry, science is taught as a process not as content (Chiappetta, 1997).

Many teachers do not know how to create inquiry learning experiences (Johnson, 2009). However, teachers who use inquiry-based teaching experience increased student achievement on local and state assessments. Inquiry-based science instruction can be facilitated using a variety of instructional strategies such as a) asking questions: activates critical thinking skills, b) science process skills: help students behave and think like scientists, c) discrepant events: spark curiosity and stimulate critical thinking , d) inductive activities: allow students to experience a concept before it is explained or defined, e) deductive activities: explain and define a concept before students experience the concept, f) gathering information: students acquire information, and g) problem solving: students identify a problem, conduct investigations, gather data, and form a conclusion (Chiappetta, 1997). Alan Colburn (2000) identified a number of ways teachers can implement inquiry-based instruction. Structured inquiry occurs when the teacher gives students the problem and the method for solving the problem but the students are unaware of the outcome.

In guided inquiry, students are only given the problem and materials to solve the problem. Students have to create their own procedure to solve the problem. Open inquiry is the same as guided inquiry with the exception that students identify their own problem to investigate. Finally, the learning cycle is an inquiry based instructional approach in which students experience a concept before it is explained or defined. The students are then challenged to use the concept in a new context. Colburn (2000) asserts it is easier to teach concrete concepts through inquiry learning than it is to teach abstract concepts. According to Colburn, if an activity is too complicated for students, very little learning will occur. Conversely, if an activity is too easy, critical thinking is not developed.

Research exists that opposes inquiry-based science instruction. Clark, Kirschner and Sweller (2012) characterize instructional methods that encourage inquiry learning, such as PBL as partially guided instruction. According to these researchers, while partially guided instruction may be effective for advance learners, it is ineffective for the average learner. They believe these students should be taught new information through direct instruction. According to them, direct instruction is more effective than inquiry learning for average learners. In direct instruction, teachers provide a thorough explanation of the concept being studied. This can be done through such instructional strategies as lectures, class discussions, or videos. The learning activities given after direct instruction are designed for individual practice in order to develop students' knowledge and skills so they can work independently. Projects and independent learning activities can be valuable tools for learning when used as ways for students to practice what they have learned.

Hmelo-Silver, Duncan, and Chinn (2007) disagree with Clark and colleagues' premises. They assert PBL is not considered a partially guided instructional strategy because the teacher facilitates the learning process; scaffolding lessons and providing direct instruction as needed.

Scaffolding makes learning less difficult by breaking down challenging tasks into smaller, manageable tasks.

The Greener Detroit project was not inquiry based. Students acquired content knowledge through Power Point lectures and reading articles that the teachers provided. Assessments were not inquiry based either and included worksheets, creating illustrations, and writing assignments. The lack of inquiry in this unit was impacted by a last minute change in the school's schedule. Towards the end of the school year the school district decided to change the school schedule by adopting a flex schedule (students had shortened classes for ½ of the school day, with students attending credit recovery classes for the remainder of the school day). This change affected the length of each class. Whereas before the schedule change, students were in class for approximately two hours, with the flex schedule students were in class less than one hour. As a result of the schedule change, there was insufficient time available to complete the Greener Detroit PBL unit.

As previously mentioned, prior to the beginning of the study, the environmental science teachers had completed a water filtration PBL unit that was inquiry based. Students were charged with designing and building a water filtration unit. Students were given materials to build their water filtration unit, but received no instructions on how to build it. According to the teachers, students struggled with the task of building the unit without instructions. One of the teachers stated students often came to her for reassurance that they were doing things right. She encouraged students to test their ideas, and if they were wrong, to try again. She stated," that is what science is all about, try, try, try to figure it out." As Meyer and others (1997) pointed out, in order for PBL to succeed, teachers must create a learning environment where students learn by trial and error.

On the other hand, the genetics project did not involve inquiry. Students researched a genetic disease and created a PowerPoint presentation. Also, the classroom activities provided throughout the unit were not inquiry based. Instead, they consisted of answering questions from the textbook and completing worksheets.

Criteria 4 Autonomy: The project provides the students with choice. Students show no interest in activities in which they have no ownership (Marx et al., 1994). Autonomy, also referred to as student voice and choice, promotes student ownership over their learning and increases student interest and engagement (Nelson, 2010). Autonomy provides students with control over what they learn and how they learn (Chin & Chia, 2006). In some PBL classrooms, students are presented with a problem and then assigned various activities to solve the problem. This approach does not stimulate problem solving or authentic learning (Savery & Duffy, 1995). Without autonomy, students do not feel ownership of the project and simply view the PBL processes as following a set of prescribed actions (BIE, 2015). Autonomy can be provided in various ways. Students can select a topic from a list provided by the teacher or they can select their own topic for investigation. Students can also be given autonomy in how they design a project or the resources they use in their research (Larmer & Mergendoller, 2010). Stefanou, Perencevich, DiCintio and Turner (2004) suggested three ways in which autonomy can be provided in the classroom. Organizational autonomy allows students to make decisions related to the classroom environment and class operations. Students can choose group members or the date which an assignment is due. Procedural autonomy offers student choice in the way in which tasks are carried out. Students have choice in such details as to the materials to use and the means by which they demonstrate their learning. Cognitive autonomy provides choice in the process by which learning is achieved. Students can participate in actions such as justifying their answers or debating ideas. Cognitive autonomy has been linked to gains in student achievement and increases in student motivation and achievement. Organizational and procedural autonomy have not been associated with these same types of gains.

