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Project-Based Learning in a STEM Academy: Student Engagement and Interest in STEM Careers

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Project-Based Learning in a STEM Academy: Student Engagement and Interest in STEM Careers

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Approval Page

This dissertation was submitted by Pamela Henry Misher under the direction of the persons listed below. It was submitted to the Gardner-Webb University School of Education and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Gardner-Webb University.

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Delight thyself also in the Lord; and he shall give thee the desires of thine heart.

Psalms 37:4

Abstract

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This case study explored the utilization of project-based learning (PBL) and how it affected student engagement and interest in STEM careers. Sixty-seven students and nine teachers participated in this case study. Three research questions addressed student engagement, perceptions, and challenges during PBL implementation.

This study was designed to understand the experiences teachers and students had when they participated in a PBL environment. This research investigated how to develop a globally skilled workforce utilizing a PBL approach and the challenges teachers encountered during implementation. The survey data and informal focus-group sessions with staff and students were utilized, analyzed, and summarized in order to obtain insight on perceptions, challenges, and implementation of PBL.

PBL is an instructional approach that was designed to encourage more engaged learning. This approach was built upon realistic learning activities that stimulated student interest and motivation. This research discovered that PBL did teach content and 21st century skills as students worked collaboratively toward a common goal while responding to a question or problem. This study revealed that rigorous projects were carefully planned to aid students in learning important academic content. This study displayed how PBL allowed students to reflect on their projects and ideas with the opportunity to voice their decisions and findings. This instructional approach provided opportunities for students to investigate and strengthen interest in future STEM careers.

The driving force of America’s future economy and maintaining the competitive edge will be through more innovation, mainly derived from advances in STEM (Science, Technology, Engineering, and Math) careers. As business and industry leaders stressed the importance of improving STEM education, there continued to be a need to better prepare students to fill STEM-related careers. This research adds to the current body of research knowledge on STEM education in a high school setting and provides guidance on integrating PBL into the academic program.

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Chapter 1: Introduction

Introduction

In May 2013, a high school student from California designed an improved supercapacitor that allows cell phone charging in 20 seconds (Kosser, 2013). Even as Americans celebrate the success of this invention, other nations' students continue to make great educational gains in Science, Technology, Engineering, and Math (STEM) subjects (Hess, Kelly, & Meeks, 2011). In order for the United States to lead in STEM, educational pathways should lead to producing a well-trained STEM workforce (National Science and Technology Council [NSTC], 2013).

How can we increase high school student interest in STEM careers? Hess et al. (2011) cited that our nation's success in STEM education will require dramatic improvement within classrooms by "creating a support system and a culture that encourages excellence in STEM achievement" (p. 1). Therefore, it is essential that the United States encourage and nurture student interest in STEM subjects.

Ryshke (2012) suggested that one possible instructional strategy for building interest in STEM subjects is through project-based learning (PBL). PBL utilizes community- and industry-based projects to nurture, directly, the development of career and college readiness skills. Chapter 1 of this case study addresses the background and history of STEM education, the status of the workforce in the state and nation, and the utilization of PBL within a STEM curriculum.

Background of the Problem

The National Science Foundation, in the early 1990s, coined the STEM acronym to refer to the individual content disciplines of Science, Technology, Engineering, and Mathematics (Ostler, 2012). As educational reform issues continue to be debated in political speeches, STEM education is often one of the major topics. According to Ostler (2012), STEM education is becoming a popular topic for politicians because American students are lacking the ability to compete with students from other industrialized nations on tests of technical subjects.

Linda Darling-Hammond (2011) stated that the United States is standing still while other focused nations are moving ahead in educating their students. In previous years, *A Nation at Risk* (National Commission on Excellence in Education, 1983), declared a rising tide of mediocrity in education and insisted that educational reforms were needed in the United States. By 2006, the Program for International Student Assessment (PISA) ranked the United States 35th in math and 29th in science (Organization for Economic Cooperation and Development, [OECD], 2010).

In 1997, OECD launched PISA to evaluate worldwide scholastic performance in math, science, and reading of 15-year-old students. More than 70 countries have participated in this assessment which is administered every 3 years. The PISA assesses how students apply their knowledge to real-life situations and how they would participate in society (OECD, 2010).

According to the OECD (2010) data, Shanghai outperforms all OECD countries in reading, math, and science. Korea, Finland, Hong Kong, and Singapore are also leading the nations in these subjects. The United States ranks 17th in reading, 31st in math and 23rd in science (OECD).

The PISA data raise the awareness for the need to create a more consistent and high-quality educational system for students in the United States. Darling-Hammond (2011) stated that Korea, Finland, and Singapore have made drastic improvements in their education systems to the extent that they graduate more than 90% of their high school students, sending most of their students to college and surpassing the United States. Strong educational programs are needed to better prepare students to compete globally and to develop skills for quality jobs.

The report *Rising Above the Gathering Storm* (National Academy of Sciences, 2005) focused on the American job market and how American high-tech companies look for skilled workers in math and science. This report also focused on how important it is for Americans to be equipped to compete globally. It painted a dismal outlook for America to continue on the same perilous path it currently travels.

In 2010, *Rising Above the Gathering Storm* was revisited. This report gave updated changes from 2005-2010 in America's competitiveness. The updated report concluded that the driving force of America's future economy and creation of jobs will be through more innovation, mainly derived from advances in math, science, and engineering. This report noted that a strong educational program should be aligned with institutions of higher education, business, and industry leaders to deliver effective STEM education (National Academy of Sciences, 2010).

As business and industry leaders stress the importance of improving STEM education, there is a need to better prepare students to fill STEM-related careers. Atkinson and Mayo (2010) stated that when we compare the students to the number of available jobs, the STEM work force has grown more rapidly than the number of STEM degree recipients. Therefore, the STEM education pipeline may not be adequate in supplying the number of workers needed to build the economy.

Atkinson and Mayo (2010) also noted the gap between growth in STEM degrees and STEM jobs is being filled by foreign workers. As of 2002, 20% of STEM workers were foreign-born. Atkinson and Mayo further stated that according to the Bureau of

Labor Statistics project, the STEM work force, through 2018, is expected to grow by 19%, doubling all occupations by 10%. Newly expected jobs between now and 2018 are computer and mathematical scientists. They further indicated that due to the growth in biotechnology and environmental industries, it is probable that the largest percentages of job increases will be biological, agricultural, and environmental (Atkinson & Mayo).

The future of the STEM workforce in the United States will depend on how well educators prepare students to fill STEM-related jobs yearly. Education Secretary Arne Duncan (2010) stated that the United States should urgently accelerate student learning so American students can compete in the knowledge economy of the 21st century. Duncan believed that the United States has a long way to go in strengthening the educational system for students to complete globally. He further stated, “President Obama has warned the nation that out-educates us today will out-compete us tomorrow” (Duncan, p. 1). This can be seen in the PISA 2010 results that show other developed nations *out-educating* us. Duncan further believed that Americans should face this educational reality head-on and know that other nations will continue to prepare their students for economic leadership.

Statement of the Problem

There is a major concern in the United States industry, businesses, and government agencies who report a greater need for STEM knowledge and skills to fulfill future jobs (NSTC, 2013). The NSTC (2013) *Federal STEM Education 5 year Strategic Plan* report theorized that companies that are more innovative in creating and producing products have an advantage in the competitive marketplace. This poses the educational concern to encourage an interest in STEM subjects and equip more students to succeed in STEM fields. STEMconnector (2013) reported, “One out of four high school students indicates interest in pursuing a STEM major or career. High School seniors are about 10% less likely than high school freshmen to indicate interest in STEM majors and careers" (p. 8), with 46.7% of high school seniors remaining on a STEM path throughout high school.

NSTC (2013) stated that economic leadership is in the jobs of the future, which are STEM careers. To prepare students for economic leadership, Boykin and Noguera (2011) stated that advanced skills in science, math, and other subjects must be taught. They advised that these skills are crucial if the country is to prepare students for jobs in areas that are vital to the performance of the U.S. economy. There is an additional need to discover ways to nurture students' creativity, imagination, and problem-solving skills so they will have the necessary skills and intellectual abilities to respond to challenges they may face. New ideas, approaches, and technology are needed if future leaders are to cope with unfamiliar challenges of the changing world and become more competitive (Boykin & Noguera).

Tony Wagner (2012) stated, "the world is changing so quickly that if you don't think forward, someone will have beaten you to market. We need people who can think out of the box and see the future in a different way" (pp. 91-92). To remain globally competitive in the United States, educators need to produce more engineers, scientists, and mathematicians.

Wagner (2008) also reminded us that as a prerequisite for job placement, most high-tech companies place little value on content knowledge alone, in either math or science. He explained that several skills such as professionalism and work ethic, learning to work collaboratively with others, adaptability in the work place, oral and written communication, and critical thinking and problem solving are ahead of content knowledge of math and science. Wagner considered these survival skills or 21st century skills essential and vital for future workers. He believed educators teach the same content in the same way, which produces students with poor problem-solving skills. Wagner emphasized the importance of providing more student engagement and relevant math and science courses to prepare future workers to compete globally. Competing globally will require creating critical thinkers with strong knowledge bases in STEM areas.

The educator's guide provided by the National Education Association (NEA, 2011) stated that 21st century skills are important in preparing students for the new global society. NEA (2011) reported that there is a challenge in incorporating the 21st century skills into the K-12 education. NEA interviewed leaders to determine which skills were most essential. They discovered that the "four C's: critical thinking, communication, collaboration and creativity," were the four specific skills that should be addressed in K-12 education (NEA, p. 3).

National Impact on STEM

In 2009, President Barack Obama called for a new effort to prepare 100,000 STEM teachers with strong content knowledge and teaching skills for the next 10 years. The president indicated his belief that students need to master science, technology, engineering, and math to succeed in the 21st century economy. This is why he set the goal of preparing additional teachers in STEM-related subjects (Education Week, 2011). President Obama's commitment to education is noted in the *State of the Union Address*:

> China and India started educating their children earlier and longer, with greater emphasis on math and science. They're investing in research and new technologies.

> We know what it takes to compete for the jobs and industries of our time. We need to out-innovate, out-educate, and out-build the rest of the world. We have to make America the best place on Earth to do business. (Education Week, 2011, p. 1)

As an essential component of improving education for American students, the Congressional Research Services (CRS, 2012) *Report for Congress* reflected a federal budget that included an investment of billions of dollars through the Department of Education and the National Science Foundation to better prepare STEM teachers across the United States. These funds will be used to help prepare teachers to inspire more students to succeed in STEM areas in order to thrive in the 21st century economy.

In the *STEM Budget Report* (White House Office of Science and Technology, 2011), "President Obama made STEM education a priority through Race to the Top (RttT) funds and through his Educate to Innovate campaign" (p. 4). These funds have helped to raise awareness of the importance of STEM education and have incited schools, universities, businesses, and foundations to do more for STEM education. The focus of the K-12 STEM investments in the 2012 federal budget is on increasing student expectations, strengthening professional development for STEM teachers, and supporting high-quality resources.

Even as the federal government contributes millions of dollars toward STEM education, there is a growing concern that the United States is drifting far behind many countries in STEM education. The *Prepare and Inspire: K-12 STEM for America's Future Report* (President's Council of Advisors on Science and Technology, 2010) stated that less than one-third of the United States' eighth graders show proficiency in science and math. It continued to state that African Americans, Hispanics, Native Americans, and women are underrepresented in most STEM fields, which may limit their participation in well-paid jobs. This report discussed the lack of interest in STEM fields of many proficient students toward other careers. Continued work is needed to encourage students from across all groups to seek STEM fields and for the United States to become a productive STEM community in the world.

To be a productive and competitive force in the world, workers with a high level of technical skill are needed to improve and sustain U.S. manufacturing. The *Capturing Domestic Competitive Advantage in Advanced Manufacturing Report* (President's Council of Advisors on Science and Technology, 2012) to President Obama stated that the past image of manufacturing jobs is driving the most technically skilled students away from manufacturing. It further posited that STEM problem-solving and decision-making skills are needed to have success in advanced manufacturing and entrepreneurship. According to this report, industry and business leaders are concerned about the gap between filling advanced manufacturing jobs and educational systems not providing students with the necessary skills for these jobs. It suggests that with unemployment at approximately 9%, there is a wide range of industries with advanced manufacturing positions available. Therefore, jobs for skilled workers are increasing at a rate that is exceeding the availability of qualified workers (President's Council of Advisors on Science and Technology, 2012).

The overall conclusion from the *Gathering Storm Report* (National Academy of Sciences, 2010) is that in spite of the efforts of the government and private sector, the outlook for America to compete globally for quality jobs is very dismal and has deteriorated over the past years. The success of America in the 21st century will depend on innovations, ideas, and skills of our workforce. STEM education may help determine whether the United States can remain a leader among other nations (President's Council of Advisors on Science and Technology, 2010).

The Economics and Statistics Administration (ESA, 2011) stated in the *STEM: Good Jobs Now and for the Future* report that new companies and industries with competitiveness (by generating new ideas) are driven by our STEM workers. This report stated that STEM jobs are growing three times faster than non-STEM jobs. STEM workers also play a vital role in growth sustainability in the U.S. economy. The report added that STEM careers are projected to grow by "17 percent from 2008 to 2018 compared to 9.8 percent growth in non-STEM careers" (ESA, p. 2).

According to Rick Stephens, senior vice president of human resources for Boeing, as the work force becomes older, there will be fewer students trained to replace the older workers (Price, 2012). Stephens recognized that student skills must include applying knowledge to real-world situations. Many jobs require an understanding of robotics and assembly-line computer programming. Stephens further stated that there appears to be fewer students selecting STEM fields in college due to a lack of interest in science and math (Price, 2012).

Price (2012) also cited Johanna Duncan-Poitier, senior chancellor for community colleges of New York. Duncan-Pointer stated, "there are 140,000 positions within the top 30 Fortune 500 companies that go unfilled for lack of STEM graduates" (Price, p. 1). She also posited that U.S. employers will require an "additional million workers trained in STEM within 10 years" (Price, p. 1).

In America, there could be a shortage of scientists, mathematicians, and engineers if the number of students entering these fields does not keep up with the expected demand. The *Tapping America's Potential Report* (Business Higher Education Forum,

2005) stated 15 of our nation's prominent business organizations have expressed a concern about the ability of the United States to sustain scientific and technological competitiveness. According to this report, maintaining our nation's competitiveness means we must produce competent and skillful scientists and engineers to create tomorrow's innovations. This report cited the goal of doubling the number of STEM graduates with bachelor's degrees by 2015 to be innovative and necessary to compete globally.

The United States is in a competitive contest with other countries to be a productive and innovative leader in STEM education. The following facts from the *Tapping America's Potential Report* (Business Higher Education Forum, 2005) demonstrated how competing countries have progressed in being committed to STEM subjects. These facts included, but were not limited to, the following details: China graduates four times as many engineers as the United States; South Korea, with one-sixth of our population, graduates as many engineers as the United States; fourth graders in the United States scoring well against international competition fall near the bottom by 12th grade in math and science.

On a recent international assessment of 15-year-olds' math problem-solving skills, as reported in the *Tapping America's Potential Report* (Business Higher Education Forum, 2005), the United States had the smallest percentage of top performers and the largest percentage of low performers compared to other participating developed countries. We may gather from these facts that education should strive to provide a strong commitment in STEM fields to increase participation and performance for global competitiveness.

The United States Congress Joint Economic Committee (JEC, 2012) report, *STEM Education: Preparing for the Jobs of the Future*, indicated that students graduating with STEM degrees have declined. Bachelor's degrees in STEM fields dropped in 1985 by 24% to 18% in 2009. This report suggested that in traditionally non-STEM fields, there is a plea for STEM-capable workers. STEM graduates working in non-STEM fields continue to contribute to the shortage of qualified STEM workers in STEM fields (JEC, 2012).

JEC (2012) further cited the concern of underrepresentation of women, African Americans, and Hispanic workers in the STEM workforce and attributed the underrepresentation to lower college graduation rates within these groups. Each group accounts for approximately 6% of STEM workers (JEC).

The Economics and Statistics Administration (2011) stated that only one-third of the bachelor degrees earned in the United States are in the STEM fields, with approximately 53% earned in China and 63% earned in Japan. The United States is trailing behind Korea, Hong Kong, Finland, and Singapore in STEM subjects when using international test scores as a benchmark.

North Carolina Economy Challenges and Changes

The Fashion Summit (2012) created a timeline of the North Carolina textile industry. This report stated that in the early 1800s, North Carolina produced more textile products than the leading state of Massachusetts. In the 1920s, North Carolina ranked as the largest producer of textiles in the United States. During this time, a large number of mills (factories) produced yarn, wove fabric, and spun cotton in North Carolina (Davis, 2010). Beginning in the 1930s through the early 1990s, new child labor laws, unionization, and price competition from overseas producers shifted textile production into other countries (The Fashion Summit).

This shift in textile production from North Carolina to other countries triggered many workers to lose their jobs. The decline of North Carolina's textile industries contributed to the loss of jobs and unemployment. In employment, the Bureau of Economic Analysis reported, "between 1977 and 1997 approximately 82,000 jobs were eliminated in North Carolina textiles" (Conway, Connolly, Field, & Longman, 2003, p. 3). This report cited, "over 100,000 jobs were eliminated in the textile industry in North Carolina, between 1997 to 2002" (Conway et al., 2003, p. 3). Manufacturing employment has been declining throughout the United States since the 1980s but is more pronounced in North Carolina (Conway et al., 2003).

In December 2012, North Carolina's unemployment rate was 9.2% (National Conference of State Legislatures, 2012). This decline in jobs, especially in mill and factory towns, may have contributed to North Carolina's unemployment rate and poverty level.

According to the United States Census Bureau (2011), approximately 14% of the United States' population is in poverty. The census bureau cited North Carolina, with 27% of its population in poverty, as having a larger population of people living in poverty areas. Within the county of the selected school for the current research study, the unemployment rate is 10% (The-Dispatch, 2012). In previous years, this county was a leader in the manufacturing industry. The loss of textile mills within this county has provided a paradigm shift and a sense of urgency to educate and develop a globally skilled workforce.

The loss of textile mills has provided a challenge in North Carolina to discover additional and creative ways to educate students for jobs that require new skill sets and 21st century jobs that have increased skill demands (Stewart, 2012). "Jobs that require routine manual tasks, are rapidly being taken over by computers or lower-paid workers in other countries" (Stewart, 2012, p. 12). There is a higher demand for jobs that require sophisticated problem-solving and communication skills. In addition, jobs that encourage and support workers with a high school diploma or less continue to disappear from the workforce (Stewart, 2012). Therefore, there is a challenge to transform education and rethink traditional high schools to better prepare students for the 21st century workforce. This study examined a STEM high school that pledged to provide different learning opportunities through PBL and student-centered instruction to prepare students for future STEM careers.

History of STEM Schools in the United States

In October 1957, the Soviet Union propelled Sputnik, the world's first artificial satellite, into space which caused the United States to move its efforts swiftly towards science (Jolly, 2009). The launch of Sputnik set the stage for Congress in 1958 to pass the National Defense Education Act (NDEA) and push the focus on training inspiring scientists. The United States' reaction to Sputnik launched the National Aeronautics and Space Administration (NASA) which also served as a beginning pipeline for STEM education (Jolly, 2009).

The Stanford Research Institute (SRI) International (2008) reported that the roots of STEM education in secondary schools can be traced to a set of elite schools around the turn of the century. For example, Stuyvesant High School for boys was established in 1909 in New York City. In the 1930s, Stuyvesant High School shifted its emphasis on science and math with a competitive examination. This high school's admission was based on test performance that became the model for the Bronx High School of Science and Brooklyn Technical High School. These schools led the way for more schools to emerge to produce students well-prepared for further STEM education and careers (SRI).

During 1988-1998, schools devoted to STEM education for high schools spread throughout the United States (SRI, 2008). This growth in STEM education established the National Consortium for Secondary Schools in Math, Science, and Technology in 1988 (SRI, 2008). Many of these schools targeted students who were identified as gifted in STEM-related subjects. Some of the schools desired participation from Hispanics and African Americans but based admissions on performance and competitive examinations, causing low enrollment (SRI, 2008).

Purpose Statement

The purpose of this case study was to explore the utilization of PBL and how it affected student engagement in the classroom and interest in STEM careers. With this foundation, this research also investigated how to develop a globally skilled workforce utilizing a PBL technique.

This case study focused on understanding how PBL may encourage and inspire students to become engaged in learning STEM subjects. High and Andrews (2009) indicated that when students are disengaged, the learning process becomes more like work. These authors also stated that when students see a link between their learning and their future, being engaged in the classroom becomes personal and important. One possible way for engaging students is through PBL. PBL is an “instructional approach that is designed to support more engaged learning” (Ravitz, 2010, p. 293).

Implementing PBL was one recommendation for high schools to increase interest in STEM subjects (President’s Council of Advisors on Science and Technology, 2012). Research has shown that students are reluctant and fearful to enter into fields that may require background knowledge of STEM subjects (Engler, 2012). It is clear that most future jobs will require the ability to succeed in STEM subjects. The purpose of this study was to observe the implementation of PBL in the classroom.

There is a need to gather information about a beginning STEM program to share with other school districts concerning the development and implementation of a STEM program and integrating STEM education through PBL. Educational leaders desiring to develop a secondary STEM high school would benefit from research that documents a beginning STEM model. The current study has provided information that may generate ideas that could be implemented in developing future secondary STEM schools.

Research Questions

1. How does student engagement in PBL influence interest in STEM careers?
2. How does teacher knowledge and perception of PBL influence PBL implementation?
3. What stages and challenges do teachers experience in attempting to implement PBL?

Background of the STEM Academy

This case study was conducted in a small, rural school system in North Carolina, specifically, at an academy designed to promote innovation and creativity in secondary education through contextual and PBL and student-centered instruction. The United States Census Bureau (2011) stated that the population in this rural city was approximately 19,000 people. The city's population included a 55% White population and a 28% Black population. During the 1940s-1980s, this rural area's (along with neighboring counties) chief industries were furniture and textiles (Porter, 2009). Due to global outsourcing of textile and manufacturing to other countries, the city's economy has been negatively impacted.

The academy opened with approximately 51 ninth-grade students and will add additional grades each year. In year 1, the academy consisted of 28 males and 23 females from three neighboring school systems. Fifty-eight percent of the students were first generation potential college students, with 51% in the free and reduced lunch category and 29% minority students (District Website, 2012).

The curricular path of this academy looks very different from the traditional high school, as it follows a curriculum designed to increase STEM-related core content through integrating industry-relevant technical applications and technologies for the local area and an internship in the 11th and 12th grade year of school. During the first 2 years, students utilize additional time to explore and study different STEM-related careers before choosing to pursue a definite career pathway. Classroom learning, based on contextual and PBL, student-centered instruction, and team driven collaboration, is supported by technology. The daily schedule is flexible with no bells and a multiple schedule design based on focused daily activities. This schedule flexibility allows the staff to incorporate team-teaching, seminars, and project work (District Website, 2012).

The staff consists of four content teachers or instructional coaches, an instructional technology facilitator, business instructional coach, wellness instructional coach, career counselor/business liaison, and the principal or CEO. Additional staff members are added each year. Staff members receive common planning in the mornings and afternoons in one centralized workspace. Students receive weekly lunch and learning sessions that provide a time for students to collaborate and communicate with guest speakers during their lunch time (District Website, 2012).

The academy is designed to encourage innovation under two broad STEM career areas: "Aerospace and Advanced Manufacturing (including industrial design and global logistics) and Health and Life Sciences (emphasizing health technology and information systems" (Steering Committee of the Career Academy, 2012, p. 1). The academy is designed to promote innovation and creativity in secondary education through contextual and PBL and student-centered instruction (Steering Committee of the Career Academy, 2012).

The Steering Committee of the Career Academy (2012) cited that the mission of the academy is to graduate students, college and career ready, with up to a 2-year associates degree or college transfer credit related to one of these emerging career fields. This mission is aligned with their vision of creating a desire in students to have a curiosity and a hunger for creativity and innovation.

This study focused on freshmen and sophomore students from various neighboring counties. In recruiting, the primary focus was on students who often do not complete additional education beyond high school. This school partnered with regional businesses, school districts, community colleges, the NC New Schools Project, Piedmont Triad Partnership, NC Global Logistics Center, the NC Lieutenant Governor and JOBS Commission, the NC State Superintendent of Public Instruction, and the Chairman of the NC State School Board (Steering Committee of the Career Academy, 2012).

According to the Steering Committee (2012), the academy was organized around themes integrating high school and college academic courses with problems designed with community partners, businesses, higher education, and the North Carolina New Schools STEM network. In the students' freshman and sophomore years, experiences with advanced technologies to "discover their career interests through field trips, guest speakers, virtual mentoring, job shadowing, contextualized curriculum and real-world projects" (p. 1) were provided.

During the junior year, students will concentrate on completing a specific 2-year Associate of Applied Science degree related to their career area. Students will continue to take responsibility and initiative for their own learning through internships, work-based projects, and use of digital curriculum resources to better develop their entrepreneurial skills (Steering Committee, 2012).

This academy is a bold initiative to reinvent high school around students' career interests, with innovative ways to utilize technology and a rigorous core curriculum integrated with community and work experiences. Students will have the opportunity to earn 15 or more hours of postsecondary credit during their 4 years. The committee further stated that each student will have three available choices upon graduation. Each student may choose to enter a training or apprenticeship in their selected field, apply their postsecondary credit hours to an associate degree in their career field at one of the partner community colleges, or apply their earned hours toward a 4-year degree at one of the partner universities. It is through one of these choices that the students will have the opportunity to compete globally as skilled, productive employees (Steering Committee, 2012).

The STEM academy follows the philosophy of standards-based grading. "If your grading system doesn't guide students toward excellence, it's time for something completely different" (Scriffiny, 2008, p. 70). Guskey (2006) stated, "standards-based grading requires teachers to base grades on specific criteria derived from learning standards and decide what evidence best reflects the achievement of that standard" (pp. 670-671). Standards-based grading reduces meaningless paperwork for students and teachers and helps teachers to adjust instruction. It allows teachers to quickly discover how to "re-examine their curriculum plans and set a clear plan of precise standards for mastery" (Scriffiny, 2008, p. 71).

Conceptual Framework

This study added to the current body of knowledge of STEM education with regard to the importance of integrating PBL. It builds on current research in PBL, demonstrating that projects may increase student interest in STEM due to encouraging students to solve authentic problems while working collaboratively with others (Fortus, Krajcik, Dershimer, Marx, & Mamlok-Naaman, 2005). As educators incorporate PBL in STEM education, students learn to utilize critical-thinking skills and to reflect on the problem-solving process. This type of learning takes place through integrated STEM projects. Satchwell and Loepp (2002) stated that students learn best when stimulated to create their own knowledge of the world around them. These researchers also posited that successful project-based STEM education allows teachers to be creative in providing authentic, real-world problems for students to solve.

Grant (2011) reported, "potential benefits of project-based learning are substantial" (p. 38). This study emphasized that in-depth investigations, when using PBL, enhance student knowledge more than memorization of content knowledge. Project-based approaches allow students to "guide, manage and monitor their learning through self-direction and self-regulation" (Grant, p. 38). Lessons incorporating PBL provide many opportunities for self-reflection through learning logs and at the end of class.

Mergendoller and Thomas (2001) reported PBL as a teaching and learning model that utilizes projects to engage students, with the task of classroom management being different from the traditional classroom structure. These authors indicated that minimal time is devoted to whole-class discussions or teacher-directed seatwork with PBL.

Students utilize their time working collaboratively in small groups or on their own. Students usually locate their own resources, conduct their research, and receive feedback (Mergendoller & Thomas). In this model, teachers do not spend an enormous amount of time on student misbehavior and are seen as coaches within the class.

This study added to the current body of knowledge on three variables: utilization of PBL, teacher implementation of PBL, and student interest in STEM careers through the use of PBL. Each variable has supporting constructs, which contribute to the concept. PBL has five constructs: collaboration (students/teachers), projects or learning artifacts, self-reflection, student-centered, and 21st century skills. PBL requires collaboration among students and a designated time for teachers to collaborate. Devising projects allows students to self-reflect and develop 21st century skills. Students and teachers are continuously engaged with the curriculum content and communicating with one another, which allows the student to be an active participant in their own learning (Ravitz, 2009).

Teacher implementation of PBL is composed of five primary constructs: time management, integrating curriculum, classroom management, coach/facilitator, and tuning protocol. These constructs both support and are a part of teacher preparation of the integration of PBL within the classroom. Teacher implementation of this process may play a role in student interest and motivation in PBL (Ravitz, 2009). Ravitz (2010) suggested PBL may require enormous commitment and focus for teachers to better handle challenges related to managing time, generating essential questions to guide student inquiry, utilizing performance assessments, developing projects, and participating in staff development.

Student interest has five constructs: teacher plays key role, active learning, motivation, STEM careers, and adult-world connections. Boss and Krauss (2007) stated student interest is an essential part of building new knowledge. Teachers may play a key role in motivating students to be active participants in their own learning of STEM careers. These authors suggest the teacher's role shifts in PBL. The teacher no longer disseminates the content to represent the scholar or expert; but, instead, the student becomes motivated to be active in their own learning. The authors further stated that active learning in PBL sets the stage for encouraging students to engage in real-world activities.

The current framework for understanding these variables and supporting constructs is presented in the conceptual framework noted in Figure 1. This figure illustrates the relationship among these variables previously discussed. This study assessed the relationship among these variables and builds on this conceptual framework.

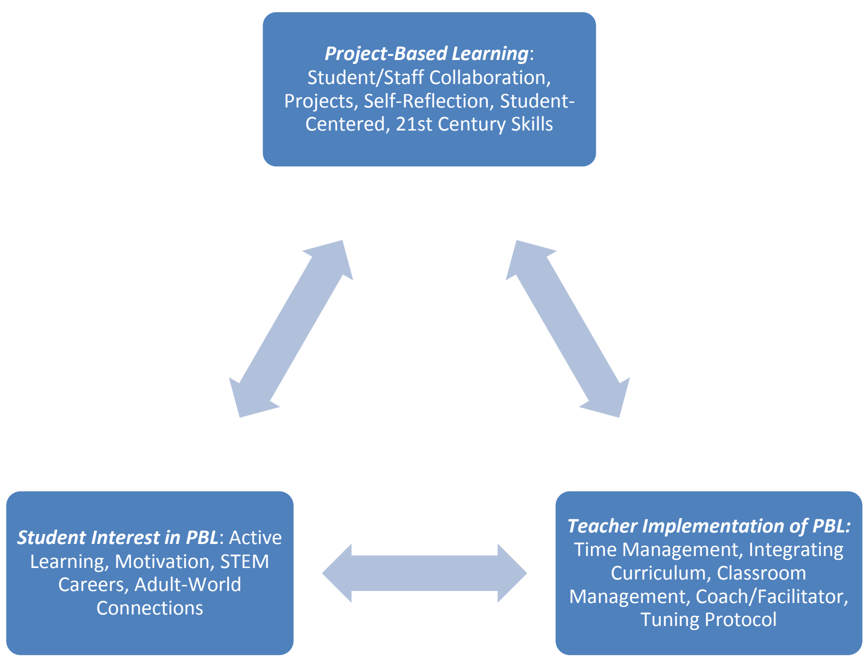


Figure 1. Conceptual Framework.

This case study examined student engagement within the context of how students respond to PBL and how this may impact student interest in STEM careers. Students are motivated to learn and to be engaged in the lesson when it is meaningful and relevant to them. PBL is one way for students to learn key academic content. Students can build workplace skills, achieve a deeper understanding of concepts and standards, and acquire lifelong habits of learning (Buck Institute for Education [BIE], 2012). Research suggests that "positive changes in student motivation, attitude toward learning, critical thinking, and problem-solving skills may result from their participation in project-based learning" (Hixson, Ravitz, & Whisman, 2012, p. 2).

Definition of Terms

Active learning. "Active Learning is an educational approach that puts the students at the center of the learning process and transfers the responsibility of the learning from the teacher to the student" (Doppelt, 2003, p. 256).

Career academy. Smaller learning community for improving academic achievement by preparing students for both college and careers and engaging the world outside of school in the work of reforming them. Career academies are widely supported by the business community and colleges (National Career Academy Coalition, 2009).

Career and college-ready skills. Focusing on the goal of having all students graduate from high school fully prepared to participate in postsecondary education and the high-skilled workforce (North Carolina Department of Public Instruction [NCDPI], 2012a).

Integrated curriculum. Making connections among disciplines while fostering collaboration among students and teachers (NCDPI, 2012a).

Perception. The process by which individuals interpret and organize sensation to produce a meaningful experience of the world. The individual interprets the stimuli into something meaningful to him/her based on prior experiences. However, what an individual interprets or perceives may be substantially different from reality (Borkowski, 2011).

Project-based learning. "An active learning technique that utilizes problems embedded in realistic situations. Problems may be drawn from real situations, which allows the students to develop connections, generate and/or invent solutions to the problems" (Mastascusa, Snyder & Hoyt, 2011, pp. 123-124).

STEM. An acronym for the subjects Science, Technology, Engineering, and Mathematics (Bybee, 2010).

STEM-related/21st century skills. The concept of these skills is based on the definition from BIE researchers. It is the ability to reason and solve problems using STEM knowledge. These skills also include developing "critical thinking skills, collaboration skills, communication skills, creativity and innovation skills, self-direction skills, local connections (applying what they have learned to local/community issues), and using technology as a tool for learning" (Ravitz, Hixson, English & Mergendoller, 2012, p. 3).

Student engagement. Represents both the time and energy students invest in educationally purposeful activities and the effort institutions/instructors devote to using effective educational practices. This includes five benchmarks: "level of academic challenge, enriching educational experiences, active and collaborative learning, supportive campus/school environment and student-faculty interaction" (Kuh, Cruce, Shoup, Kinzie, & Gonyea, 2008, p. 542).

Student participation. Giving students a voice in their education, listening to them, and involving them as much as possible within the lesson. Valuing their opinions and ideas and giving them control of their learning (Participation Works, 2013).

Tuning protocol. The presenting teacher receives feedback on a project from colleagues to help fine-tune or improve the project (National School Reform Faculty [NSRF], 2012).

Delimitations

This case study did not seek to compare a traditional high school setting utilization of PBL to this STEM high school. Rather, this study sought to explore and examine how this new STEM high school develops and implements PBL to encourage student engagement and develop interest in STEM careers. Data collection was limited to classroom observations, online surveys, and focus groups during one school semester period. The participants included freshmen and sophomore students and staff.

Summary

The case study has added to the current body of research knowledge on STEM education in a high school setting. This study utilized an online survey along with student/teacher focus groups to obtain knowledge of PBL and student engagement in a STEM school setting. Information from the focus groups added a deeper understanding of how to better implement and develop PBL projects and activities. This study provided information to schools, administrators, teachers, and community members desiring to start a STEM school and provide guidance on integrating PBL into the academic program. Insights gathered from this case study can be used to influence and encourage high levels of student engagement, strengthen the understanding of PBL, and develop an interest in STEM careers.

Chapter 2: Literature Review

Introduction

When students enter high school, the anticipated outcome is to graduate and be career and/or college ready. There is a need and responsibility of educators to provide an educational environment that promotes critical thinking, creativity, innovation, and collaboration with other students. Educators should provide classrooms that promote thinking and learning and encourage students to be responsible for their own learning. These needs could be met through PBL where students learn an extended process of inquiry to a profound question, problem, or challenge (Larmer & Mergendoller, 2010).

The purpose of this chapter is to present a literature review that provides background in pertinent research and policies influencing STEM, the background necessary for understanding the key aspects of PBL, labor needs, and the history and interpretation of STEM education.

During the late 1960s, Christensen, Horn, and Johnson (2011) stated many Japanese companies began to disrupt United States companies. The United States began to evaluate and question its competitiveness, turning to schools for possible answers. A landmark report, *A Nation at Risk* (National Commission on Excellence in Education, 1983), raised the awareness of education in the United States in hopes of renewing the nation's educational commitment. This report further stated, "our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world" (National Commission on Excellence in Education, 1983, p. 1). This very important report opened the door for crucial conversations pertaining to educational reform in the United States. It stressed the importance of strengthening the United States' educational system to maintain and improve the "slim competitive edge" it has in world markets (National Commission on Excellence in Education, 1983, p. 1).

Maintaining a competitive edge to compete globally marks an increase in the attention given to STEM education. President Obama and Secretary Duncan are working to push STEM to the forefront of the nation's education dialogue for a competitive workforce and resilient economic development (Education Week, 2011). Current literature addresses the growth and importance in STEM education, integration of PBL, importance of closing the skills gap to compete globally, as well as the need to better prepare students to fill STEM-related careers.

National Concern and Policies for United States Education

Schools in the United States are in constant reform and change to remain one of the top leading countries in education. In October 1957, the Soviet Union propelled *Sputnik*, a satellite that orbited the earth. The launch of this satellite created a sense of urgency to examine the quality of math and science instruction in America. In 1958, the U.S. Congress enacted the NDEA to counteract the Soviet school system and to focus on training mathematicians and scientists (Jolly, 2009).

The nation's reaction to Sputnik, along with the ongoing criticism of American schools, raises the awareness for school curricula focus to shift. Schools can no longer design their classrooms in a factory model where the teacher teaches (output) and the students sit, with no interaction (input). This model represents a management style that "shifts all responsibility for the organization (classroom) from the worker (students) to the manager (teacher)" (Morgan, 2006, p. 23). In this model the manager (teacher) does all of the thinking, leaving the students to receive the information without thinking, collaboration, and problem solving or asking key questions. This way of thinking does not develop the necessary skills to be competitive with other nations.

In order to compete with the Soviet Union and other countries, NDEA aims to strengthen America's education in providing student loans and scholarships in science, mathematics, and foreign language instruction (Institute for Defense Analyses, 2007). This funding is important in keeping the focus of improving math and science instruction.

To continue scientific leadership and economic growth, reports have been written on the quality of education in America. In 1983, *A Nation at Risk: The Imperative for Educational Reform* became the driving force for improving America's curriculum and standards to compete globally (National Commission on Excellence in Education, 1983). This report cited a shortage of quality math and science teachers at the secondary level, which led to substantial numbers of unqualified teachers teaching these subjects. The report recommended that schools and colleges adopt more rigorous and measurable standards for higher academic performance and more time to learn the new basics and new sequences of science and math courses/materials that match the stages of intellectual development of students (National Commission on Excellence in Education, 1983).