Students in the environmental science classes had autonomy in developing the design plan for the school's parking lot. Students were also given choices through the learning activities they completed throughout the unit. For example, students were given the choice to write a letter to the governor about urbanization in the city of Detroit; make an illustration describing the problems of urbanization; or create a poem or rap to describe the problems associated with urbanization. Likewise, students in the Biology class were given autonomy in selecting the genetic disorder they wanted to study. These findings are consistent with the research claims concerning autonomy.

Criteria 5 Realism: The projects are relevant. Realism is among several features of a good project. Projects reflecting realism purport problems that are likely to occur and are therefore meaningful to students. Projects lacking realism are typically viewed as exercises. Other descriptors associated with realism include relevance and authenticity. The presence of realism, relevance and authenticity increases student learning and motivation. Relevance describes how a project relates to the real-world. A relevant project presents students with a problem they are likely to encounter or that would have a large influence on their community (Nathanson, 1997). A project can demonstrate authenticity in a variety of ways. A project with an authentic context engages students in solving problems experienced by individuals outside the school setting. Such projects may involve students designing an energy efficiency plan for an organization. Authenticity can also be provided through the use of real-world tasks or tools. Students can use professional software to develop a final product. A project can provide authenticity if it has an impact on others. An example would be developing a recycling program for a school. Lastly, a project that relates to students' own experiences is referred to as personal authenticity (BIE, 2015).

The Greener Detroit project was relevant to students because the final project had an impact on the community. The Greener Detroit project was grounded on the Detroit Future City framework; a compilation of land usage suggestions for the city of Detroit. The Greener Detroit project built on the Detroit Future City framework by requiring students to develop a plan for how to use the land of the school's parking lot. On the other hand, the genetic disorder project did not have any relevance for students unless the student or someone they knew had the disorder.

Models of PBL other than Thomas (2000) include as key features collaboration, reflection and the use of technology (Krajcik et al.,1998; Harada, Kirio, & Yamamoto, 2008; Ladewski, Krajcik, & Harvey, 1994; Krajcik & Blumfeld, 2006). Students in the environmental science classes were encouraged to collaborate. Teachers were able to get students to collaborate by having them work on group projects. Some students struggled with collaboration because they were accustomed to working independently. Collaboration is essential in PBL because students gain a greater understanding of content by working together (Krajcik & Blumfeld, 2006; Akçay, 2009). The complexity of the PBL problem serves as a catalyst for collaboration. Students share and develop ideas and hypotheses and collaboratively develop a plan of action (Nelson, 2010). Collaboration also enriches student investigations. The comments, ideas, and questions generated help students develop purposeful experiments (Krajcik et al., 1998).

Technology is commonly used as a tool for students to conduct self-directed research (Cook, 2009). Technology was used on a frequent, almost daily, basis in each of the classrooms. Technology was used to scaffold lessons, conduct research, and create presentations. However, unlike other PBL studies (Krajcik et al., 1998; Ladewski et al., 1994; Krajcik & Blumfeld, 2006), technology was not used as a means of electronic communication.

Reflection is an important step in project-based learning because it gets students to think about what they are learning or have learned (Ngeow & Yoon-San, 2001). After identifying a possible solution to a problem, students discuss what they learned during the problem-solving process (Barrows, 1998). In this study, the element of reflection was not observed in any of the classrooms.

Challenges in the Implementation of PBL

The challenges identified in this study can be grouped into three themes: student attributes, support and resources, and professional development.

Student Attributes. Study participants identified a number of student attributes that challenged the implementation of PBL. High student absenteeism prevented teachers from completing the PBL unit in a timely fashion. Teachers felt school attendance was not important to students. These findings are consistent with the findings of Balfanz and Byrnes (2012) who stated poor attendance is common among low-income students. Research indicates student absenteeism increases as students progress from middle to high school. According to Balfanz and Byrnes (2012), the reasons students miss school fall into three categories: students who cannot attend school, students who will not attend school, and students who do not attend school. Students who cannot attend school are those who have an obstacle that prevents them from attending school such as an illness or family responsibilities. Students who will not attend school are individuals who purposely choose not to attend school out of fear for their safety or harassment. Finally, students who do not attend school are characterized by those who are disinterested in school and choose not to attend. Teacher comments suggest students at the school fell into the category of students who did not attend school because they did not feel attending school was important.

Teachers felt students were not motivated to learn. They found themselves engaging in battles with students to complete their work. Their experience contradicts what research states about PBL and its impact on student motivation. The benefits of PBL include increased motivation and engagement, a deeper understanding of concepts, and the development of critical thinking skills (Chin & Chia, 2006; Tarmin & Grant, 2013). Student motivation should increase with PBL because students have a choice in how they learn and the learning activities stimulate student interest (Nelson, 2010; Hulleman & Harackiewicz, 2009; Chin & Chia, 2006). Unfortunately, and as previously discussed, the students in this study had few choices on how they learned.

Disengaged students are commonly viewed as behavior problems and appear to not be concerned with their future. Research has shown student engagement is determined by students' belief in their ability to complete a task. If a student feels incompetent to complete a task, the student will not be motivated to engage in the task. Conversely, if students believe they have the ability to succeed, they tend to participate in learning activities. However, there are some unmotivated students who are disengaged not because they lack the academic ability but are disengaged because they are disinterested in school. These students are more than capable to do the assigned work but choose not to do it. Students become disengaged when they feel school does not value their interests and skills. Students have to see the relevance of learning activities in which they are expected to participate. If students understand the relevance, they will participate (Daniels & Arapostathis, 2005). The findings of this study suggest students were not engaged in the learning activities because they did not feel they were relevant or the activities were too difficult. This is consistent with classroom observations in which students demonstrated frustration by putting their heads down or sitting idle. One teacher commented that if she taught the unit again she would be more consistent with rubrics and making sure students understood early on the expectations of certain assessments. She added she would include a lot more hands-on activities.

Teachers commonly feel students should be motivated because grades are linked to learning tasks. Unfortunately, often grades are not motivators for some students. When students devote their energy to complete assignments, only to earn a poor grade, their motivation to continue engaging in learning experiences diminishes. Teachers must maintain a balance between allowing students to struggle to the point of frustration and providing the necessary assistance to help them succeed. If frustration progresses too far, students feel discouraged and therefore disengage. On the other hand, if the teacher gives too much assistance, students become dependent on the teacher and unwilling to explore on their own (Daniels & Arapostathis, 2005).

Poor student behavior presented another challenge for the teachers in this study. Teachers were confronted with students' engagement in off-task behavior and their refusal to follow school rules. As one teacher mentioned, "I can not get this class under control. I have too many groups of students that are loud and want to play." Yet, PBL is generally associated with an improvement in student behavior. Colley (2008) found that teachers who used project-based approaches experienced less classroom disruptions. Furthermore, the increase in student motivation and engagement that often results from PBL should in turn decrease classroom behavior issues (Tarmin & Grant, 2013; Blumenfeld et al.,1991). Given the research on PBL, the students in this study were most likely behavior problems because the learning was not interesting or relevant. PBL should motivate students to learn (Kanter & Schreck, 2006). Moreover, due to the inquiry nature of PBL, students are given ownership of their learning. Many of the students in this study lacked the skills to work without teacher-led direction. Therefore, frustrations arose resulting in disciplinary problems. Another reason for poor student behavior could be that students did not view their learning as meaningful. Although genetic disorders and urbanization may be interesting topics, some students may not have found them relevant because they did not have any personal connection to these topics.

Support and resources. The results of this study indicate that certain school and district policies and requirements were not conducive to PBL implementation. Purchasing and technology policies, as well as curriculum requirements interfered with the implementation of PBL. District policies also made it difficult for teachers to obtain supplies needed for PBL projects. Furthermore, the district's decision to change the school schedule in the midst of PBL implementation significantly impaired PBL efforts. These barriers resulted in modifications and delays in the progression of the PBL units. Despite these barriers, teachers were still expected to implement PBL. Teachers felt lost and hopeless. According to the teachers, they felt they had very little support from school and district leaders.

Decisions made by the principal and district leaders hindered teachers' PBL efforts. These decisions resulted in the teachers not having adequate time to properly plan and implement their PBL units. Teachers lost planning and collaboration time in order to cover the classes of absent teachers. Teachers also lost instructional time to attend mandatory district meetings. Although there is no magical number for the amount of time teachers need to plan, teachers need planning time, particularly when implementing a new teaching approach such as PBL. Lesson planning, both individual and collegial, increase teacher knowledge of the content, student learning, and teaching strategies (Shen, Poppink, Cui, & Gan, 2007). One of the teachers in the study offered as a recommendation that teachers must have time and resources. She added,

> I would say number one, prepare a large block of time to plan and make sure you are backwards planning. I would say that you have to, have to, have to collaborate. If you do not collaborate you will not be as successful.

Another teacher stated time was important. She recommended teachers clear their schedule because PBL will become their primary focus.

A lack of support can have a negative impact on teacher motivation. Lam and Choy (2010) studied the impact of three types of school support on the implementation of PBL. The three types of support were competence, autonomy, and collegial. Competence support was defined as the school making the proper preparations to facilitate the implementation of PBL workload. Autonomy support was defined as the school giving teachers freedom in the implementation of PBL. Collegial support was defined as the school supporting collegiality among staff. They found that when all three types of support were present, teachers were motivated to change. Although the teachers in this study lacked all three types of support, they did not view lack of support as an excuse for them to abandon PBL.

The use of technology is an integral part of PBL. Technology is used as a tool for students to conduct research and increases teacher and student motivation to implement and complete projects (Cook, 2009). Unfortunately, technology was another resource in low supply. Teachers expressed they were faced with a shortage of computers for students to complete assignments and a number of technology issues interfered with the teachers' ability to implement PBL. Technology issues included problems with Internet connectivity, inoperable computers and software problems.

Professional development. Professional development has been described as the key to educational reform because it increases and deepens teachers' knowledge. Professional development should not be what is typically referred to as sit and get learning. It should evoke active learning; requiring teachers to take on the role of students in order to gain knowledge of the subject and of their students (Wilson & Berne, 1999).

According to Murray and Savin-Baden (2000), staff training in PBL should occur at least one year prior to implementation. In this study, training did not follow this recommendation. Teachers received training approximately two months prior to implementation. Teachers felt the training should have occurred towards the end of the school year; allowing them time over the summer to plan PBL units. The science instructional coach thought the PBL training had been more theoretical rather than practical in nature. He felt it trained teachers on how to plan a PBL lesson, but not on how to implement a PBL lesson. The lack of the practical application of PBL was evident in the challenges teachers experienced.

Successes in the Implementation of PBL

The successes identified by teachers included student engagement, student achievement, and teacher collaboration.

Student engagement. Teachers not only viewed student engagement as a challenge but as a benefit as well. Although there were students who were noticeably disengaged, there were others who exhibited the opposite behavior. Teachers stated they saw an increase in student engagement and involvement in lesson activities. According to Schwalm and Tylek (2012), students tend to be actively engaged in projects that focus on their interests, needs, or questions.

Student achievement. Research has shown that in project-based learning students perform higher on standardized and classroom assessments (Schneider et al., 2002; Alacapinar, 2008; Geier et al., 2008)). Although students in this study did not take any standardized tests, one teacher reported she noticed higher academic performance on classroom assessments in comparison to student performance on assessments the previous school year. Teachers also noted an increase in students' ability to problem solve. Such an increase is expected due to the fact PBL is premised upon problem solving.