As the nation studied and reviewed many educational reports and other research, former President Bush signed a bill known as the "America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act," or simply "America Competes Act." Becoming law in 2007, this act stressed improving the competitiveness of the United States by investing in innovation through research and development. This act authorized an increase in STEM education from kindergarten to postdoctoral education with an increase in science and engineering research (CRS, 2008).

In January 2011, President Obama continued to push the importance of research and development of STEM education by signing the "America COMPETES

Reauthorization Act of 2010" (Holdren, 2011). This amended version of the 2007 bill provided additional funding for STEM education and ongoing research. Holdren (2011), when addressing the amended Act, indicated that "this act represents a major milestone on this nation's path to building an innovation economy for the 21st century–an economy that harnesses the scientific and technological ingenuity that has long been at the core of America's prosperity" (p. 1). This act gave the National Science Foundation a financial boost to continue its work in STEM research and development (Holdren, 2011).

According to the Partnership for 21st Century Skills (2007), the United States can no longer ignore the importance of "student acquisition of 21st century skills" (p. 1). This report stated that education and competition are changing internationally. American students are not performing well on assessments that measure 21st century skills when compared to other countries. Several 21st century skills include " learning and thinking skills, critical thinking and problem-solving skills, communication skills, creativity and innovation skills, collaboration, ethics, accountability, adaptability, people skills, self-direction and leadership skills" (Partnership for 21st Century Skills, p. 2.)

Creativity and innovations no longer set the nation apart, which affects the overall workplace. The workplace, jobs, and skill demands are continuously changing. Partnership for 21st Century Skills (2007) cited the importance of reassuring that every student is qualified to succeed in work and life in the new global economy.

William Bennett (2013), former U.S. Secretary of Education under President Reagan, discussed the concern of a STEM-deficient education system. Bennett cited, "There is a national education disaster in the making, due to America's K-12 and postsecondary education systems failing in their mission to prepare our nation's children and young adults in STEM fields" (p. 1). The lack of academic rigor and relevance not being delivered in America's classroom in STEM-related fields is emphasized in Bennett's report.

An additional concern was raised by John Calabrese, vice president of global engineering for General Motors. Calabrese declared that the auto industry is concerned that the K-12 education system is not sparking the interest of students in STEM-related fields (Bennett, 2013). Many industries continue to stress their concern of the lack of students being prepared to work in their companies. The President's Council of Advisors on Science and Technology (2010) believed that approximately 1 million additional college graduates will be needed in STEM-related subjects during the next 10 years. Bennett (2013) stressed that the U.S. is "nowhere near meeting this goal" (p. 1).

The Lemelson-MIT Invention Index (2012) provided a study on the importance of invention and innovation. This study suggested that most of America's youth are aware and understand the importance of invention and innovation, especially in their personal lives. Most American youth realize there are factors that may prevent them from entering inventive and STEM-related fields.

Lemelson-MIT (2012) provided a survey of students, ages 16-25. Data showed the impact of new technology such as smartphones and tablets. Forty percent of participants could not imagine their life without this technology. Sixty percent of participants believed there are factors that may prevent them from pursuing a career in STEM-related fields or from fields that may lead towards innovation.

According to Lemelson-MIT (2012), "Hands-on invention activities are critical, but few students are given opportunities to learn and develop their inventive skills" (p. 1). Less than half of the participants used a drill or hand tool or had made something from materials. It is important to engage students in different types of experiences, encouraging future innovators which could provide a strong STEM education.

Participants believed that providing invention projects during school and through field trips or by giving the students a place to develop an invention could support the improvement of education. To become more creative, 80% of the participants expressed an interest in courses outside of the classroom. To encourage inspiring inventors, findings suggest that 58% of the participants believed a training program that allows shadowing working professionals is needed (Lemelson-MIT, 2012).

The Lemelson-MIT (2012) study assessed innovation aptitude among and between the participants to discover the factors that may prevent them from pursuing further education in STEM-related fields. Participants reported they did not know much about STEM-related subjects and fields, and their subjects were too demanding and challenging. Several participants believed they were not prepared to pursue further education in STEM careers (Lemelson-MIT, 2012).

These statistics continue to show the need for an educational reform that encourages creativity, innovation, and more ways to encourage participating in STEM-related careers. John Engler (2012), former governor of Michigan, cited the lack of preparation of students for STEM careers is a problem for our nation. Engler suggested that for our nation to remain a global innovation leader, educators should develop STEM talent and seek new ways to encourage more participation. Businesses continue to stress the need for a "talent pipeline to provide the skilled employees who can routinely use scientific and technological skills in their jobs" (Engler, p. 2). Improving STEM education will continue to allow the nation to compete globally and to keep this country strong.

A Curriculum Framework for Defining STEM Education

STEM education is complex and complicated to define due to many interpretations from various researchers. How STEM education is implemented continues to differ within the classroom. Currently, educators continue to teach STEM subjects separately and independently from each other. Additionally, ways to improve STEM education are still evolving. From the literature reviewed, there are several interpretations of STEM education as it applies in a high school educational setting in the United States.

The first interpretation of STEM education involves the integration of science, technology, engineering, and math with the emphasis on math and science. The Hanover Research (2011) report stated these STEM schools have less emphasis on technology or engineering. Seldom does it refer to technology or engineering. Engineering involves problem solving and innovation (Bybee, 2010). STEM education stresses increasing the "visibility of technology and engineering in the standard K-12 curriculum" (Hanover Research, p. 7). Bybee stated engineering has very little presence in some schools and not the amount consistently needed to meet our society's needs.

To meet the challenge of integrating STEM subjects and not teach them in isolation or silos, the STEM academy in this study partnered with the local community college to provide courses on the collegiate level (Academy Executive Committee, 2013). This academy also includes incorporating the North Carolina New Schools Project (2012) engineering design process in the curriculum and projects (Figure 2).

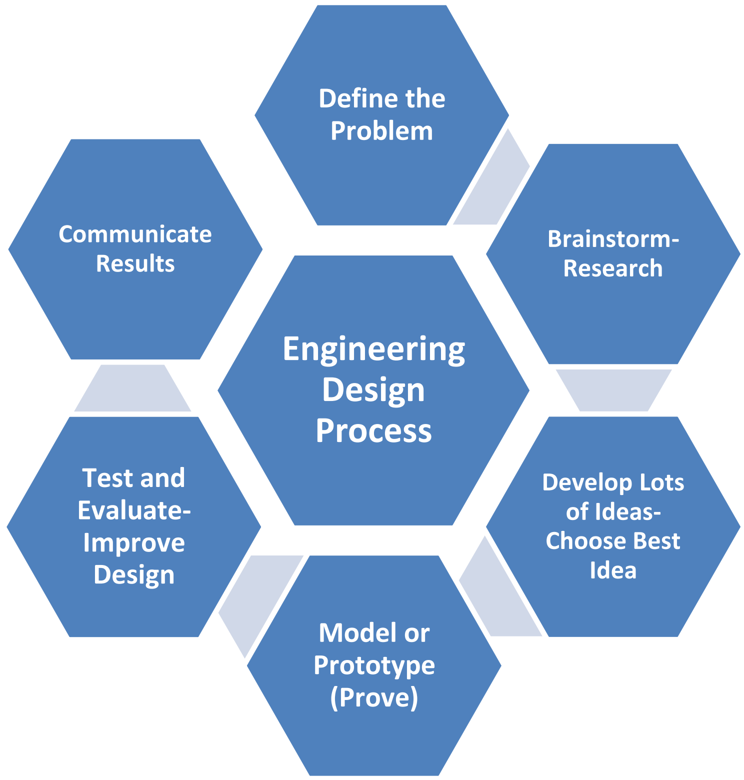


Figure 2. Engineering Design Process.

As STEM schools search to develop content knowledge in these areas, STEM education should strive to develop soft skills such as problem solving and scientific inquiry. Schools should encourage students to ask good questions which lead to developing problem-solving skills. Employers look for someone who asks good questions, engages in good discussion, and has the ability to think. Today's workforce is not only defined by specialty but by the "problem you and your team try to solve or accomplish" (Wagner, 2008, p. 15). These skills will enhance the opportunity for the current student to be a productive contributor in today's workforce.

The second interpretation of STEM education is blending academic coursework with career-technical education (CTE) courses with the goal of increasing the numbers of high school students attending college. Dobbins (2000) stated vocational and academic integration is a great connection of curricula in teaching necessary skills for students' future successes in the workplace. Dobbins reported the benefit of integrating vocational and academic curricula is it allows students to learn abstract academic concepts through concrete, real-life examples. One barrier of vocational and academic integration is that it requires more time to develop the curricula, plan activities, and work with other staff members on the integration. He also stated that some teachers are reluctant to change and do not believe that curriculum integration can help the career-bound student.

The third interpretation of STEM education is an integration of all four subjects: science, technology, engineering, and mathematics. Recognizing the T and E in STEM is an important way to increase interest in innovation. All STEM disciplines can present opportunities for highlighting 21st century skills (Bybee, 2010).

This interpretation stresses an integrated curricular approach, which means to purposefully integrate technology and engineering within the lessons. Engineering education should motivate students to understand concepts and engage them to enthusiastically design and construct solutions to solve problems they may encounter (President's Council of Advisors on Science and Technology, 2010).

One of the best known STEM curriculum providers, a leader in integrating engineering, is Project Lead the Way (PLTW, 2011). PLTW, established in 1996, provides rigorous and innovative curricular programs for middle and high schools throughout the nation. PTLW provides three curricular programs: technology, engineering, and biomedical sciences. The hands-on, project-based program exposes students to many different areas of study and provides them with a foundation for college and career success. This program shows the student how what they are learning in math and science connects and applies to real-world situations in technology and engineering

(PLTW).

The fourth interpretation of STEM education stresses an integrated curricular approach and also fosters a culture of collaborative inquiry and exploration. In the State of North Carolina, the North Carolina New Schools Project (NCNSP, 2011) has a clear focus in integrating all four disciplines within the curriculum. NCNSP's vision for STEM education includes emphasizing connections between math and science, integrating technology and learning, and applying the engineering design process (NCNSP). The engineering design process to identify and solve problems is "highly iterative, open-ended, a meaningful context for learning scientific, mathematical concepts, and a stimulus to systems thinking and analysis" (National Academy of Engineering, 2009, p. 6).

NCNSP (2011) stressed the importance of developing organizational, critical thinking and problem-solving skills. This vision includes a STEM curriculum that cultivates creativity and nurtures strong communication and collaborations skills. Extracurricular activities and internships are a vital part of learning experiences, which allow for increase in student awareness of STEM-related careers. NCNSP's goal is to strengthen instructional practices and build a more challenging curriculum. This curriculum includes supporting the implementation of "*Core-Plus Mathematics* (problem-based, integrated math) and Arizona State University's *Modeling Instruction* approach to teaching" (NCNSP, p. 2).

The fifth interpretation of STEM Education, High Tech High (HTH), integrates all four disciplines with a strong emphasis on PBL. HTH is a charter school in San Diego, California, with the mission of "giving students an interdisciplinary and hands-on education through PBL, internships and senior projects" (Paek, 2008, p. 1). HTH focuses on three design principles: “personalization of students’ learning, adult world connection through project-based learning/internships, and common intellectual mission through common planning time for teacher collaboration/professional development” (Paek, 2008, p. 3).

HTH teachers reportedly receive extensive professional development on how to utilize PBL, which increases their use of PBL when compared to earlier years (Ravitz, 2008). HTH teachers stated PBL allows them to teach skills beyond academics, conduct projects that specify content standards, and utilize rubrics to guide student work. These teachers reported that students are constantly involved in inquiry activities and are given the opportunity to support their peers as learners (Ravitz, 2008).

History of STEM Education

There is a long history of disagreements about how to educate our nation’s children in the United States. These past struggles cannot be ignored when reviewing STEM education. There have been extensive differences regarding content and pedagogy (Klein, 2003). The ideas of integrating content in a problem-centered environment came from a variety of sources which predate to the 20th century. John Dewey introduced his viewpoint as early as the 1920s, when he put greater emphasis on intellect and development of problem-solving and critical-thinking skills rather than simply on memorization of lessons (Dewey, 1897).

The efforts of these and other early groups received little attention until the Soviet Union launched the first space satellite, *Sputnik.* This Sputnik moment challenged educators to think differently about STEM-related subjects. Sputnik “stimulated political, military, technological, and scientific developments, creating an atmosphere of educational reform, and a *new math era*” (Steen, 2007, pp. 86-87).

During the decade of the 1990s, math education policies and programs in our nation's schools had a sense of unrest due to particular math textbooks and curricular programs (Klein, 2003). In the mid-1990s, math was a major topic of heated controversy among educators known as *The Mathematics Wars* (Schoenfeld, 2004).

Looking ahead, the recent *Trends in International Mathematics and Science Study* undertaken by the National Center for Education Statistics (2011), posited the leading countries in math and science continue to be Singapore, Korea, Hong Kong (China), Chinese Taipei, Japan, Belgium, and Finland. This report also cited North Carolina and Florida as displaying high achievement but lower than the East Asian countries.

The current study has brought good news and a ray of hope, but there is still much work to do in the nation's math and science curricula. The future ability of the nation's education institutions to produce citizens literate in STEM concepts to produce future scientists, technologists, engineers, and mathematicians is still a concern (U.S. Department of Education, 2007). The progression of mathematics and science in the United States is in desperate need of reform if we plan to rise above and meet the expectations of competing with nations of higher standards. For a nation that thrives on competition and being at the top of our innovations, we need to make STEM education a priority.

Labor Needs

Rodney Adkins (2012), senior vice president of IBM's Systems and Technology Group, suggested when advancing the economy and society, we should produce the next great technology innovations by increasing a resilient workforce of experts in STEM. According to the U.S. Department of Labor, Adkins cited that 5% of U.S. workers are employed in fields related to science and engineering, yet they are accountable for more than 50% of our economic growth. Adkins's report theorized the trend of American scientists and engineers has declined, with 40% of the nation's scientists and engineers existing in the U.S., but today's numbers continue to shrink to nearly 15%. To turn this trend around, Adkins suggested increasing the size of the STEM education pipeline by creating an interest and passion for STEM-related subjects and fields throughout college.

According to the President's Council of Advisors on Science and Technology (2010), Adkins (2012) concluded that approximately 40% of college students preparing to major in engineering and science consistently shift to other subjects. STEM-related degrees symbolize approximately one-third of all bachelor's degrees endowed in the U.S., which does not fulfill the rapid growth of STEM-related jobs (Adkins).

Three organizations combined their efforts to produce a report on foreign workers in STEM-related fields. According to the report by the Information Technology Industry Council, Partnership for a New American Economy (2012), and the U.S. Chamber of Commerce (Information Technology Industry Council, 2012), there is evidence that foreign-born students are complementing the American students in STEM-related fields, but there still remains a shortage in STEM talent. Congress is currently considering bills that will provide opportunities for foreign-born students who earn degrees (in STEM-related fields) in the U.S. to receive green cards to remain in the U.S. This report also cited that foreign-born students who remain in the U.S. create approximately 2.6% jobs for American workers. This is due to their assistance in research and innovation.

The Information Technology Industry Council (2012) suggested when reducing the shortage in STEM-related fields, there must be a reform in the U.S. educational system. There is a need to encourage more American students to enter STEM occupations and not shift to other careers. Currently, according to The Information

Technology Industry Council,

> the number of U.S. students pursuing STEM fields is growing at less than 1% per year, and by 2018 there will be more than 230,00 advanced degree STEM jobs that will not be filled if every single new American STEM graduate finds a job. (p. 1)

One potential solution to this challenge is Change the Equation (CTEq, 2011). CTEq is an initiative that works with businesses and communities to improve and sustain STEM learning in the nation. CTEq cited two views on STEM jobs. One view stated that STEM-related careers open doors for filling jobs even in a tough economy. STEM skills are in high demand with "unemployment rates in STEM occupations being low and with STEM workers receiving higher salaries" (CTEq, p. 2). Skeptics counter the first view by stating the nation's colleges graduate more than enough students with STEM degrees to fill the new STEM jobs. Some debate that "STEM wages aren't rising fast enough to indicate scarcity" (CTEq, p. 2).

CTEq (2011) suggested there is data and evidence to support that STEM skills are in high demand, as the U.S. relies heavily on other countries to fill the nation's demand for workers with STEM skills. It is expected that the number of jobs requiring a STEM background will grow with STEM employment growing "17% between now and 2018" (CTEq, p. 2).

The Georgetown University Center on Education and the Workforce (2010) stated that the "United States is not producing enough STEM workers to compete successfully in the global economy" (p. 1) and the demand for workers is increasing at every level of education. Georgetown University Center on Education and the Workforce cited that STEM competencies and workers are needed in a broader reach of occupations other than mathematics, science, and engineering. Since 1980, "the number of workers with high levels of core STEM competencies has increased by almost 60%" (Georgetown University Center on Education and the Workforce, p.1).

In projections completed by the Georgetown University Center on Education and the Workforce (2010), STEM is second only to healthcare as the "fastest-growing occupational category in the economy with the least supply demand of workers" (p. 2). These projections suggest that many students drop out of the STEM pipeline between high school and college, or in college, and that of 100 students entering college to obtain a bachelor's degree in a STEM education-related career, only eight will graduate and continue working in a STEM occupation after 10 years. Figure 3 denotes the percent of predicted career outcome of STEM workers by 2018.

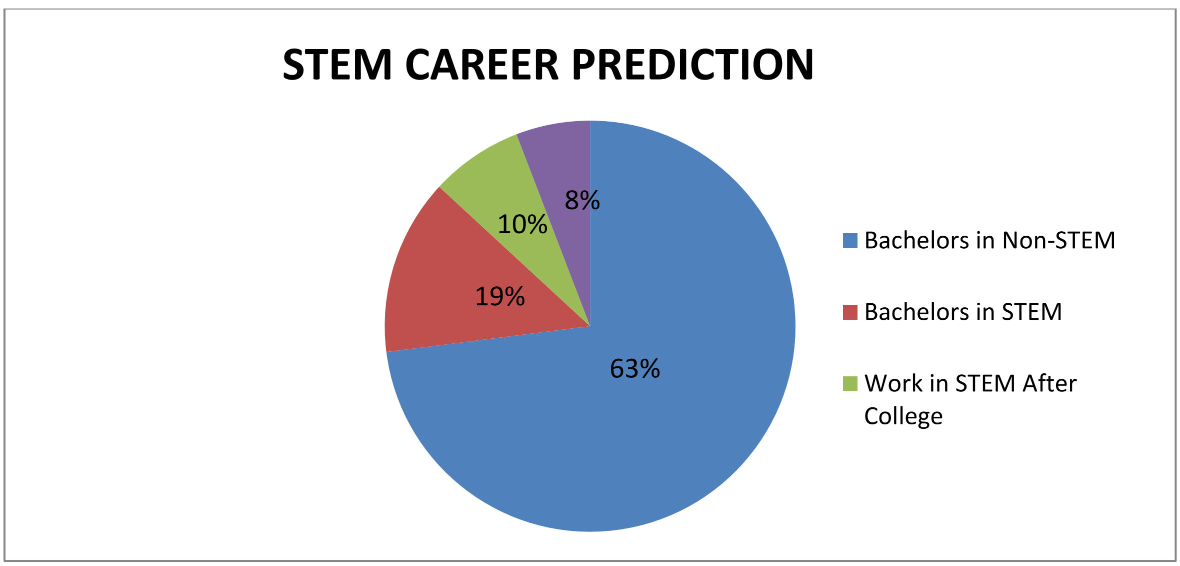


Figure 3. STEM Career.