Teacher collaboration. Collaboration is an essential part of teacher learning (Ladewski et al., 1994). Two of the teacher participants shared a common planning period and were able to plan and collaborate together. They reported great benefits from this symbiotic relationship. They were able to share and discuss ideas, resources, and lessons. These findings are consistent with those of Blumenfeld and others (1994). They found that collaboration was deemed beneficial if all parties had their needs and concerns met. Teacher needs included materials, activities, and the sharing of ideas. Collaboration is a powerful tool because it is a synergetic process. The end product of collaboration is greater than the sum of the individual parts. In other words, teachers gain more when working together than they do when working individually.

Role of the Administration and Support Staff in the Conceptualization and Implementation of PBL

One of the primary concerns of a low-performing school is student performance. According to Kouzes and Posner (2002), effective leaders reject maintaining the present state of affairs and take responsibility and authority over change. As a result, when faced with the challenge of turning around a low-performing school, a school principal must have a clear vision of what intervention(s) to use and be prepared to prioritize the areas of focus (Duke, 2010; Wagner et al., 2006). Although staff consensus should be sought when designing an intervention, the school principal ultimately has the final say in terms of the focus areas that guide the everyday activities and operations of the school.

In this study the school principal (Steve) was disturbed by the lack of student academic progress. He recognized a need for instructional improvement, specifically in the areas of science and social studies, and identified PBL as a school reform initiative. The conceptualization of PBL began with Steve's vision for the school to use PBL as an instructional strategy to raise student achievement. In his previous experiences, Steve had implemented PBL and believed in the value of this teaching approach. He assembled a leadership team comprised of the school improvement grant coordinator, Title I coordinator and the school science instructional coach to facilitate the implementation of PBL. Steve's actions were consistent with the claim of Wagner and colleagues (2006) that school leaders must communicate the urgency for change and identify a group of individuals to supervise the process. The team was responsible for identifying a PBL training provider, coordinating the PBL training sessions, and oversight of the implementation of PBL in the classroom. After review and consideration of three companies, the leadership team selected Educurious as the provider of the PBL training. The science instructional coach served as the liaison between the school and Educurious -- scheduled the PBL trainings and communicated with the teachers about when and where the PBL training would take place.

Blair (2000) proposed six actions a school leader should take to facilitate change. The actions include (a) developing an atmosphere and context conducive to change, (b) developing and communicating a shared vision, (c) planning and providing resources, (d) investing in professional development, (e) monitoring and checking progress, and (f) continuing to give assistance.

Developing an atmosphere and context conducive to change. In this role a school leader creates a supportive and collaborative environment which allows staff to share ideas, discuss concerns, participate in decision-making, and assess their progress towards meeting school goals. The premise of this specific principal-led action is to create a professional learning community. Steve allocated PLC time for the science teachers to collaborate, however the frequency of these meetings was scarce. During the three months of this study not a single science department PLC meeting was held. The two environmental science teachers were able to collaborate because they shared a common planning period, however this common planning period was coincidental and not intentionally planned by the principal. On the other hand, the Biology teacher did not share a planning period with any of the other science teachers and therefore was unable to reap the benefits of teacher collaboration.

Steve's leadership did not create an atmosphere that supported change. The implementation of PBL requires a substantial change in teachers' instructional beliefs and routines. One member of the science department staff was resistant to the change and declined to participate in the study. Even though he participated in the PBL training and received individual support from the science coach, this teacher chose to continue with his traditional teaching methods. According to the science coach, the teacher was apprehensive about his ability to implement PBL and therefore elected not to participate in the study. Unfortunately, the principal did not invest the time to discuss the teacher's concerns regarding PBL and to provide the teacher with the encouragement and support needed to implement PBL in his classroom.

Developing and communicating a shared vision. This action requires the school leader to include all stakeholders in the creation of a school vision which guides all school decisions. Steve mentioned his own vision for the school but not of a shared school vision. There was no evidence that others were familiar with or shared a school vision.

Planning and providing resources. School leaders ensure there are adequate resources, time, and personnel to implement a reform initiative. According to Spillane and others (2001), resources are among the leading factors needed to lead change in instruction. In an interview with the principal, he identified providing resources and support as his role in the implementation of PBL. However, teacher interviews suggested otherwise. The environmental science teachers expressed discontent with the availability of and access to resources. They referenced their experiences with two PBL projects in which they did not receive the supplies necessary to complete the projects. Although orders were placed for the supplies, the supplies were never received. As a result, they had to purchase the supplies from their personal funds. Furthermore, some of the principal's actions suggested he did not value instructional time. Teachers lost instructional and planning time to attend district workshops or to cover the classes of absent teachers. There was, however, time allocated once a month for teachers to attend departmental PLC meetings. Unfortunately, these meeting did not occur during the course of this study.

Investing in professional development. This action implies the school leader views professional growth as essential to improvement in classroom instruction. The principal ensures staff receives the necessary training to strengthen their teaching capacity and provides opportunities for teachers to reflect on their teaching practice and collaborate with others. Steve provided staff with the PBL training. The training provided teachers with the knowledge and tools to create PBL units, however teachers lacked support during the process of PBL implementation. Teachers expressed they needed assistance with lesson planning, modifying lessons to meet district requirements, and troubleshooting implementation problems. Although Steve made the financial investment in PBL, he did not make a personal investment in PBL. He did not attend all the training sessions and when he did attend, he was not fully present. He never attended an entire session -- he stayed for a few minutes and then left. Steve may not have felt inclined to fully participate in the PBL training because he had prior PBL training. However, had he attended the sessions, he might have been better equipped to assist teachers with the implementation of PBL and to identify potential problems with the implementation.