Also according to the Georgetown University Center on Education and the Workforce (2010), by the year 2018, 92% of traditional mathematics and scientific STEM jobs will be for those with at least some postsecondary education and training.

They further stated that close to two-thirds will be for those with bachelor's degrees and higher and roughly 35% of the workforce will be comprised of associates' degrees, certificates, and industry-based certifications. This leads to one common denominator of STEM talent being in increasingly high demand at the sub-baccalaureate level.

The nation's educational system has let America down in preparing students for this role. As the United States moves forward to becoming competitive in the STEM field, it is important that the Career and Technical Education system, high schools, and sub-baccalaureate level programs link more tightly together on competencies for career-related STEM jobs (Georgetown University Center on Education and the Workforce, 2010).

Another factor that may affect STEM labor needs is preparing the students for future STEM jobs. Students may find themselves unprepared to pursue STEM-related careers if their math and science foundation is inadequate. K-12 science and technology curriculums often do not provide a solid foundation in STEM (JEC, 2012). The quality of math and science teaching is one of the greatest factors in improving student achievement in STEM fields. There are insufficient K-12 math and science teachers with hands-on experience working in STEM. The JEC (2012) suggested that teachers may lack an educational background in STEM.

The National Science Foundation found 36% of middle school science teachers and approximately 30% of middle school math teachers lack in-field training. In addition to improving the quality and quantity of STEM educators, a greater emphasis on communicating the benefits of STEM education to students is needed. College students may not have necessary information regarding career prospects to make educated decisions in selecting a course of study. Therefore, it is vital that the United States produce STEM graduates to meet the demand for STEM-skilled workers (United States Congress Joint Education Committee, 2012).

Business Initiatives and Partnerships

Businesses have joined in the challenge of improving student's preparation for career fields. Employers in many industries lament that job applicants lack the needed mathematics, computer, and problem-solving skills to succeed; therefore, international students are filling an increasing proportion of elite STEM positions in the United States businesses (National Research Council of the National Academies, 2011). The National Science Teachers Association (NSTA) fully supports *Educate to Innovate* and is a proud sponsor of National Lab Day (NLD), a cornerstone of Obama's initiative. NLD is a teacher-driven nationwide effort to build local communities of support between STEM professionals and STEM teachers who will foster ongoing collaborations to strengthen the education provided to students (Eberle, 2010).

Bo Miller, a representative from the Dow Chemical Corporation, posited similar corporations are in jeopardy unless the STEM crisis in education is solved and companies get involved (U.S. News Report, 2011). In his news statement, Miller (2011) confirmed that the "time for action is now" (p. 1). Dow Corporation joined as an ally for STEM in education by supporting events and initiatives around the world that get students from kindergarten to college excited about science. Dow makes significant funding and employee volunteerism to increase and accelerate the impact of the partner in education programs.

One particular way Dow funds STEM education is through a $3 million contribution to the NSTA to create and promote quality science teaching for new teachers. They also committed $1.2 million to the expansion of the Chemical Education

Foundation that engages fifth- through eighth-grade students in learning chemistry across 20-30 more states over the next 3 years. Miller stated there is an urgency because the "future of the industry is at stake if there is not enough *human capital* to power it forward" (Miller, 2011, p. 2). Dow strongly supports events and initiatives throughout the world to encourage more K-12 students to get excited about STEM-related subjects. Dow Chemical Corporation believes "not taking advantage of our nation's science and technology enterprise will impact future prosperity for the United States" (Miller, 2011, p. 1).

According to the Bayer Foundation (2010), there are increasing numbers of companies that participate in business-education partnerships. The Bayer Foundation surveys cited both "Fortune 1000 and emerging STEM company CEOs as viewing the support of STEM education programs as a corporate responsibility to society" (p. 12). These CEOs realize that science and math literacy are crucial to their own companies and to American's position in the world. Many companies are taking action through partnerships with educators and government officials to raise awareness of the need to develop such partnerships in STEM education.

To stress the importance of business partnerships, the Bayer Foundation (2010) cited challenges and rewards for education and business partners. One such challenge is helping the companies to realize that the timeframe for educating and producing a better-prepared workforce in STEM-related fields will take time. Companies investing monies in education must be risk-takers and understand the kind of commitment they must make to help generate an atmosphere of radical change in "standards-and research-based teaching and learning" (Bayer Foundation, 2010, p. 13). This will also involve businesses committing to supporting this initiative for several years until the students have graduated from secondary education.

Another challenge involves assembling and maintaining all partners together in the process–university/community college partners, other business partners, and the schools. This will involve continuous and consistent communication with all parties, including delegating a key representative or spokesperson from each party. When communicating with the businesses, any new adoptions of curriculum could potentially impact the partnership. This would require reeducation of the business partners so they will continuously understand any changes in STEM-related subjects.

Changing staff at partner schools and/or district leaders may often cause disruption of collaboration and commitment between all partners. This challenge may cause frustration and uneasiness on how to sustain and preserve the partnerships. Therefore, it is important to reeducate the businesses about why it is essential to retain the partnership (Bayer Foundation, 2010).

There are various rewards for schools when partnering with businesses. As STEM-related schools partner with businesses, there are diverse levels of resources available to enhance the program. The Bayer Foundation (2010) stated that one resource is receiving STEM expertise. Professional mathematicians, scientists, and engineers may work with teachers, serve as mentors, help with curriculum implementation, and become informal career counselors. Bayer suggested additional rewards such as "creating an environment where the partners have an open dialogue, building employee morale and enthusiasm, recruiting and retaining high quality staff and fostering goodwill for companies in their communities" (Bayer Foundation, 2010, p. 14).

Two corporate leaders theorized about the importance of STEM schools and partnerships. Niel Tebbano, vice-president of Project Lead the Way, stated, "We've been very fortunate to be able to utilize engineers and scientists from major corporations in the development and revision of our curriculum" (Bayer Foundation, 2010, p. 14). Michael Rouse, Corporate Manager of Toyota Motor Sales, said, "For Toyota, the biggest reward is lasting relationships that work . . . we understand that educating a child is a minimum fifteen-year process and could go to 25 years" (Bayer Foundation, 2010, p. 14).

Project-Based Learning

The BIE is an organization that consistently dedicates its research in refining 21st century teaching and learning through PBL. BIE provides PBL professional development workshops for secondary teachers and other educators (Partnership for 21st Century Skills, 2012). In the late 1990s, project-based curriculum units for high school economics and for high school courses in the U.S. government could be located through the BIE.

BIE (2012) emphasized that in PBL, students utilize an "extended process of inquiry when responding to questions, problems and challenges" (p.1). PBL is an instructional approach built upon realistic learning activities that encourage student interest and motivation. These activities are intended to respond to a question or solve a problem while reflecting on the types of learning and work people may do outside of the classroom.

BIE (2012) emphasized that PBL teaches content and 21st century skills such as communication and presentation skills, research and inquiry skills, reflection and self-assessment skills, and group participation and leadership skills. Students work together toward a common goal with the student's performance being assessed on an individual basis. PBL allows students to reflect on their projects and ideas with the opportunity to voice their decisions (BIE).

Rigorous projects are carefully planned to aid students in learning important academic content. Effective and meaningful PBL utilizes goals derived from content standards. PBL requires and promotes critical thinking, problem solving, and several modes of communication. Students are given the opportunity to use higher-order thinking skills, work together as a team, practice public speaking, and make effective presentations (BIE, 2012).

Beers (2011) stated that 21st century skills are about the "thinking processes and behaviors" (p. 2) that students utilize as they acquire subject area content and work with others to expand their understanding of the content. The key components to integrating 21st century skills into the classroom are "application, connections and participations" (Beers, p. 3). These skills, embedded with subject content areas, strengthen students' learning capacities and help them retain the learning continuously (Beers).

When incorporating 21st century skills, the instructional focus shifts to being able to utilize and apply information. Beers (2011) advised that students who are prepared for the 21st century will be involved in "continuous cycles of learning" which will generate and cultivate critical skills needed to face future challenges (p. 4).

When generating and cultivating critical skills, creativity, communication, and collaboration, STEM curricular content is a foundation for the 21st century curriculum (Beers, 2011). PBL in STEM schools encourages students to be active learners and learn essential concepts through creative projects. Beers reported that student involvement in problem solving shapes an environment for inquiry and high levels of thinking.

The Association for Middle Level Education (2010) conducted a study pertaining to providing insights on possible effects when implementing PBL in math classes. This study defined PBL as engaging students in a common project with clear, expected outcomes. PBL, evolving from medical and engineering schools, emphasizes that students construct "individualistic and shared understanding of important content and concepts as they explore the learning context" (Association for Middle Level Education, p. 1). Students were given the opportunity to pose and cultivate questions. They constructed simple and difficult investigations which allowed them the chance to analyze and interpret data to support their findings.

This study found that PBL is linked to increased academic achievement; however, implementing PBL successfully requires extended professional development for teachers, on-site support, and collaboration among teachers. PBL encourages and allows differentiated instruction and allows teachers to become coaches. Students are given the opportunity to direct their own learning by constructing decisions pertaining to how they will work to achieve their goals. An environment that supports student freedom to learn on their own, collaborate with others, ask questions, and to acquire the initiative to seek answers from multiple resources, is needed to promote PBL (Association for Middle Level Education, 2010).

The Association for Middle Level Education (2010) suggested that "longitudinally, the mathematics performance for students engaged in PBL is greater than those students who did not participate in PBL" (p. 3). This study further posited when supplemented by continuous and substantial professional development for teachers, the PBL group demonstrates modest gains over comparison groups. The PBL environments consistently demonstrate an increase in problem-solving skills over time. This effect was most noticeable when matched comparison groups were utilized in pretest and posttest designs. The study also suggested "current research findings about the implementation of PBL in math classrooms provide evidence for affective advantages of PBL such as increased student achievement" (Association for Middle Level Education, p. 4).

The Center of Excellence in Leadership of Learning, University of Indianapolis (CELL, 2009) provided a series of studies that demonstrated the impact of PBL as related to student learning. This study theorized that, when compared to traditional classes, students in PBL classes achieved better on assessments of content knowledge. "Students with average to low verbal ability and students with little previous content knowledge learned more in PBL classes than in traditional classes" (p. 1). In addition, higher levels of student engagement were observed in PBL classes. CELL suggested PBL units engage all levels of students (lowest and highest), with a positive effect on student motivation to learn. According to elementary teachers, when using PBL, the students' confidence, motivation, and attitudes towards learning improved. CELL cited one study reporting that "high school student engagement and /or participation were difficult to maintain" (p. 1).

CELL (2009) suggested PBL is an integral part of improving critical thinking and problem-solving skills. Research demonstrates that PBL produces a positive effect on skills such as "synthesizing, evaluating, predicting and reflecting" for low-ability students (Horan, Lavaroni, & Beldon, 1996, p. 1). Social skills, such as patience and empathy, are noticeable for special education students through PBL. PBL increases enjoyment as it provides additional opportunities for students to interact with their friends while working on projects (Belland, Ertmer, & Simmons, 2006).

CELL (2009) discussed the possible barriers that teachers may face when successfully implementing PBL. Such barriers include the following:

> Projects are time-consuming, classrooms feel disorderly, teachers cannot control the flow of information, difficult to balance giving students, independence and

> providing support, difficult to incorporate technology as a cognitive tool, a challenge to negotiate between giving students opportunities to explore their interest and to cover the state standards, and authentic assessments are hard to design. (CELL, p. 2)

Even though there are many barriers reported by teachers, this study indicated that PBL has "a positive effect on student content knowledge, it benefits students by increasing their motivation and engagement, and develops critical thinking and problem-solving skills" (CELL, p. 2). Much support is needed for teachers for planning and collaboration as the students need support to organize their time to complete projects and tasks (CELL).

Vega (2012), in a discussion of research to engage students in STEM learning, suggested that PBL improves student understanding of STEM subjects and develops problem-solving and collaboration skills. Students who learn STEM subjects through PBL stated that it is more engaging than in traditional instructional classrooms. Taylor and Parsons (2011) indicated that an interdisciplinary curriculum has been shown to support student engagement in learning. In addition, research has shown "integrating science with reading comprehension and writing has improved students' understanding in both science and language arts" (Taylor & Parsons, p. 3).

Student engagement has the goal of "enhancing all students' abilities to learn how to learn or to become lifelong learners" (Taylor & Parsons, 2011, p. 4). The authors posited that students live in a world that engages them differently than their parents. Students want to frequently connect and communicate and desire an engaging atmosphere that supports these connections. Dunleavy and Milton (2009) reported that students believe three criteria are needed to nurture and increase student engagement:

"(1) learn from and with each other and people in the community, (2) connect with experts and expertise and (3) have more opportunities for dialogue and conversation" (p. 10). Dunleavy and Milton suggested student engagement and dialogue extends beyond the classroom.

When students engaged in science or math, they expressed a desire to talk to engineers and mathematicians. This positive interaction outside of the classroom helps to spark interest within the subject and encourages engagement. This opportunity to engage in dialogue with practitioners allows students to actively construct their learning and build new knowledge.

In the current study, Coates's definition for student engagement, as cited by Trowler (2010), was used. Coates defined student engagement as "students' involvement with activities and conditions likely to generate high-quality learning" (Trowler, p. 7). Coates suggested that student engagement comprises "active and collaborative learning, participation in challenging academic activities and communication with teachers" (Trowler, p. 7).

Boykin and Noguera (2011) cited the greater the student's curiosity, positive attitude, and interest level in the subject, the greater the engagement. Bowen (2002) stated, "engagement is not just keeping busy" (p. 10). Engaged students have the tools to work with others and know how to transfer information to decipher problems creatively. This can be achieved as teachers inform students about how they can utilize prior knowledge and address how the lessons will be beneficial at the present time and in the future. Quality designed lessons are an important feature that will enhance student engagement in PBL (Bowen, 2002). Professional development opportunities are needed for teachers to understand how to design lessons through PBL, to ultimately enhance student engagement.

Researchers Hixson et al. (2012) conducted a study focusing on extended professional development in PBL from 2008 to 2010. PBL was utilized in the Teacher Leadership Institute as an approach to teach 21st century skills. This study investigated the effect of PBL implementation on teachers' perceived abilities on student achievement, and their abilities to teach and assess 21st century skills. Twenty-four teachers trained using PBL were compared to a group of teachers who did not utilize PBL and had not participated in the training provided by the BIE. Achievement gains in four areas of language arts, math, science, and social studies were compared to two groups of teachers (Hixson et al.).

Findings from the extended professional development in the PBL study suggested the trained PBL-using teachers extensively taught 21st century skills more often than the group of teachers who did not utilize PBL. However, when assessing the skills, the teachers did not feel as successful. This study cited that students in the class with teachers who did not receive extensive PBL training did not show any significant academic gains when compared to the students in the class with the PBL-trained teachers. This study suggests that due to the lack of significant gains in the four academic areas, educators who teach PBL should not believe PBL will hinder standardized test preparation (Ravitz & Whisman, 2012).

Students in PBL classes are performing better on assessments of content knowledge and are consistently being emerged in real-world content knowledge that they can apply in a variety of tasks (Barron et al., 1998). In addition, students with previous content knowledge are learning more in PBL classes than in traditional classes (Mergendoller, Maxwell, & Bellsimo, 2006). Students demonstrate initiative by using resources and revising work during PBL (Barron et al., 1998). An example of this success is seen in the study conducted by Ravitz (2010). Findings suggest that reform model new schools that adopted PBL were more successful in changing the staff and student culture and in successfully executing PBL than larger traditional schools.

Chu, Tse, Low, and Chow (2011), from the University of Hong Kong, conducted an inquiry in PBL and reading outcomes of elementary students. A case study design was utilized to document the inquiry PBL approach with the collaboration of teachers, to support the development of reading abilities and elementary students' interests. Findings suggest students' reading abilities are linked to their academic performances. Reading abilities and student interests can be enhanced through inquiry learning.

Similarly, students' reading abilities were evaluated with Progress in International Reading Literacy Study (PIRLS) tests. Participants' perceptions and attitudes of the inquiry PBL were measured by the PIRLS survey, questionnaires, and interviews. Data taken from these instruments reveal positive effects on the reading abilities and attitudes. Findings verify that improvements in reading abilities are identified by students' attitudes and self-perceived abilities. The researchers cited that the insight from this study offers support to further implement inquiry into PBL in schools (Chu et al., 2011).

Jason Ravitz (2009) from BIE conducted a study that explored the role of PBL in small learning communities. This study offered evidence that PBL supports the development of learning communities. Ravitz suggested that "project-based learning thrives when teachers and students experience schools as learning communities and when teachers and schools who use PBL more frequently see themselves as realizing the goals of learning communities for their students" (p. 1).

Creating learning communities for both teachers and students is usually one of the goals of newly formed small schools (Ravitz, 2009). Creating learning communities in small schools may aid in removing structural barriers that hinder effective teaching and learning and meet students' needs. This study suggests PBL is instrumental in creating conditions that engage students, support critical thinking, and support learning. The PBL model is beneficial to learning communities since "students and teachers are engaged continuously with the content and with communicating with one another, and for making the student an active, participating member in the shaping of his/her own learning" (Ravitz, 2009, p. 2).

According to the study by Ravitz (2009), PBL can be more effective than traditional instruction in increasing academic achievement. The study also suggested PBL helps

> facilitate students' knowledge application, supports students to develop a deeper understanding of content, assists students to become more adept at integrating and explaining concepts, boosts student engagement in learning, improves students' retention of knowledge over time and their mastery of 21st century skills and increases students' achievement on state-administered, standardized tests. (p. 3)

Ravitz (2009) suggested this study demonstrates that PBL may help to engage students and stimulate collaboration and partnership among teachers and students. However, there are components of learning communities that do not necessitate the use of PBL. Learning communities can take place independently of PBL, and, in some cases, PBL is shown to hinder efforts to create learning communities (Ravitz). Regardless, Ravitz posited that "in order for PBL to work optimally, its adoption as a framework for instruction should be school wide" (p. 10).

Larmer and Mergendoller (2010) cited eight essentials for project-based learning.

These essentials confirm the importance of students being engaged in meaningful learning versus busy work. The authors suggested the distinguishing factor between busywork and PBL is whether students are cognitively engaged in an in-depth learning process that results in a project rather than just an assignment with a rubric designed for creating a product. A project is meaningful when it fulfills the educational purpose and is significant to students and their perceptions of what is meaningful to learning. Every good project needs to start with standards that reflect concepts derived from state standards and is important to the students, with a topic significant and concrete in the lives of students and encourages them to engage (Larmer & Mergendoller). Larmer and Mergendoller have discovered that many students find school pointless due to not finding the schoolwork applicable to life. They cited that students are sometimes unmotivated when teachers stress knowing information because it is needed later in life or that it will be on the test. With projects, "the reason for learning relevant material becomes clear while learning the content to meet the need of the challenge or problem" (Larmer & Mergendoller, p. 2).

The teacher needs to launch an entry activity to engage student interest to develop open-ended driving questions. The entry activity can be a video, fieldtrip, discussion group, presenter, or mock scenario. The entry activity leads to the driving question that gives students a clear picture of the purpose and challenge of the project and how to problem solve for solutions to the project. The driving question gives students a better understanding of why they are undertaking the project. Lamar and Mergendoller (2010) suggested a project "without a driving question is like an essay without a thesis" (p. 2).

Once the student interest is challenged by thought-provoking questions, students develop their work by choices. Students should have a clear voice in choosing the project's topic and driving questions. As students learn to express their learning in their own voice, there is an increase in student engagement. This engagement involves students presenting their work to teachers and peers, which increases student motivation to perform excellent work.

Students use their driving questions to guide them in discovering answers and generating new questions to develop their student-based product. Preparing students for 21st century skills is a key element in PBL. Building 21st century skills during PBL such as collaboration, communication, critical thinking, and technology will better prepare students to be competitive in the future workforce industry of America (Larmer & Mergendoller, 2010).

Boss and Krauss (2007) also defined PBL as "students investigating open-ended questions and applying their knowledge to produce authentic products" (p. 12). These projects encourage student choice to promote active learning and teamwork. Boss and Krauss stressed "reinventing the project-based approach" by building on what is already known about PBL by utilizing technology (p. 12).

Boss and Krauss (2007) believed when teachers skillfully integrate technology tools, PBL moves into another level. Several components are visible in a successful project. These components include projects being the center of the curriculum, not an add-on at the end of the unit. Students engage in real-world activities and work collaboratively to solve problems. Technology is utilized as a tool for communication and discovery. As teachers integrate technology into the projects, this requires collaboration to design and implement projects. This reinvigorated approach helps to prepare students to "compete globally and thrive in a world that continues to change" (Boss & Krauss, pp. 12-13).

PBL can be challenging for teachers to implement, despite the many benefits to students. In one study reported by Marx, Blumenfeld, Krajcik, and Soloway (1997), several barriers to successful implementation of PBL are cited. These barriers include "projects are time-consuming, classrooms feel disorderly, teachers not controlling the flow of information, difficulty in balancing coaching students and encouraging independence, and difficulty in incorporating technology as a cognitive tool" (p. 341). An additional barrier is the challenge teachers may face when designing alternative assessments and integrating a new instructional method that may require reorganizing the structure of their classrooms (Doppelt, 2009).

Problem-Based Learning

Delisle (1997) stated, "the roots of problem-based learning can be traced to the progressive movement, especially to John Dewey's belief that teachers should teach by appealing to students' natural instincts to investigate and create" (p. 1). Educators who utilize problem-based learning continue to emphasize that students and adults shape their knowledge and skills as they solve a real problem, not abstract activities.

Problem-based learning begins with adults in medical schools seeking how to approach and solve medical problems. Howard Barrows (2002), a medical educator and physician at McMaster University, Canada, had an objective to cultivate methods of instructing physicians to use their knowledge successfully in the assessment and care of patients' health problems and to better prepare them for future problems. In medical fields, problem-based learning enables the students to apply their medical information to real-life situations (Delisle, 1997). Barrows defined problem-based learning with the following key components:

Ill-structured problems are presented as unresolved so that students will generate

> multiple thoughts about the cause of the problem and how to solve it; a student-centered approach in which students determine what they need to learn; and teachers act as facilitators and tutors, asking students the kinds of meta-cognitive questions they want students to ask themselves. (Delisle, 1997, p.120)

Barrows (2002) designed a series of problems by not giving the students all of the pertinent information to solve the problem but required them to research a situation, develop crucial questions, and produce their plan to solve the problem. He discovered that problem-based learning encourages students to be more self-directed to learn and strengthens the development of working toward the resolution of a problem.

Strobel and Barneveld (2009) conducted a study comparing problem-based learning to conventional classrooms and comparing and contrasting different conceptualizations of learning. This study observed the effectiveness of problem-based learning. Generally, staff and students specify greater satisfaction with the problem-based learning approach to learning versus the traditional classroom. When observing basic science retention and short-term acquisition, standardized tests favored the traditional approach. As the knowledge demanded a level of explanation beyond multiple-choice/true-false questions, results preferred the PBL approach (Strobel & Barneveld). This study suggested that problem-based learning is not the only successful strategy to achieve effective learning. It demonstrated that problem-based learning is considerably more effective than traditional instruction to support long-term retention of knowledge and skills (Strobel & Barneveld).

Savery (2006) stated that *project-based* and *problem-based* approaches are "valid instructional strategies that promote active learning and engage the learners in higher-order thinking such as analysis and synthesis" (p. 15). PBL and problem-based learning are similar in that the learning activities are structured around attaining a collective goal or project. When working on a project, the students may encounter several problems that generate utilizing critical thinking skills. Also according to Savery, teachers, who are considered coaches who provide feedback, suggestions, and guidance, should keep these challenges in mind as they engage learners in various learning activities.

Challenges Facing STEM Education

There are challenges that need to be addressed in order to advance STEM education across our nation. One such challenge includes integration of STEM-related subjects in the curriculum. Integrating these subjects within the curriculum provides the students with opportunities to develop 21st century skills including adaptability, complex communication, social skills, and non-routine problem solving. Bybee (2010) stated STEM needs an integrated curriculum to approach the grand challenges of the era, and integrating STEM-related subjects requires a skillful and effective teacher.

In order to be an effective science, mathematics, or technology educator, a teacher should be “well-equipped to deliver integrated, project-based STEM learning experiences” (NCNSP, 2011, p.1). Teachers should have the skills to deepen and extend student learning through inquiry. There is a need for more STEM educators who are willing to extend their teaching beyond conventional methods. Bybee (2010) stated that conventional STEM education leaves too many students behind, with too many students losing interest in STEM-related subjects at an early age. Therefore, the curriculum needs to change from great length and little depth to encompass a deeper depth of learning (Gearon, 2012).

William Bennett (2013) former secretary of education and a senior advisor to Project Lead the Way, gives three possible ways to improve STEM education and to encourage innovation. Bennett (2013) suggested front loading STEM-related teaching, which entails beginning STEM instruction at an early age, such as preschool, to peak the child's interests. Bennett added that more professional development for teaching in STEM-related subjects should be provided, so that teachers learn to integrate subjects as early as possible.

School districts should turn away from specialized math and science schools and strive to place these areas of focus in all schools. Classes should adopt forms of math and scientific methods in its pedagogy to encourage students to learn concepts of STEM-related subjects at a deeper level. School districts and principals should partner with businesses and nonprofit organizations that are dedicated to supplemental teacher training in STEM areas. It is important to "develop strong teachers that can raise awareness about STEM subjects and create excitement, creativity and innovation" (Bennett, 2013, pp. 2-3).

North Carolina is working to integrate and improve curricula through reform by using Common Core State Standards (CCSS):

> Common Core State Standards provide a consistent, clear understanding of what students are expected to learn, so teachers and parents know what they need to do to help them. The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers. (Common Core State Standards Initiative, 2012, p. 1)

CCSS is the first step in building a foundation to provide students with a high-quality education. CCSS is a clear way for students, parents, and teachers to know the standards of success in every school (NCDPI, 2012b). The common core curriculum encourages teacher collaboration. "Teachers, as scholars, must collaborate rather than compete with one another" (Hrabowski, 2012, p. 3).

Another remaining challenge is aligning high schools and universities on the same page for preparing students to enter college and the workforce with STEM careers. The alignment of high school graduation expectations and state college admission requirements do not match according to the National Academy of Engineering (2009). The problem lies in higher institutions separating science and engineering departments rather than combined and collaborative departments. Textbooks in the high school and university levels do not satisfy the aligned state standards for providing students with rich material to achieve learning in STEM subject areas (Hrabowski, 2012).

Many district administrators are taking an interest in technology and engineering; however, there is a decline in student interest, which is also a challenge facing STEM education today. There is widespread concern for STEM education due to many students opting out of rigorous science and mathematics middle and high school courses and many students who graduate high school with low science and math ability (Sanders, 2009). One way educators can help students overcome this obstacle is to stress the importance in them succeeding in their first 2 years of college in the areas of science and engineering, at least at the bachelors' level. Student interest is peaked when classrooms are "loud, collaborative and engaged" (Hrabowski, 2012, p. 4). Teaching strategies that utilize these methods may be the key to success.

An additional challenge is for educators to stay current with new technologies. It is very evident that technology has been woven into our everyday lives. This means that we must provide teacher training and financial support to handle possible challenges that come with the use of new software, hardware, and integrating current technology in the curriculum. The integration of technology within the curriculum will better prepare students for the workforce.

The academy in this current study continued to work with curriculum challenges of a STEM school by consistently revising course selections for students (see Appendix A). The academy worked closely with district leaders and local college representatives to provide needed course to prepare the students for future 21st century careers. Course selections will be added with each additional grade.

Summary

There is a call to action on the local, state, and national levels in education for America to be globally competitive. STEM education is one way educators can meet this challenge in preparing students for future careers. Although university, community, and business leaders have partnered with local schools to provide resources that stimulate interest in STEM-related careers, there still remains a shortage in creating and maintaining student interest in STEM-related subjects.

There are overwhelmingly disturbing signs that the U.S. may be failing to meet its responsibility to prepare students to be successful in the 21st century. For example, the U.S. has fallen behind many nations in educational accomplishment and achievement (Pathways to Prosperity, 2011). The Pathways to Prosperity (2011) report stated that there has been a decline in the ability of young adults to find work due to their lack of soft skills and work ethic. This *skills gap* may cause a decline in filling jobs that pay a middle-class wage, which could in turn affect the U.S. economy (Pathways to Prosperity).

Businesses are looking for workers to fulfill positions that require scientific, mathematic, and engineering skills that foreign-based companies have already embraced and created. Companies are searching for and are in need of skillful workers who are willing to complete work-based internships and learn how to integrate in-depth knowledge of the curriculum into their projects. This is where PBL comes into practice as students learn STEM-related subjects from completing the projects. Students learn when they can apply knowledge obtained in class to real-world problems and when they participate in projects that require critical thinking and collaboration (Goyal, 2012).

The educational field benefits from STEM education as it requires critical thinking, problem solving, communicating, and the exploration outside of the traditional learning box. This requires that school districts and higher education institutions help create rigorous curricula that support instructional change. This change may cause educators to rethink traditional school settings and to invent effective ways to teach students. The nation must be prepared to discover new ways to develop and support innovative schools that result in graduating all students ready for careers and/or college.

Chapter 3: Methodology

Introduction

The primary purpose of this case study was to explore the utilization of PBL and how it affects student engagement in the classroom and interest in STEM careers. This case study was designed to understand the experiences teachers and students had when they participated in a PBL environment. This chapter describes the methodology used to conduct the case study. This chapter includes the research design, selection of subjects, and description of the instrument, data collection, and analysis.

Implementing PBL has been perceived as challenging (Grant, 2009). Grant cited the importance of understanding how students work and collaborate with others to create their projects and what they learn during PBL lessons. Therefore, this case study sought to explore the students' perspectives of engaging in PBL and how this may increase their interests in STEM careers. As the implementation of PBL was observed, this study noted possible challenges teachers encountered during implementation.

This case study, used as the framework for conducting this research, was guided by the following questions:

1. How does student engagement in PBL influence interest in STEM careers?
2. How does teacher knowledge and perception of PBL influence PBL implementation?
3. What stages and challenges do teachers experience in attempting to implement PBL?

A crosswalk has been developed to illustrate the connection between the specific constructs, instrument measures, and research questions (see Appendix B).

Participants

The target population for this case study was approximately 55 freshmen and 50 rising sophomores at a selected STEM Career Academy beginning in the 2013-2014 school year. All classrooms participated in this study. Two focus groups, each consisting of 12 students, were randomly selected. Nine teachers also participated in focus-group discussions.

The academy is located in a rural area in the piedmont triad region of North Carolina. Staff members consist of the principal (CEO) and the following teachers or instructional coaches: language arts, physical education/wellness, business, math, science, social studies, career counselor/business liaison, and instructional technology facilitator. In this study, all teachers/coaches were study participants.

The participants for the two, 12-student focus groups, were randomly selected from approximately 55 freshmen and 50 sophomore students at the selected STEM academy. Creswell (2009) defined random selection or random sampling as “when each individual has an equal probability of being selected from the population, ensuring that the sample will be representative of the population” (p. 155). Participants were randomly selected through the school’s computer data system entitled PowerSchool (2013). PowerSchool is a web-based student information system, which is used throughout the State of North Carolina.

Research Site Information

The school district is located in a rural area of North Carolina. The district is nestled in a region that previously contained many traditional manufacturing industries. Due to the loss of manufacturing, tobacco, apparel, furniture, and textile mills, this region of the state has seen a rise in unemployment (North Carolina Commission on Workforce Development [NCCWD], 2011). This small, rural community once heavily depended upon the manufacturing industries that hired semi-skilled workers with very little education. It is very clear that educational levels must rise to create new job opportunities and train more skilled workers in this region (NCCWD, 2011).

There are 35 schools with approximately 1,300 teachers within the district (District Website, 2012). This new academy was selected due to its innovation in secondary education, with two broad STEM career areas: Aerospace and Advanced Manufacturing (including industrial design and global logistics) and Health and Life Sciences (emphasizing health technology and information systems) (Steering Committee of the Career Academy, 2012).

The academy opened in 2012-2013 with approximately 51 ninth-grade students and will add additional grades each year. This academy opened with 28 males and 23 females from three neighboring school systems. Fifty-eight percent of the students are first generation potential college students; 51% of the students qualify for free and reduced meals; and 29% are minority students (District Website, 2012).

Each year, the selection process for students involves completing an application and receiving an interview with the principal (CEO). The CEO and teachers (instructional coaches) review applications, conference with student and parents, and then select students for the academy. Students from neighboring school districts can also apply and attend this academy. The primary focus for recruiting students is directed toward students who would not typically complete additional school beyond high school and are from families with no college degrees or families living in poverty (Steering Committee, 2012).

Research Design

This case study incorporated a concurrent triangulation mixed-method approach utilizing both qualitative and quantitative measures. Creswell (2009) defined concurrent triangulation as when the "researcher collects both quantitative and qualitative data concurrently and then compares the two databases to determine if there is convergence, differences, or some combination" (p. 213). This model is used when the researcher strives to use "two different methods in an attempt to confirm or corroborate findings within a single study" (Creswell, p. 213). The concurrent data result in a shorter data collection time period when compared to other methods.

Using a mixed method means "either the qualitative and quantitative data are actually merged on one end of the continuum, kept separate on the other end of the continuum, or combined in some way between these two extremes" (Creswell, 2009, pp. 207-208). It is a way to combine both qualitative and quantitative approaches in a single study to build on the strength that exists between both approaches (Gay, Mills, & Airasian, 2011).

Qualitative data were collected through classroom observations utilizing the Classroom Observation Protocol (see Appendix C). An official approval letter from the International Center for Leadership in Education (2009) was received for permission to utilize an adaptation of their observation tool (see Appendix D). In addition, student and teacher focus groups were conducted. Qualitative data from focus groups were used to corroborate findings from the survey questionnaires. The expectation was that student focus groups would provide descriptive data about student engagement and their views on PBL and STEM careers. Students for the focus groups were randomly selected and nine teachers participated in the teacher focus group. The goal of the teacher focus group was to provide rich insight into the successes and challenges of PBL implementation. Quantitative data were collected using an online survey questionnaire assessing student engagement in PBL and interest in STEM careers.

Mills (2011) defined focus groups as a group interview where one is trying to "collect shared understanding from several individuals as well as to get views from specific people" (pp. 212-213). Focus groups are useful techniques to encourage interaction among individuals while providing an atmosphere in which all participants have an opportunity to respond to each question. Focus groups help lead to a common understanding of the research questions.

Focus-group interviews are another essential source of case studies (Yin, 2009). Interviews provide important insights about a specific topic. Yin (2009) further cited the importance of attaining a sense from the prevalence of opinions by comparing them to others. Interviews may focus on behavioral events but should always be considered "verbal reports only" (Yin, p. 108).

Qualitative data from the focus groups were utilized to substantiate the findings from the survey questionnaires. The researcher was optimistic that the descriptive data would serve to clarify the impact of student engagement in PBL and enhance the understanding of the implementation of PBL and student interest within this STEM school.

The results of this study may be used by educators to gain a better sense of what PBL looks like from an observer's point of view. Educators may utilize this research to discover how PBL impacts student engagement and student interest in STEM careers. These results may then be used to better organize and manage projects that boost student interest and encourage enrollment in STEM careers.

Case Study

Case study research is “a comprehensive research strategy; an essential form of social science inquiry in which investigators desire to define topics broadly and not narrowly” (Yin, 1993, p. xi). Yin (1994) further stated, a case study’s “unique strength is its ability to deal with a full variety of evidence-documents, artifacts, interviews and observations–beyond what might be available in the conventional historical study” (p. 8). It investigates a phenomenon within a real-life context (Yin, 2003). Creswell (2009) explained case study as a “strategy of inquiry in which the researcher explores in depth, a program, event, activity, process or one or more individuals; cases are bounded by time and activity” (p. 13).

The case study methodology was the best fit for the needs of this inquiry, which was to describe teaching and learning when integrating PBL into the academic program. Yin (2003) indicated that there are three types of case studies: exploratory, explanatory, and descriptive. Exploratory case studies are used to define the framework of a future study. In exploratory case studies, “fieldwork and data collection are undertaken prior to the final definition of study questions and hypotheses” (Yin, p. 6). Yin also defined an exploratory case study as a study that is used to explore those situations in which the problem being examined has no clear, single set of outcomes. Explanatory case studies strive to define how or why an experience took place. These cases suggest “possible clues of cause-and-effect relationships” (Yin, p. 7). The descriptive case study presents a “complete description of a phenomenon within its context” (Yin, p. 8). Descriptive case studies are used to present answers to questions based on theoretical constructs. These case studies try to obtain information on the particular features of an issue (Yin).

This case study design was selected to further develop an understanding of integrating PBL in the academic program. This design is an informative way to explore innovative programs designed to facilitate entrepreneurship. It is an opportunity to inform or describe one way to engage students in learning through PBL.

Creswell (2009) stated some case studies may go beyond qualitative research and use a mixed method of qualitative and quantitative research. This case study used a mixed-methods design or a QUAL-quan model (Gay et al., 2011). In this model, "qualitative data are collected first and more heavily weighted than quantitative data and is typically an exploratory study in which observation and open-ended interviews are conducted" (Creswell, 2009, p. 135).

Instrument

A survey provided a "quantitative description of trends, attitudes or opinions of a population" (Creswell, 2009, p. 145). The survey used for this study was cross-sectional; in other words, data were collected at one point in time. Student survey questionnaires were designed by YouthTruth, initially funded from the Bill and Melinda Gates Foundation and developed by the Center for Effective Philanthropy in 2008 (YouthTruth, 2012). Since 2008, YouthTruth has surveyed over 200,000 students from 27 states and across 36 school districts. YouthTruth surveys provide "rigorous and actionable data to schools that gathers comparative feedback from students" (p. 1).