Monitoring and checking progress. School leaders that perform this action consistently assess the status of the implementation of a change initiative. They have measures in place to provide them with data measuring the effectiveness of the initiative. Steve did not monitor the progress of the implementation of PBL. He did not conduct meetings with the science teachers to discuss the PBL implementation, neither did he conduct classroom walk-throughs or observations in any of the science classrooms during the course of the study. Steve relied heavily on the science instructional coach to monitor the PBL implementation, however the instructional coach had a number of other obligations that prevented him from monitoring the teachers' progress in implementing PBL.

Continuing to give assistance. This action requires the school leader to provide the staff with additional instructional support and assistance. Steve did not personally provide the teachers with instructional support or assistance, but he did purchase online support for teachers through Educurious. Unfortunately, the teachers did not use this support. Observations indicated the teachers needed "in-person" support in the form of modeling and on-the-spot feedback.

Other roles school leaders take when implementing reform. Kathleen Trail (2000) identified twelve roles that school principals take when implementing a school reform program. The roles include the principal as a philosopher, diplomat, psychologist, teacher, mentor, coach, cheerleader, facilities manager, police officer, social worker, public relations director, and collaborator. In this study the principal performed a few of these roles (philosopher, diplomat, and collaborator) to a limited extent, and delegated four others (teacher, mentor, coach, and psychologist) to the instructional coach.

Principal as a philosopher. The principal is the conveyor of the school vision. The vision must be shared by those involved in bringing the vision to fruition (Mendez-Morse, 1992). The vision incites others to take an active role in improving school quality. It is the responsibility of the principal to unite stakeholders to embrace and achieve the school vision (Hoyle, English, & Steffy, 1998).

Neither Steve nor the teachers made reference to the school's vision in debriefing sessions or observations. The school's vision might have been a written statement in the school improvement plan, nevertheless such vision did not appear to be shared by the school's staff who did not appear to be familiar with it. If a school vision existed, it was limited to the document in which it was contained.

Principal as a diplomat. The principal serves as a representative and advocate of the school in its relationship with others. He has a persuasive character that impels others to act. He is involved in the development and implementation of policies that regulate school policies (Hoyle, English, & Steffy, 1998; Deal & Peterson, 2007).

As a diplomat, Steve advocated for the adoption of PBL at his school. His advocacy for PBL not only influenced district leaders to approve the implementation of PBL at his school, but to adopt PBL at the district level as well.

Principal as a collaborator. A collaborative culture is characteristic of a successful school. Collaboration is made possible through the development of teams (DuFour & Berkey, 1995). Within these teams, staff are able to discuss issues and make decisions regarding pertinent school matters. As a collaborator, the principal also shares leadership responsibility. Successful school leadership is not the result of the actions of one person, but is the result of the combined efforts of a leadership team. A good principal establishes a school culture that supports distributive leadership, thereby increasing the leadership capacity of the school. Distributive leadership is common in schools enacting reform. It entails the principal delegating responsibilities to other members of the staff and empowering them to make decisions related to school matters (Harris, 2011; Kouzes & Posner, 2002). Reform is only possible if delegation is accompanied by the power to act (Hoyle & Steffy, 1998).

Steve was a collaborator because he involved staff in decision making and delegated responsibilities to members of the leadership team. After Steve's arrival to the school, he solicited staff members to join the school improvement team. When the team convened, Steve presented the team with the idea of PBL. He mentioned the success he had had with PBL at his former school and believed it would help increase the school's student achievement. The team made the decision to adopt PBL as a school improvement strategy. Steve worked with his leadership team to identify how PBL would be implemented. With the assistance of his leadership team, he identified the company to provide PBL training and Steve delegated the oversight of the PBL implementation to the science instructional coach.

Collaborator is the most important role of a principal because it allows the principal to delegate the responsibility associated with the 11 other roles. According to Kouzes and Posner (2002), principals cannot turn around a low-performing school by themselves. Effective leaders understand they must involve those who are invested in change. Field notes suggest Steve delegated the roles of psychologist, mentor, and coach to the science instructional coach.

The principal as a teacher. In his role as a teacher, the principal is an instructional leader. Instructional leadership is among the 21 leadership responsibilities identified by Marzano, Waters and McNulty (2005) that have an impact on student achievement. As an instructional leader, the principal is knowledgeable and skilled in effective practices. He serves as a resource for staff and keeps them current regarding new educational developments (Jenkins, 2009). The principal serves as a staff developer; providing staff with the knowledge and training to effectively transform their classrooms into engaging learning environments.

Steve described himself as being knowledgeable in PBL, and referenced his prior PBL experience as both a teacher and an administrator. However, Steve did not use his PBL experience to advance the PBL implementation. He did not share his knowledge or any resources with the teachers. As a result, despite his prior experience, the teachers did not appear to view him as a resource. They sought instead the assistance of the science coach, other staff or online resources for ideas, suggestions, and feedback.

In the role of teacher, the science instructional coach assisted teachers with the implementation of PBL. He was knowledgeable in PBL and used his expertise to guide the implementation process. As time permitted, he observed lessons, provided feedback, assisted with lesson plan development, and facilitated professional development meetings. He provided teachers with videos and other instructional resources to assist the development of their PBL understanding.

Principal as a mentor. The principal is supportive of staff's pursuit to improve their practice. He is knowledgeable, encouraging, and motivating. Research has shown that mentoring is necessary for the professional growth of a teacher. Mentoring relationships help teachers grow in their practice and assist them in managing the everyday demands associated with teaching. The knowledge and support provided by mentoring relationships help teachers become successful in the art of teaching (Hargreaves & Fullan, 2000).

Steve stated he provided support to teachers through observations and feedback. However, field notes indicate Steve neglected to perform any form of teacher observation during the study. In interviews, teachers only referenced the science coach as a support. They did not mention any support or feedback received from the principal.