YouthTruth addresses three challenges when collecting data. These challenges include "providing quantitative and qualitative data in user-friendly comparative formats, engaging school leaders and students early and often, and generating feedback with reports that are action-oriented; with resources on how to use the data to support school improvement efforts" (YouthTruth, 2012, p. 2). YouthTruth partners with other organizations working to improve student outcomes, such as The New Teachers Project, RTI International, and The Children's Trust.

The school-wide survey gathered student feedback about their overall experience and took on average 20-30 minutes to complete. YouthTruth provides survey components such as student engagement in school, relationships with teachers, academic rigor of classes, school culture, college and career readiness, PBL, and STEM. This case study utilized data from the following five components: student engagement in school, PBL, academic rigor, college and career readiness, and STEM. YouthTruth's survey themes are regularly tested for reliability and validity and are designed to work as building blocks (YouthTruth, 2013a).

YouthTruth (2013a) survey results check all data, qualitative and quantitative, for response bias and response rates to ensure that the student feedback is representative. The survey responses are measured through a 5-point Likert scale. The 5-item response scale ranges from 1=strongly agree, 3=neither agree nor disagree, and 5=strongly agree (see Appendix E).

In addition to the student measures, teachers participated in focus-group discussions. The researcher was interested in understanding whether students participating in PBL produced a higher motivation in pursuing STEM careers as measured by teacher observations of student participation and the use of STEM-related skills. To further understand the impact of PBL, during the focus-group discussion, teachers were asked to discuss student behaviors such as motivation and willingness to participate, ability to successfully work in groups, motivation to lead within the group, and their ability to design and present projects.

Procedures

The researcher met with teachers/coaches to provide a description of the study and necessary background information. Educator consent forms, providing information on participants' rights to withdraw, the purpose, procedures, anonymity, and voluntary participation were disseminated. Parental consent forms for selected student participants were given to students to take home to their parent or guardian. The consent forms met all of the Gardner-Webb Institutional Review Board requirements as well as all requirements by the school district for conducting research. No research surveys, observational documentation, or data were collected prior to informed consent forms being approved and signed by participants and/or parents.

Grant and Sugarman (2004) discussed the ethical issue of utilizing incentives with human subjects. In their study, results showed that small incentives used to recruit or retain subjects are generally innocuous. Upon completion of the survey and student observations, staff participants received a $15 iTunes gift card to thank them for their participation. The $15 incentive was minor and not a necessity to persuade the staff to become participants. Rather, the incentive functioned as a gift of appreciation for participating in this study.

During the summer of 2012, to determine if the STEM school was interested in participating in this research, the researcher presented information about this potential research to the principal and staff. In May 2013, the researcher contacted YouthTruth to inquire about opportunities in designing and utilizing possible survey questionnaires. The researcher was interested in contributing to the many studies on PBL in STEM high schools.

In June 2013, the researcher provided the staff information about the expectations of the research study and indicated that this request to participate could provide the staff with additional insight about the utilization and perceptions of PBL. In July 2013, an official letter was received from YouthTruth, representing the partnership and permission to utilize their survey (see Appendix F).

In October 2013, the principal was given a school participation consent form that confirmed the principal's participation in the research (see Appendix G). This form was used to confirm the consent of this school to participate in the research study. This allowed the participants to better understand the expectations and the purpose of the study.

The principal and staff were reminded that participation in this study was voluntary and they could withdraw from participation at any time. The principal was given informed consent forms for the teachers (educators) to complete (see Appendix H). The principal was also asked to distribute the consent forms in October and return them to the researcher by October 18, 2013.

Once the signed teacher informed consent letters were received, teachers were given the expectations for participation in the study, the researcher's contact information for concerns and questions, and timelines for the research study and surveys. Teachers were then notified of the $15 gift card incentive in appreciation for participation in the study.

In October 2013, all students received informed consent letters to deliver to their parents to sign and return to the school (see Appendix I). These students were also asked to sign informed consent forms specifying their willingness to participate in the research project (see Appendix J). Several reminders were sent to encourage students and parents to return their forms. Students were given 2 weeks to return the letters in order for the researcher to cross-reference the names and identification numbers of the students participating in the study. Students and parents were informed of their right to be excluded from the data and their right to withdraw during any stage of the research study.

As informed consent forms were returned, students were randomly selected for the two focus groups. A focus-group interview for teachers was also conducted. The focus-group interviews consisted of a series of six questions for students and teachers (see Appendices K and L). Participants for the focus-group interview sessions signed a participant sign-in list that had a brief statement that they assented/consented to participate in the focus-group interviews (see Appendix M). The district superintendent provided a letter of support for the school to participate in this research (see Appendix N).

To record and track signed informed consent letters, a data request was submitted to the STEM academy to receive the student's name and parental contact information. The data file used consisted of only students who returned signed informed consent letters.

In October 2013, the researcher began observing classes 1 day a week for 4 weeks. Observations were made on student engagement and the interest in PBL. The researcher hoped to grasp how students prepared and worked on their projects, including the process for presenting. Several guiding questions suggested by Stix and Hrbek (2006) were utilized during classroom observations of projects. These guiding questions were

1. Do the students have a clear understanding of the project?
2. Does each student have ownership of the role within the group?
3. Are the students attentive and working together cooperatively?
4. Are the resources that students use geared to their comprehensive level of understanding?

5. Are any groups stumbling in a way that is blocking their work due to heightened emotions? (Stix and Hrbek, p. 2)

In November 2013, the online survey devised by YouthTruth was administered. It was expected that the students would complete this survey in 20-30 minutes. The YouthTruth organization provided the staff and researcher copies of the survey administration instructions, talking points, and login student codes for administering the online survey to the students (YouthTruth, 2013a). No names were shown for any data collected in this study.

In November 2013, two focus groups consisting of a small sample of students (12 students each) were assembled to collect additional survey question data. All student group discussions were intended to elicit deeper discussions on students' perceptions on school culture, academic rigor, college and career readiness, PBL, and their experiences learning about STEM.

In December 2013, the teacher focus-group (9 teachers) discussion was conducted. One goal of the teacher's focus-group discussion was to gain insight into their perceptions of implementing PBL and any roadblocks encountered transitioning from traditional instruction to PBL.

Project-Based Learning Integration Strategies

The design of this research called for a concurrent triangulation method of the academic program by observing how integrating the project designs are implemented into the lesson. Thomas (2000) suggested projects are the central teaching strategy. The project work may "follow traditional instruction in such a way that the project serves to provide illustrations, examples or practical applications for material taught initially by other means" (Thomas, p. 3).

A case study has the unique ability to deal with multiple types of data in order to create an accurate picture of a phenomenon. The overarching questions in this case study were *how* does PBL become a focal point in the academic program and *how* does becoming a focal point in the academic program increase student engagement. To answer the *how* questions in this case study, the research questions addressed data points that allowed for a convergence of information. This convergence of data helped to create a clearer picture of integrated instruction. Data collection follows a logical flow from teacher to student and arranges around four stages. According to Thomas (2000), the four stages include the following:

Stage one: Pre-Teaching Collaboration. This stage involves collecting data at tuning meetings/PLCs to identify strategies for the purpose of integrating project-based learning in STEM content. Researcher will observe teachers (instructional coaches) tuning sessions and protocol.

Stage two: Observing Project-Based Learning and Projects. This stage involves viewing student presentations and critique projections. During this stage, the researcher will observe the teachers coaching the students as they work in teams on their projects.

Stage three: Teaching Practice. Teachers (instructional coaches), will participate in a focus group discussion to identify strategies of purposeful integration of STEM content through reflecting on project-based learning practices. Teachers will discuss possible stages and challenges teachers may experience when implementing PBL.

Stage four: Student Learning Artifacts. Data is collected through student work and project rubrics used to assess this work. The goal will be whether students

> are able to make the desired connections from the projects and display interest in completing and presenting their projects. The researcher will observe if students display engagement throughout the lessons/projects. Students will receive an online survey devised by YouthTruth. (p. 5)

Thomas's (2000) four stages are organized around the following themes: (1) integrated teaching practice through implementation of PBL, (2) student engagement in PBL, and (3) student interest in STEM-related careers, as depicted in Figure 4. Data of integrated teaching practice was collected from classroom observations and tuning protocol.

The tuning protocol was first developed by the Coalition of Essential School's Exhibitions Project to receive feedback on portfolios and projects (NSRF, 2012). It is "often used to look at writing prompts, open-ended problems, research project designs and rubrics for all kinds of activities and projects (NSRF, 2012, p. 1). The presenting teacher presents a piece of curriculum, assessment, or possible project with the goal of colleagues helping the teacher to fine-tune or improve the curriculum or project so all students can meet the high expectations (NSFR, 2012).

During the tuning protocol, the staff developed a method to support teachers in sharing their students' work with colleagues and to view student-created projects. This collaborative reflection assisted teachers to plan and enhance their assessment methods and discover ways to encourage advanced quality student performance.

Information on teacher knowledge of PBL implementation was collected through teacher focus-group discussions. Student learning data were collected from student surveys and focus groups. The three themes (PBL implementation, student engagement in PBL, and student interest in STEM careers) provided a device for the convergence of data through triangulation, seen in Figure 4.

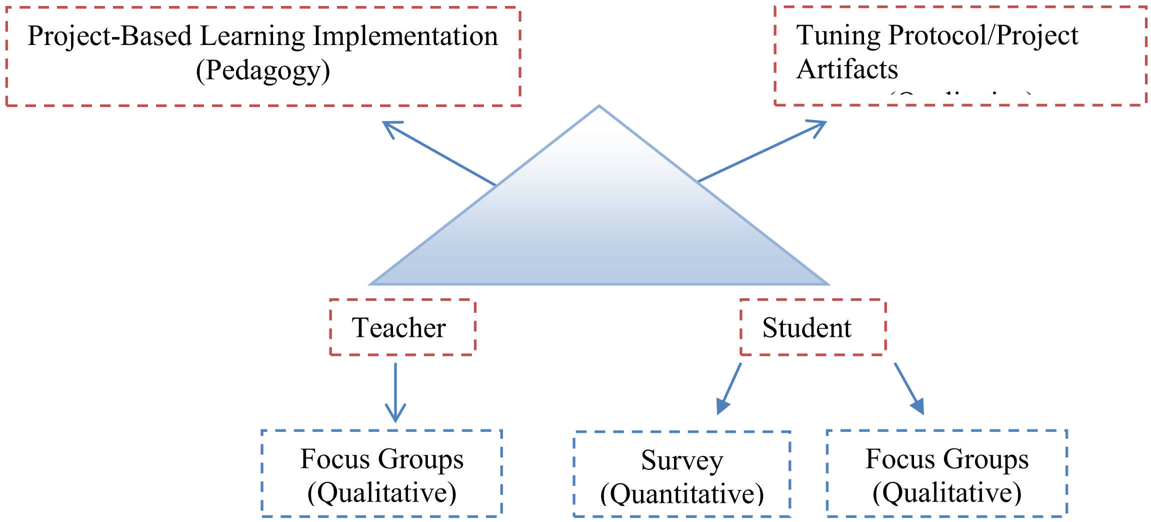


Figure 4: Concurrent Triangulation Convergence of Data.

The researcher explored how teachers coach, collaborate, and view PBL in the face of classroom and curriculum challenges that may occur. The researcher observed how students learn and engage in a PBL environment. These different perceptions were captured through researcher summaries of findings in interviews and observations.

Data Collection

Qualitative and quantitative data were collected concurrently during this study. The qualitative data collection of this case study began in October 2013 through classroom observations/student artifacts and teacher focus-group meetings. Quantitative data collection began in November 2013 through the online survey. A data request was submitted to the school district for names of all of the students. The data request included students' names and parental contact information. These data were used to record and track signed informed consent letters. Students who did not have signed informed consent letters were removed from the data file. Confidentiality and anonymity were not compromised in any phase of the research. Student and teacher names were not used in this study. Alphabet codes were assigned to participants as needed.

Data Analysis

Creswell (2009) suggested the data analysis process involves "making sense out of text and image data, moving deeper into understanding the data, and making an interpretation of the larger meaning of the data" (p. 183). It is an ongoing process involving constant reflection about the data and collecting open-ended data (Creswell).

Research Question 1 focused on how PBL impacts student engagement in the classroom and their interest in STEM careers. To address this research question, the researcher administered an online student survey and conducted classroom observations and student focus-group discussions. Focus groups involved discussing the development/presentation of projects and digging deeper into the survey questions. Written notes and audiotapes were also utilized.

Research Question 2 focused on understanding how teacher knowledge and perception of PBL influence the PBL implementation. To address this research question, the researcher discussed this question during focus-group discussions and classroom observations. Written notes and audiotapes were utilized.

Research Question 3 focused on the stages of implementing PBL in the classroom by observing projects and discovering any possible challenges teachers may encounter during this implementation. To address this research question, the researcher made classroom observations and held conferences/focus groups with teachers about this process. The researcher utilized written notes and audiotapes during classroom observations.

Data were collected through classroom observations, student/teacher focus-group interviews, tuning protocols, project artifacts, and the online student surveys. During classroom observations, the observer asked students questions as needed regarding their work on their projects.

All audiotapes were transcribed. To help with transcribing the interviews, participants were given an alphabetical letter as needed for identification. The researcher underlined key words or phrases during the interviews to locate possible themes or common patterns. Once transcription was complete, all participants were given the opportunity to check for accuracy. Open-ended questions were asked to promote expanded discussions during the interviews.

This study explored the utilization of PBL and how it affects student engagement in the classroom and interest in STEM careers. The researcher, through this study, sought to understand the students' perspectives of engaging in PBL and how this may increase their interests in STEM careers.

Limitations

Mixed-methods research designs combine both qualitative and quantitative data in one study. The purpose is to build on the strength between qualitative and quantitative research methods to better "understand a phenomenon more fully than is possible when using either quantitative or qualitative methods alone" (Gay et al., 2011, p. 134). These researchers also indicated that one potential limitation is that few researchers have the needed knowledge and skills to master research techniques incorporated in quantitative and qualitative research approaches. More strategies are needed to better link qualitative and quantitative methods in this research study (Gay et al., 2011). An additional limitation for mixed methods is this research involves the need to have additional time and resources to successfully implement an extensive approach.

Other limitations involve the small number of participants and interviews. The STEM academy is a new school site with a limited number of students. This site has two grade levels, freshmen and sophomores, in the school year 2013-2014. Within the limited number of students, interviews have limitations. This study was based on a small number of interviews, and results may not be representative of the population that is a part of the implementation of PBL. Patton (2002) theorized that “interviewees are always reporting their perceptions and the researcher will have perceptions of the interview” (p. 264). Accuracy of interview data is dependent upon how relaxed the participant feels during the interview process as well as trusting the researcher to accurately recall the facts and events.

Chapter 4: Results

Introduction

The purpose of this case study was to explore the utilization of PBL and how it affected student engagement in the classroom and interest in STEM careers. With this foundation, this research investigated how to develop a globally skilled workforce utilizing a PBL technique and focused on understanding how PBL may encourage and inspire students to become engaged in learning STEM subjects and STEM careers.

To further understand how PBL may inspire student engagement in STEM subjects and careers, teacher (coach) and student perceptions were examined. Data were collected to address the following research questions:

1. How does student engagement in PBL influence interest in STEM careers?
2. How does teacher knowledge and perception of PBL influence PBL implementation?
3. What stages and challenges do teachers experience in attempting to implement PBL?

To answer these questions, a mixed-methods approach was utilized to qualitatively analyze classroom observations and teacher and student interview responses. The quantitative component involved collecting additional data in the form of an online survey.

Project-Based Learning

This study adopted the definition of PBL from Mastascusa et al. (2011), who defined PBL as "an active learning technique that utilizes problems embedded in realistic situations. Problems may be drawn from real situations which allows the students to develop connections generate and/or invent solutions to the problems" (pp. 123-124).

This instructional approach engages students in student inquiry that is designed around authentic questions and carefully designed projects with clear learning tasks (Boss, 2013). Projects may vary in length from 1 week to several months. They can take an interdisciplinary approach or focus on one subject area. Boss (2013) suggested that implementing PBL successfully involves a high level of student engagement while driving students to pursue their own inquiry. It is essential that projects enable students to "master academic content while learning how to solve problems, collaborate, think critically, and communicate effectively" (Boss, p. 7).

Student engagement in this study was defined as representing the time and energy students invest in educationally purposeful activities, which include active and collaborative learning (Kuh et al., 2008). Students who are challenged and engaged are more likely to understand the connection between school-related activities, the real world, and their future (Steinberg, 1998).

To connect school-related activities to the real world in the current study, teachers spent substantial planning and sustained effort while drawing on combined efforts of several teachers to design quality projects. The teachers at this academy utilized Steinberg's (1998) Six A's of Designing Projects to encourage student engagement and to connect with real-world issues. Steinberg's design was developed as a self-assessment tool for teachers to help guide them to address key elements of PBL when designing projects. Steinberg's (1998) Six A's are

1. Authenticity – Does the project originate from a question that has meaning to the student?
2. Academic Rigor – Does the project challenge students to use methods of inquiry and lead students to acquire/ apply knowledge?

3. Applied Learning – Does the learning take place in the context of a semi-structured problem, grounded in life and work in the world beyond school?
4. Active Exploration – Are students expected to communicate what they are learning through presentations and performances?
5. Adult Relationships – Do students meet and observe adults with relevant expertise and experience?
6. Assessment Practices – Do students reflect regularly on their learning, using clear project criteria that they have helped to set? (pp. 24-25)

Procedure

Parental consent forms were given to all students to return to the researcher. Signed forms from 67 of 102 students (65%) were returned. Four requests were made to receive the forms, and a $15 iTunes card drawing was held to encourage more student participation. Principal (CEO), superintendent, and 10 teacher (coach) consent forms were signed and returned to the researcher.

A key strength of case study data is the opportunity to utilize multiple sources of evidence (Yin, 2009). Case studies using multiple sources of evidence were regarded more highly in relation to those relying on one source of information (Yin, 2009). This study utilized an online survey provided by YouthTruth as one source of evidence. Other resources included classroom observations and teacher and student focus groups.

YouthTruth provided comparative data in a user-friendly format. The school or academy's results were compared to the results of all schools that consisted of the national YouthTruth sample. This comparison provided an understanding of the schools' relative strengths and weaknesses that will be shared with principal and staff.

Online survey data were collected from 67 approved student participants. Sixty-seven students were administered the survey which was coordinated by the technology coach at the academy. If fewer than five students of any given subgroup responded to a particular question, the average rating of that particular subgroup for that question did not appear (YouthTruth, 2013b).

Several reporting thresholds were utilized in describing the rating scales. A Likert-type 1-5 scale was used: 1=strongly disagree and 5=strongly agree. The participating academy's average rating was ranked along a percentile scale. There were questions that allowed multiple responses (e.g., Do any of the following make it hard for you to do your best in school? – home life; extracurricular commitments; etc.) Categorical questions allowed only one response such as yes, no, maybe, I'm not sure; ranking from never to very frequently were also used. Text boxes were used to state student comments to open-ended questions. Executive summaries of the data were provided by YouthTruth.

The researcher was given the option to sort cohort comparisons and compare data to that of a smaller subset of similar participants. Sorting by different cohorts included the following options: high-poverty, small schools, large, STEM, early college, small city, suburban, rural, and none. Sorting by subgroup consisted of the following: grade level, self-reported grades, race/ethnicity, gender, free-reduced priced lunch, English Language Learners, and none. For the purpose of this study, the researcher selected *none* for the cohort and *none* for the subgroup.

YouthTruth (2013b) provided data in the following constructs: student engagement, academic rigor, relationships with teachers and peers, school culture, college and career readiness, academic support services, strengths and areas for improvement, PBL, STEM education, and student comments. To answer the three research questions, the researcher utilized data from the following areas: student engagement, academic rigor, college and career readiness, PBL, STEM education, strength and areas of improvement, student comments, and executive summaries.

Survey Data

Compared to students at regular schools who have participated in the YouthTruth survey, the academy students had mixed perceptions of their school experience. In the area of student engagement, academy students strongly agreed that they took pride in their school work and projects, and teachers' expectations made them want to do their best. Students less strongly agreed that they enjoyed coming to school most of the time and tried to do their best in class. In Figure 5, the white box displays the average rating of 3.81 and its corresponding percentile rank of 56. In the overall summary for student engagement, the academy students rated positively on student engagement. This measure describes the degree to which students perceive themselves as engaged with their school and their education.

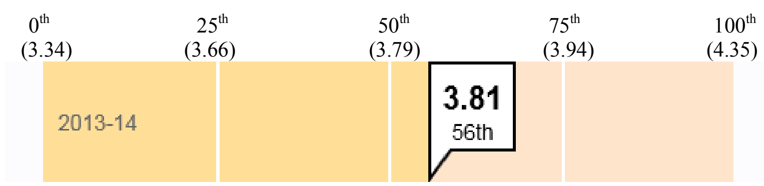


Figure 5. Overall Student Engagement.

In further disaggregating the data, several questions were asked to better understand student responses to student engagement. The questions asked were given a "percent of positive ratings" to display the levels of student engagement. This summary of positive ratings described the degree to which the teacher posed work and expectations to encourage student engagement. This positive rating demonstrated what percentage of students answered the questions favorably, signifying that their teacher effectively accomplished what the student engagement questions tried to measure. Positive rankings may be used as a benchmark for determining how many students were impacted positively and responded favorably to student engagement in the areas listed below (YouthTruth, 2013b).

In Figure 6, five areas were addressed with each question having a positive rating over 50%. Question 1, "I take pride in my school work," rated 75%. Question 2, "I try to do my best in school," had the highest positive rating of 79%. When compared to other participating schools, the academy students showed a high emphasis on doing their best. Question 3, "I enjoy coming to school most of the time," scored 52%. Question 4, "My teachers' expectations make me want to do my best," rated 69%. Lastly, question 5, "What I learn in class helps me outside of school," rated 56%.

Question	Percent of Positive Ratings
I take pride in my school work.	75%
I try to do my best in school.	**79%**
I enjoy coming to school most of the time.	52%
My teachers' expectations make me want to do my best.	69%
What I learn in class helps me outside of school.	56%

Figure 6. Percent of Positive Ratings for Student Engagement.

These questions were given an average rating ranked along a percentile scale. In this data, the question "My teachers' expectations make me want to do my best" scored an average ranking of 3.92, with its corresponding percentile highest rank of 83 noted in Figure 7. Only 17% of the participating schools scored higher. With regard to the question, "I try to do my best in school," the average score of the Likert-scale rating was

4.15 with a corresponding percentile rank of 22, denoted in Figure 8.

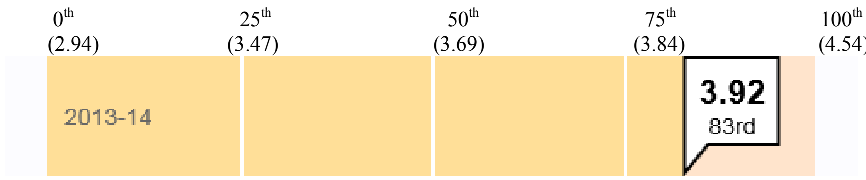


Figure 7. My teachers' expectations make me want to do my best.

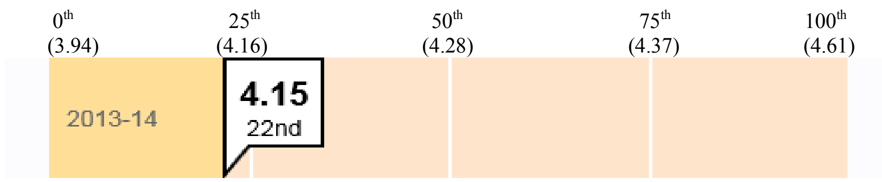


Figure 8. I try to do my best in school.

In connecting school-related activities to the real world, the question was asked, "What I learn in class helps me outside of school." Students showed an average rating of 3.50 with a corresponding percentile rank of 43. Students felt being engaged in classroom activities helped to connect what they learned to the outside world as noted in Figure 9.

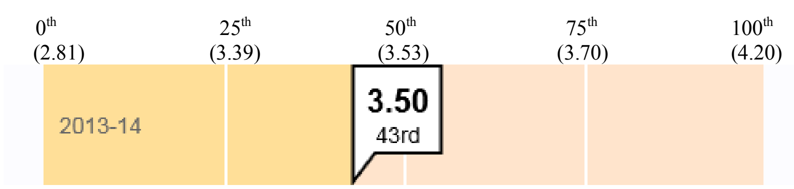


Figure 9. What I learn in class helps me outside of school.

To connect learning to the outside world, PBL leads to learning across disciplines as students explore real-world questions that do not fit precisely into content silos (Boss, 2013). Critical thinking is strengthened in inquiry-driven projects, which promotes academic rigor and motivates students to dig deeper for understanding (Boss, 2013). In the area of academic rigor, academy students rated the rigor of their classes and instruction as highly as students in participating schools. Students agreed strongly (4.00) that their classwork challenged them to think (Figure 10). The students did not feel as strongly about their teachers giving them assignments that helped them to better understand the subject.

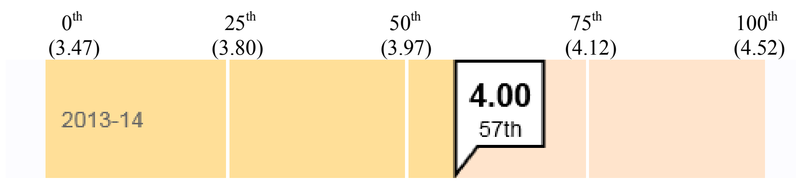


Figure 10. The degree students feel they are challenged by coursework/teachers.

In the academic rigor questions, students expressed their opinions about whether their classes made them think; the importance of utilizing thinking skills instead of memorization and the importance of explaining and supporting their answers.

Three questions in the academic rigor area displayed the students' feelings about classwork, thinking skills, and justifying/explaining their answers. The students strongly agreed that their classes were more rigorous and provided the opportunity to think; to solve problems. For the question "The work that I do for my classes make me really think," the academy students' average rating was 4.16 and the corresponding percentile rank was 86 (Figure 11). Regarding the question "Most of my teachers want us to use our thinking skills, not just memorize things," the academy students' average rating was 4.29 with a corresponding percentile rank of 91 (Figure 12). For the question "Most of my teachers want me to explain my answers – why I think what I think," the academy students' average rating was 4.44 with a corresponding percentile rank of 95 (Figure 13).

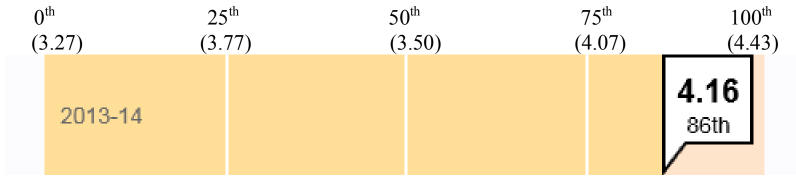


Figure 11. The work that I do for my classes makes me really think.

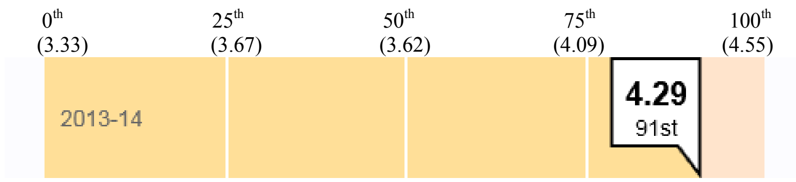


Figure 12. Most of my teachers want us to use our thinking skills, not just memorize things.

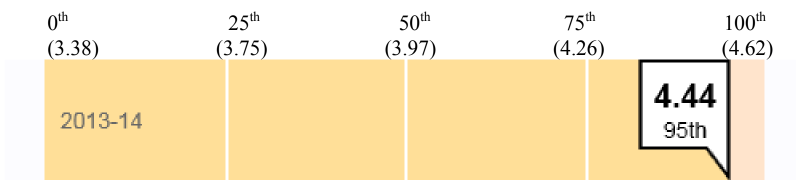


Figure 13. Most of my teachers want me to explain my answers–why I think what I think.

In the *percent of positive ratings*, there were two academic rigor questions with the high rating of 79%. These positive ratings stress the positive beliefs of the academy students about working hard in class and that the work allows them to think (Figure 14).

Question	Percent of Positive Ratings
In order to receive a good grade, I have to work hard in my classes.	79%
The work that I do for my classes makes me really think.	79%
I can tell that my teachers understand the subjects that they are teaching.	77%
My teachers give me assignments that help me to better understand the subject.	61%

Figure 14. Percent of Positive Ratings for Academic Rigor.

To be prepared for the future, students should have a foundation in critical thinking, academic knowledge, and excellent communication skills (Larmer & Mergendoller, 2012). Essential skills are needed for students to be ready for a variety of postsecondary learning environments (Conley & McGaughy, 2012). These skills include "study skills, time management, the ability to formulate problems, collect information, interpret analyze findings, communicate in a variety of modes and to apply knowledge to real-world problems" (Conley & McGaughy, 2012, pp. 29-30).

In the area of "college and career readiness" from the survey, students had more favorable perceptions of what the academy has done to prepare them for life after high school. The students' summary measure was 3.71 with a corresponding percentile rank of 74 which described the degree to which students felt equipped to pursue college and careers. Sixty-one percent of the students reported college and career readiness was a strength at the academy; 95% of the students stated they wanted to go to college.

With regard to the question "My school has helped me develop the skills and knowledge I will need for college level classes," the average score of the Likert scale was on the positive end (3.81) with the percentile ranking of 66 (Figure 15).

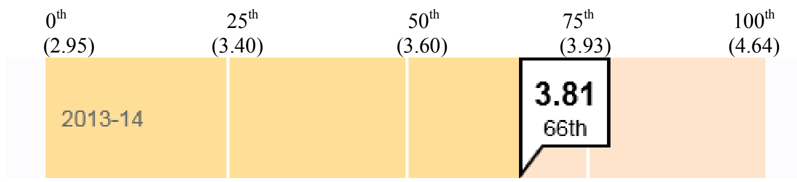


Figure 15. My school has helped me develop the skills and knowledge I will need for college level classes.

The question "My school has helped me understand the steps I need to take in order to apply to college," was positive (3.56) but closer to the 50th percentile (Figure 16).

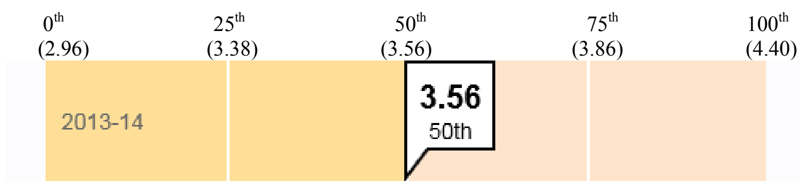


Figure 16. My school has helped me understand the steps I need to take in order to apply to college.

The question "My school has helped me figure out which careers match my interest and abilities," displayed a higher percentile (84th) with a positive rating of 3.66 (Figure 17).

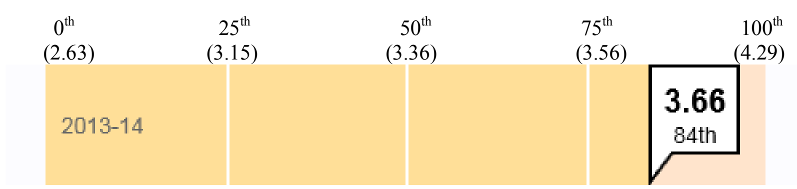


Figure 17. My school has helped me figure out which careers match my interests and abilities.

The question "My school has helped me to understand the steps I need to take in order to have the career that I want," displayed the highest percentile (88th) with a positive rating of 3.81 (Figure 18). Throughout the data, students revealed their confidence in school and staff providing needed information to make career decisions. Students felt motivated to continue their education after high school.

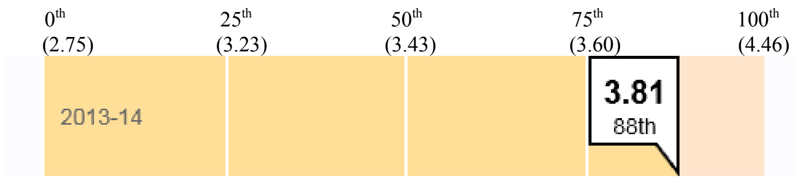


Figure 18. My school has helped me to understand the steps I need to take in order to have the career that I want.

Survey results showed the students agreeing that the academy assisted them in discovering which careers matched their interests at 3.66 (84th percentile). With the ranking of 3.81 (88th percentile), students agreed the academy helped them understand the steps needed to develop a career plan. Students reported positive feedback in having thoughts pertaining to future goals after high school (Figure 19). These data show that approximately 70% of the students have a desire to attend college (4-year or 2-year), after high school.

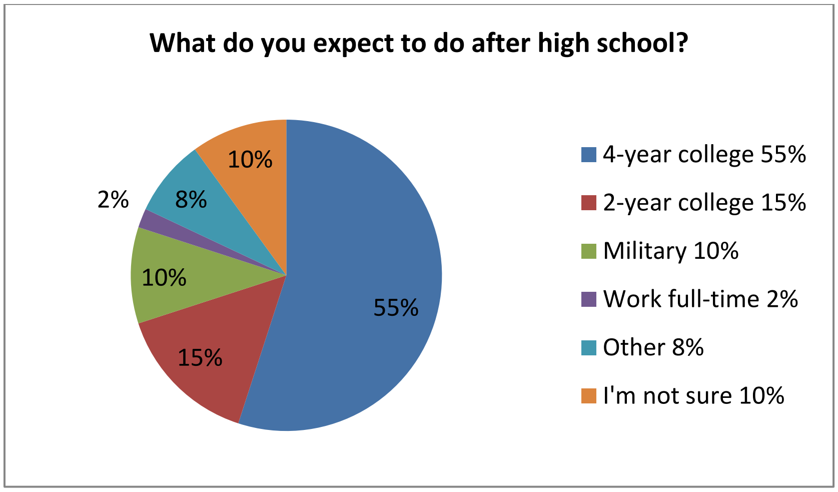


Figure 19. After High School.

To further prepare students for college and future careers, North Carolina adopted the CCSS in 2010 (NCDPI, 2012b). These state-led, goals-desired outcomes are to develop needed skills to ensure that all students are college and career ready. As teachers prepare students for college and future careers, PBL is one instructional strategy that provides a smoother transition when implementing CCSS (Hallerman & Larmer, 2013).

PBL is one instructional strategy that integrates well with Common Core. In Common Core, students need the necessary skills to dig deeper into a complex text which requires critical thinking. In PBL, projects teach students how to dig deeper, think analytically, and to analyze and solve problems (Hallermann, 2013). Common core requires a "shift from teachers doing much of the talking to creating conditions in which students can engage in meaningful conversations" (Hallerman, 2013, p. 2). PBL encourages collaboration and working in collaborative teams which meets one of the demands of Common Core. PBL involves "real-world tasks, builds 21st century 4 C's competencies, and has an open-ended question while emphasizing student independence and inquiry to create a product" (Larmer, 2013, p. 3).

In the survey, students were asked a series of questions about their engagement with PBL. The pie chart in Figure 20 displays student impressions of this educational strategy. The first series of questions asked "how strongly the students agreed or disagreed with the questions asked." Students answered the questions positively, ranging from 3.52 to 4.08 on a 1-5 Likert scale.

The question "I have learned how to work well with other students by participating in group projects" indicated the students' positive agreement of the statement with a measure of 4.08. The question "I learn lessons more deeply with projects than with other types of assignments" rated positively but not as strong as the first question which had a 3.81 rating. The question "Doing projects makes me a better student (for example: I get better grades, I understand the subject better)" had a rating of 3.77. The question "I care more about what I'm learning when I feel like I'm solving a real-world problem" had a rating of 3.52. Overall, students agreed with the listed statements (Figure 20).

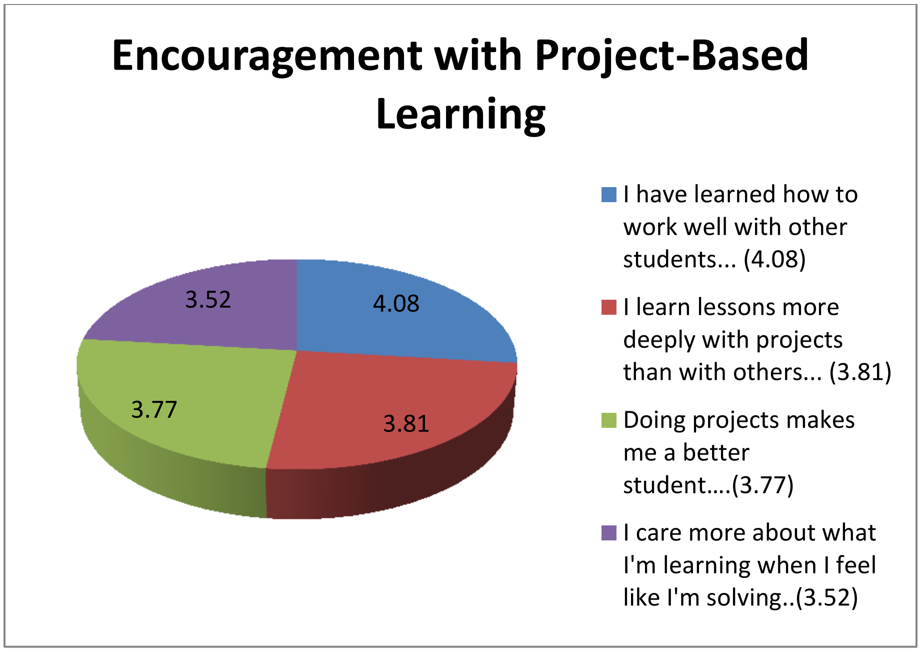


Figure 20. Engagement in Project-based Learning.

Boss and Krauss (2007) discussed the importance of "arousing curiosity and inspiring learners to look deeper" (p. 97). Promoting inquiry and deep learning can be seen through real-world connections. Questions were asked about how students dealt with real-world problems. Students were asked how often they have discussed real-world issues with students or teachers within the past month. Students' statements were listed in the ratings of never, rarely, sometimes, frequently and very frequently. Each chart will display the highest single rating for each question for the academy students.