The role of mentor was instead fulfilled by the instructional coach, who provided support and encouragement to teachers as they undertook the implementation of PBL. The environmental science teachers referenced how the instructional coach assisted them in the planning of their PBL unit. He provided feedback and gave suggestions and was confident in their ability to work through the challenges they experienced with PBL. The instructional coach mentioned how he had worked with a science teacher who had been resistant to implementing PBL, to help him develop a PBL unit. Unfortunately, his efforts were deemed futile as the teacher abandoned PBL soon after the training.

Principal as a coach. As a coach, the principal establishes a team that productively works together to accomplish a specific goal. The coach strives to develop the knowledge and skills of each team member to produce a highly functional team (Trail, 2000). Lencioni (2005) uncovered five characteristics of an effective team: 1) team members trust each other, 2) team members are not afraid to engage in constructive conflict with one another, 3) team members are faithful to the decisions made by the team, 4) team members hold each other accountable to the decisions of the group, and 5) team members are dedicated to achieving the desired results of the team. The skills necessary to be an effective coach are similar to those of an effective manager. The coach needs to know how to be observant, take action when needed, and have a good sense of reasoning. His primary goal is to help all members of his team reach their potential. One of the main responsibilities of a coach is to motivate others to see the need to change for the betterment of the team. Characteristics of an effective coach include being reflective, encouraging members of his team, being supportive, acting as a teacher, seeking to understand, and creating a collaborative team culture (Waldroop and Butler, 1996).

In this study the instructional coach performed the role of coach, bringing together social studies and science faculty to accomplish the goal of implementing PBL to improve student achievement. He coordinated the PBL trainings to develop the teacher’s knowledge of PBL. He worked with teachers individually as well as in small groups to provide instructional support. As an instructional coach, he believed his responsibility was to motivate teachers to achieve their greatest potential in teaching. He mentioned he set goals with teachers and worked with them to meet these goals by providing supports to develop and strengthen their teaching skills. However, due to a change in the instructional coach's job responsibilities, time for his various roles was greatly diminished; reducing the amount of time he could devote to provide instructional support. One of the teachers stated she never had any interaction with the instructional coach during the time she implemented the PBL unit. Responses from the other teachers indicated they received suggestions and feedback on ideas; however, that was the extent of the support received. In addition, neither the principal nor the coach had invested time and resources in creating a team atmosphere among the school's staff.

The principal as a psychologist. As a psychologist the principal is a good listener and communicator (Mendez-Morse, 1992), and acts as one in whom the staff can confide and present their problems and struggles without the fear of condemnation. The principal seeks to build close relationships with staff by getting to know them on a personal level. He is supportive of staff as they deal with the day to day difficulties of teaching (Rieg and Marcoline, 2008). In this study the principal's role as psychologist was delegated to the instructional coach who worked much more closely with the teachers. The instructional coach was viewed as a psychologist because teachers were able to express their fears and frustrations to him without the fear of condemnation or negative consequences. He heard their concerns and provided support and encouragement in response.

Conclusion

In this study, project-based learning was conceptualized by the school principal as an approach to improve student achievement specifically in the school's science and social studies classes. In his efforts to implement PBL in the school, the principal involved the science instructional coach, the Title I coordinator, and the school improvement grant coordinator in reviewing PBL training proposals and determining which company's program aligned best with the school's vision. The team selected Educurious, and the school's instructional coach and a representative from Educurious provided the PBL training, which included the development of PBL units to be implemented in the teachers' classrooms.

The principal's role in PBL implementation was to provide resources and support throughout the PBL implementation process. However, the findings from teacher interviews indicate they received neither the resources nor the support they needed. Teachers often had to use their personal funds to purchase needed materials. Actions taken by the school principal and teacher leaders created additional barriers to the implementation of PBL. These barriers included teachers being pulled from their classrooms to cover classes or attend various school and/or district activities and school interruptions such as movie days, school assemblies, school drills, and building fires, which resulted in loss of instructional time.

The science instructional coach was given the responsibility of coordinating the PBL training and with assisting the teachers with the development and implementation of the PBL instructional units. Although he played an active role in the PBL process, he was unable to provide timely and adequate assistance to the teachers. Unfortunately, additional responsibilities related to the coordination of other school and district initiatives prevented him from providing the type and level of support the teachers needed.

The results of this study indicate the implementation of PBL did not fully align with the major components of PBL identified by Thomas (2000). Although the project was the starting point for each PBL unit that the teachers implemented, the project did not remain the focus throughout the units. The connection of the classroom activities to the final product was not evident to the students or the observer. Often the students were unable to link what they were learning through class activities to the final project they were expected to complete. Other components of PBL such as a driving question, constructive investigations, and realism were not consistent across classrooms. This inconsistency could be attributed to teachers' misunderstandings of PBL and the lack of training one of the teachers received because she was hired after the PBL training had begun. All teachers provided their students with some form of autonomy whether through the final product or topic of study.

Other challenges related to the implementation of PBL included high student absenteeism, poor student behavior, and student abilities. The average daily attendance for all the participating teachers' classes was less than 50%. Chronically absent students fell behind in their work and struggled with assignments because they lacked the knowledge to complete the assignments. Student engagement decreased when students struggled with the content or when they had idle time. During these instances, students were observed with their heads down, talking, or engaging in disruptive behavior. Students also lacked the skills to engage in inquiry learning. These skills are often not inherent in most students and must be taught. The teachers did not take the necessary steps to assist students in making the transition from a traditional to an inquiry-based classroom. Many students were unable to work independently on learning activities and consistently required the assistance of the teacher. Students relied heavily on the teacher to give them information. Without direct instruction from the teachers, students did not know what to do.

Student engagement, student achievement, and teacher collaboration were found to be successes in the implementation of PBL. According to the teachers, they did not have to beg and plead with students to pay attention once they became involved in the hands-on activities. Some students who had never worked on in-class assignments actually participated in class activities. One teacher reported she noticed higher academic performance on classroom assessments in comparison to student performance on assessments the previous school year. Teachers also noted an increase in students' ability to problem solve. Collaboration was noted as a success by the two teachers who shared a common planning period. During this time, they were able to share and discuss ideas, resources, and lessons.

Implications for Practice

Project-based learning is an inquiry-based instructional strategy. The use of inquiry learning can be stifled by (a) school leaders who implement policies and curricula that do not support inquiry, (b) teachers' lack of experience with inquiry learning, (c) insufficient knowledge on how to implement inquiry in the classroom, (d) the pressure to cover the curriculum, (e) a lack of resources and human capital, and (f) students who lack the prerequisite skills to engage in inquiry learning (Chin & Chia, 2006).

School and district leaders must create and follow policies and procedures that support conditions that support inquiry learning. In successful cases of PBL, administrators ensured teachers had the time to collaborate with colleagues and other instructional staff to plan lessons and discuss issues related to PBL implementation (Scott, 1994). According to Goodnough and Cashion (2006), professional learning communities are important in PBL because they provide teachers with the opportunity to share ideas. This collaboration time should be considered "sacred" and not taken away from teachers to perform other duties. Ladewski and colleagues (1994) point out that not only do teachers need the opportunity to implement what they learn, they must also have the opportunity to collaborate with others about their experiences and to reflect upon their experiences. School leaders should take action to limit or eliminate school disruptions such as those experienced in this study which detract the amount of time students have to engage in inquiry learning. Additionally, school and district policies and procedures should not thwart or interfere with teachers' efforts to carry out PBL activities. Policies and procedures that restrict the implementation of PBL ought to be reconsidered or modified. Teachers should not be placed in a position in which PBL requirements and school expectations are in conflict.

For project-based learning to be effective, it must be effectively conceptualized and implemented. Teachers and other instructional staff impacted by the implementation of PBL should be included in the decision to implement PBL. By doing so, staff buy-in is achieved. Adequate and extended PBL training, resources, and support work collectively to ensure proper PBL implementation. PBL training should be on-going. As teachers begin to implement PBL, questions and challenges arise which need to be addressed. These issues can be addressed in the on-going training sessions. The training should be provided at least a year prior to implementation to allow teachers time to begin planning their PBL units. The training should not only consist of the process of designing PBL units, but it should also teach teachers how to create and manage inquiry-based classrooms. Inquiry-based classrooms require teachers to create investigative activities and to be able to manage multiple learning activities occurring simultaneously. Teachers' educational or prior teaching experiences may not have provided them with the knowledge and skills needed to create and manage an inquiry-based classroom. Teachers struggle when they have no frame of reference for inquiry learning. They also struggle with their desire to maintain order in an environment in which students should be free to explore. They may have never witnessed the process teachers should follow to implement inquiry learning (Marx et al., 1994).

Teacher beliefs surrounding inquiry and project-based learning must be addressed. Teacher beliefs and unwillingness to change can interfere with PBL implementation. Adopting new pedagogy is not a simple task for teachers. They must be willing to replace old habits with new habits (Johnson, 2009). Traditional classroom beliefs such as the need to cover the curriculum, following a prescribed set of procedures, and maintaining a teacher-led classroom can impede PBL implementation. Teachers tend to view the requirement to cover the curriculum as a priority over inquiry learning and are apprehensive in using PBL (Chin & Chia, 2006; Marx et al., 1994; Ladewski et al.,1994). PBL training can address these beliefs by equipping teachers with the skills to create PBL units that address content expectations while promoting inquiry learning (Chin & Chia, 2006).

Teachers need resources to overcome the challenges associated with project-based learning (Tarmin & Grant, 2013). Teachers need resources such as materials, equipment and technology when implementing PBL. These materials should be easily accessible to teachers and be fully operational.

The implementation of PBL involves a shift in the way students learn. The classroom is transformed from one of "sit and get" to one where students take control of their learning (Krajcik & Blumfeld, 2006). Because PBL presents the problem first, students that are accustomed to the project being presented after a teacher-led lecture may be opposed to PBL (Chin & Chia, 2006). These students are unfamiliar with the discovery learning implied by PBL. Steps should be taken to ensure students have the prior knowledge and skills to engage in PBL. If students lack particular skills, the teacher should teach them to the students (Chin & Chia, 2006; Krajcik et al., 1998). Therefore, teachers must scaffold student learning throughout the PBL process. Students need to be taught science inquiry skills such as generating questions, collecting and displaying data, and analyzing data and drawing conclusions (Krajcik et al., 1998). Students should be eased into the process of PBL. Students should be given an introductory PBL unit to allow them to experience the PBL process (Krajcik et al., 1998). As suggested by Etmer and Simons (2006), teachers should use mini units to practice PBL skills. Mini PBL are shorter units than the typical PBL units. These units provide an introduction to the PBL process which generally spans two to three days. Mini PBL units give students the opportunity to develop the skills they will use in future PBL projects. At the conclusion of the mini unit, the teacher conducts a whole class discussion to review the PBL process.

It should also be noted that PBL is not a "one size fits all" approach. Teachers need to have the freedom to have a vision for the implementation of PBL that fits their particular classroom context. Factors such as time and students' background knowledge can limit the degree to which PBL can be implemented (Scott, 1994). Teachers should be free to make modifications to meet the learning needs and skills of their students. Teachers must create and structure learning activities so that students can attain success while keeping in mind that developing independent, self-directed learners is the ultimate goal.

PBL motivates students to learn (Kanter & Schreck, 2006) and makes student learning meaningful (Chin & Chia, 2006). The main aspects of PBL that appeals to students is that the problems are interesting and that students can exercise choice in their learning (Chin & Chia, 2006; Nelson, 2010). Students tend to participate in activities in which they feel they have the ability to succeed (Daniel & Arapostathis, 2005). Providing relevant and interesting projects can address the issues of student disengagement and poor attendance. If students feel learning activities are relevant, they will come to school and participate in learning.

Limitations and Recommendations for Future Research

The following variables limited the results of this study. Future research should be conducted to address these limitations.

Number of study participants. This study investigated the implementation of PBL in the classroom of three teachers. Due to the small sample size, the external validity of this study is limited. Future studies should try to include a larger sample size.

Number of schools in the study. This study was limited to one school in the Detroit area. Future studies should include a larger number of schools representative of urban, suburban, and rural areas.

Number of years teaching experience. The years of teaching experience varied among the study's participants. Two of the teachers were first year teachers. Not only were these beginning teachers new to the PBL process, but to the teaching profession as well. Their lack of classroom experience could have been a contributing factor to the challenges they experienced with the implementation of PBL and their practice in general. Future studies should include a larger number of veteran teachers.

Transition from a traditional to project-based classroom. Results indicate teachers experienced challenges in transitioning students from a traditional method of learning to a project-based method of learning. Students struggled with independent and collaborative learning. Further investigation on how to establish a PBL classroom culture merits investigation.

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ABSTRACT

VARIABLES THAT IMPACT THE IMPLEMENTATION OF PROJECT-BASED LEARNING IN HIGH SCHOOL SCIENCE

by

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Wagner and colleagues (2006) state the mediocrity of teaching and instructional leadership is the central problem that must be addressed if we are to improve student achievement. Educational reform efforts have been initiated to improve student performance and to hold teachers and school leaders accountable for student achievement (Wagner et al., 2006). Specifically, in the area of science, goals for improving student learning have led reformers to establish standards for what students should know and be able to do, as well as what instructional methods should be used. Key concepts and principles have been identified for student learning. Additionally, reformers recommend student-centered, inquiry-based practices that promote a deep understanding of how science is embedded in the everyday world. These new approaches to science education emphasize inquiry as an essential element for student learning (Schneider, Krajcik, Marx, & Soloway, 2002). Project-based learning (PBL) is an inquiry-based instructional approach that addresses these recommendations for science education reform.

The objective of this research was to study the implementation of project-based learning (PBL) in an urban school undergoing reform efforts and identify the variables that positively or negatively impacted the PBL implementation process and its outcomes. This

study responded to the need to change how science is taught by focusing on the implementation of project-based learning as an instructional approach to improve student achievement in science and identify the role of both school leaders and teachers in the creation of a school environment that supports project-based learning.

A case study design using a mixed-method approach was used in this study. Data were collected through individual interviews with the school principal, science instructional coach, and PBL facilitator. A survey, classroom observations and interviews involving three high school science teachers teaching grades 9-12, were also used in the data collection process.

The results of the study indicated that the use of PBL increased student engagement, ability to problem-solve, and to some extent academic performance. The results also revealed several factors that impacted the implementation of project-based learning: (a) Student attributes such as high student absenteeism, lack of motivation, and poor behavior prevented teachers from completing the PBL unit in a timely fashion. (b) Certain school and district policies and requirements were not conducive to PBL implementation. Policies and practices impacting instructional time and teaching supplies acquisition made it difficult for teachers to plan lessons and obtain necessary supplies. (c) Teachers did not receive PBL training in a timely fashion. Teachers received training approximately two months prior to implementation. (d) Teacher collaboration influenced PBL implementation as it enabled teachers to share and discuss ideas, resources, and lessons.

Implications for practice include: (a) School and district leaders must create and follow policies and procedures that support conditions that support inquiry learning, (b) Teachers need resources to overcome the challenges associated with project-based learning, (c) Teachers must have the freedom to have a vision for the implementation of PBL that fits their particular classroom context, and (d) Steps should be taken to ensure students have the prior knowledge and skills to successfully engage in PBL.

AUTOBIOGRAPHICAL STATEMENT

Kellie Cunningham's professional career includes 23 years of experience in education. During this time, Kellie has served in an array of positions including Curriculum Director, High School Principal, High School Assistant Principal, High School Teacher, K-12 Substitute Teacher, and a Field Instructor for teacher education students. From 2002-2015, Kellie held administrative positons at both the elementary and high school levels. Her administrative experience spans urban and suburban schools as well as public and charter schools. Prior to becoming a school administrator, Kellie worked as a science teacher in Detroit Public Schools. Later she accepted a position as a science teacher in Southfield Public Schools where she subsequently transitioned to an administrative position. Currently, Kellie is serving as a professional service contractor with CREATE for STEM at Michigan State University. Her work involves the development and oversight of the implementation of project-based science units in Michigan schools.

In 2009, Kellie obtained a position as principal of Robichaud High School in Dearborn Heights, MI. Through her leadership, Kellie helped Robichaud attain adequate yearly progress after six years of no academic growth. Other accomplishments Kellie achieved during her principalship include the establishment of a ninth grade academy, the creation of an Engineering Academy, and acquiring North Central Association (NCA) accreditation.

Kellie has earned several academic degrees including: an Education Specialist (Ed.S) certificate in General Administration and Supervision, a Master of Arts (MA) degree in Education Administration, and a Bachelor of Science (BS) degree in Biology. Kellie earned her teaching certificate in 1995 in Biology, General Science, and Spanish (7-12) and a K-12 and Central Office school administrator certificate from Wayne State University in 2001.