The favorable ratings of sometimes, frequently and very frequently were combined within each question for the academy and YouthTruth students. The question "How often did you discuss real-world issues that need solutions with other students?" received a higher combined favorable rating of 85.49% than YouthTruth's students rating of 70.59%. When discussing real-world issues with their teacher, the academy's combined favorable rating of 79.03% was higher than YouthTruth's combined rating of

64.13% (Figure 21).

Students were asked how often they worked with other students or peers to design a solution to a real-world problem. When working with real-world issues, the academy students' favorable rating was 88.70% and the YouthTruth favorable rating was 65.53% (Figure 22).

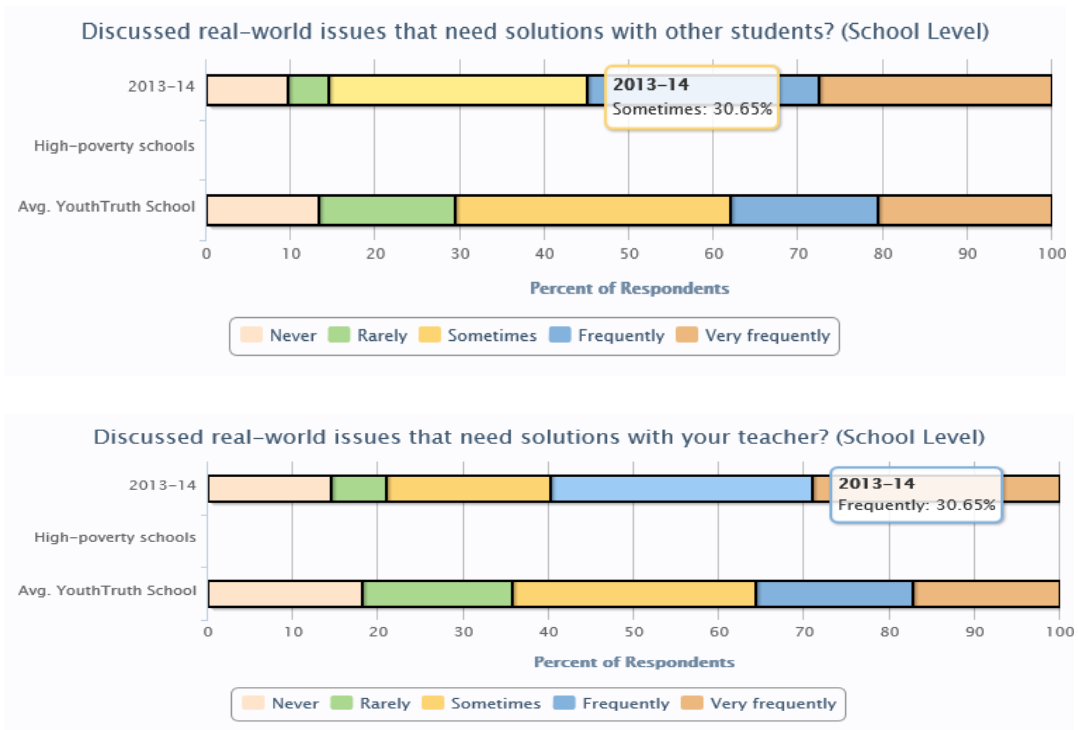


Figure 21. Real-World Issues with Students and Teachers.

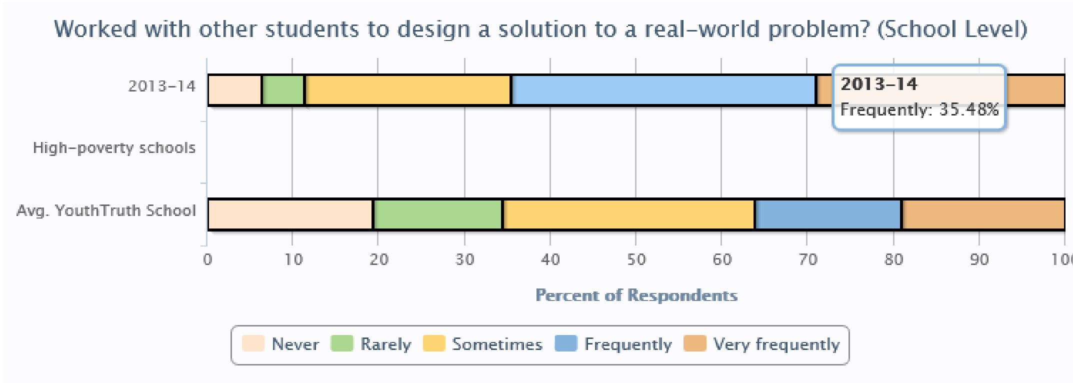
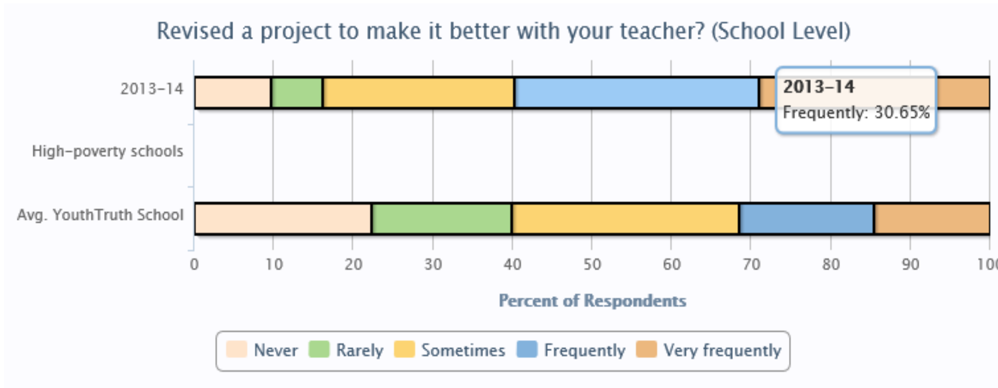


Figure 22. Problem Solving with Peers.

Larmer and Mergendoller (2012) stated that an essential component of good projects is students presenting their projects to an authentic public audience. Presenting to an audience beyond their peers motivates the students to produce work of a higher quality. These authors stated that "project-based learning is the ideal way to build the speaking and presentation skills called for in the Common Core State Standards (CCSS)" (Larmer & Mergendoller, p. 74).

CCSS asked students to design and explain their ideas in oral presentations. These skills can be seen through PBL. To simply require students to explain their work aloud when creating projects is not enough. Designing effective presentations should be taught by teachers (Larmer & Mergendoller, 2012). Projects should be carefully planned and facilitated to assist students in growing as writers, readers, speakers and listeners (Hallermann & Larmer, 2013).

The survey asked students to discuss their experiences with revising, improving, and presenting projects and how often this was done within the past month. Academy students reported revising and improving projects with their peers occurred 91.80% of the time (YouthTruth 67.84%), while working with their teachers was not reported as high, 83.87% (YouthTruth 60%). Students replied that opportunities were given to share and present their projects at 90.32% (YouthTruth 82.15%) (Figure 23).



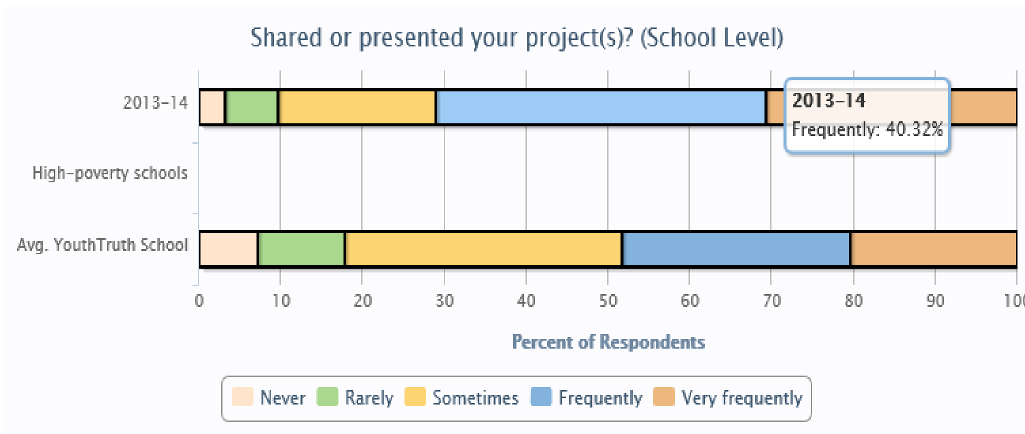


Figure 23. Revising, Improving, and Presenting Projects.

Applying the knowledge learned from completing projects is essential when designing projects. Worthwhile projects allow for developing problem-solving strategies that can be applied outside of the classroom (David, 2008). Projects aim to engage students in realistic problems that may prepare them for future careers and college.

Students were asked to express their impressions (agree/disagree) about how projects assist them in applying learning for future careers and college. In all four questions, students reported slightly more than average within the Likert scale range between 3.11-3.62 (Figure 24).

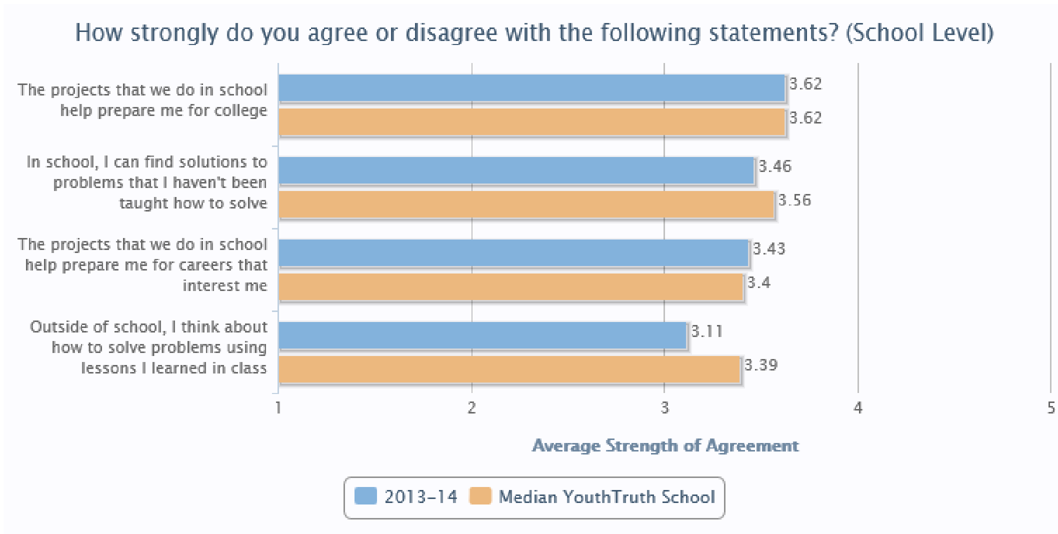


Figure 24. Application of Learning (projects).

Common Core requires teachers to move away from teaching skills and subjects in isolation. Students should be able to connect and transfer skills in the classroom to the outside world. PBL is one instructional strategy that allows and encourages students to dig deeper within each subject (Hallermann & Larmer, 2013).

As students work on projects, it is important to continue to design projects that will support subject disciplines. Projects take teaching the content out of isolation and challenges students to create connections across disciplines. Students are better equipped to integrate knowledge from two or more disciplines to create products and to solve problems when working on projects (Krauss & Boss, 2013). These connections allow students to think, apply their knowledge, and be better prepared for future careers.

Scardamalia and Bereiter (2003) discussed the importance of developing students who have a strong knowledge base and are able to participate in creating new ideas. The process of knowledge building involves creating new ideas, formulating questions, and critical thinking (Scardamalia & Bereiter). This is needed to better prepare American students to be competitive for the future. The Programme for International Student Assessment (PISA) data support the importance of improving education in the United States. Newly released 2012 data state that the United States ranked 26th in math (35th in 2009), dropped to 21st in science (17th in 2009) and dropped to 17th in reading (14th in 2009) (Arkin, 2013). These data reinforce the fact that improvement in America's education is needed.

In the survey, students discussed whether projects taught and supported necessary skills within each subject. Students were asked, "Are projects the main way you learn in Social Studies, Science, English/Language Arts and Math?" All subjects were over 65% in being the main way of learning except math, which reported only 36% (Figure 25).

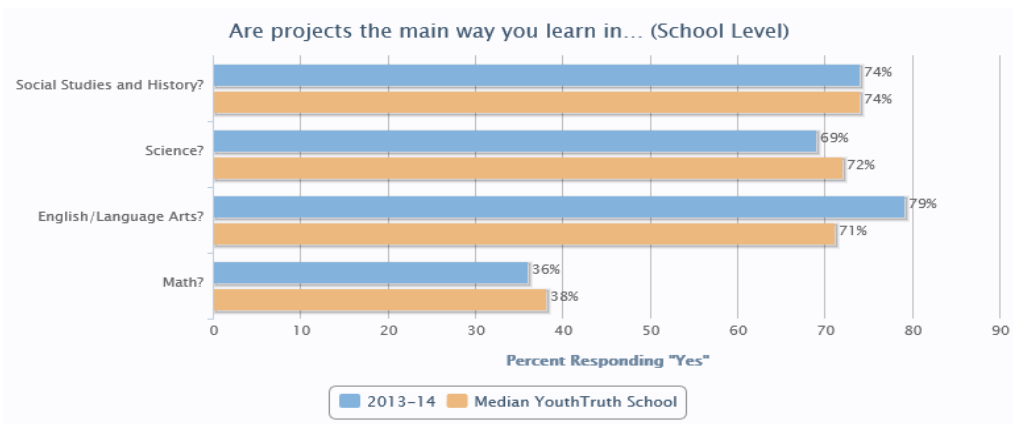


Figure 25. PBL across Disciplines.

The STEMconnector (2013) cited the top two jobs (in the United States) by the year 2018 will be in computing and engineering. The highest interest in STEM is in the southern region of the United States. Among STEM-interested students, mechanical engineering was the most popular career interest, followed by biology.

In the survey, students were asked questions about their engagement in STEM education. Figure 26 details students' thoughts on the relevance of STEM careers/fields, which clearly shows students relating to STEM careers and how the school has developed student interest in STEM careers.

Students reported the highest rating of 4.11 in agreeing with understanding how STEM is used in different careers. All ratings were above 3.0 (average strength of agreement) on the Likert scale, with two lower ratings. The two lowest statements and beliefs were "choosing to take additional math/science courses" (3.02) and "working in STEM field careers in the future" (3.37).

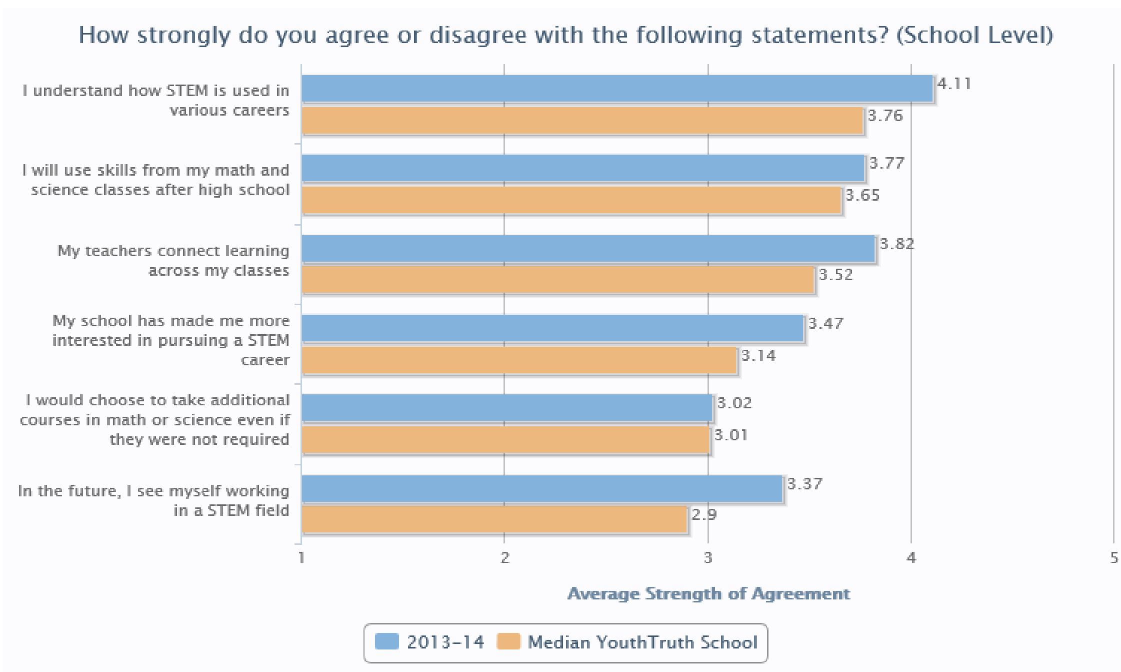
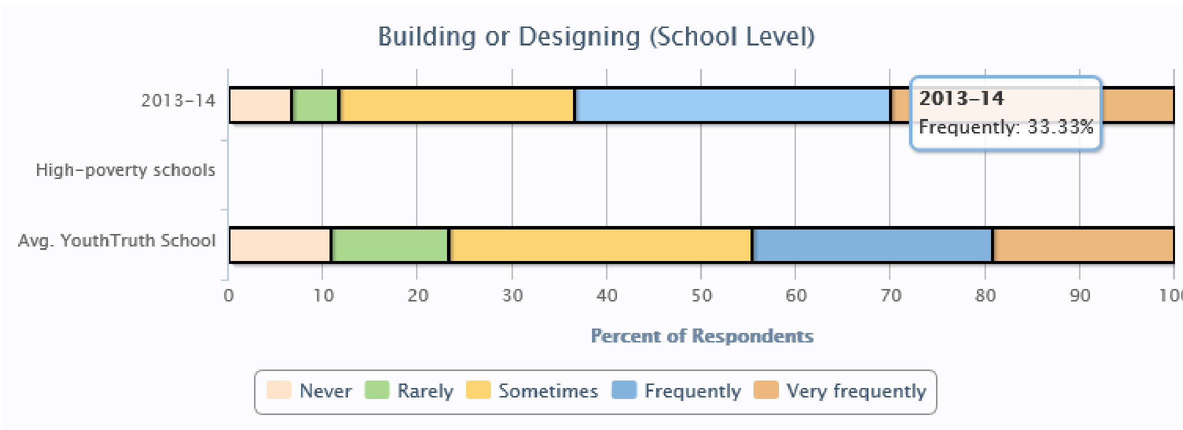


Figure 26. STEM Education.

When working on projects, it is important to encourage effective teamwork (Boss, 2012). Boss (2012) stated that working together as a team is "essential for breaking a big, open-ended question into manageable pieces" (p. 40). Boss suggested that as a project changes from research to real-life application, interest will be nurtured and developed.

Students were asked how frequently they participated in group projects involving building or designing. Students at the academy reported this occurred 88.33% of the time and YouthTruth reported designing at 76.73%. When designing a solution to a problem, the academy reported solving problems at 90.16% which was higher than the YouthTruth schools at 84.07% (Figure 27).



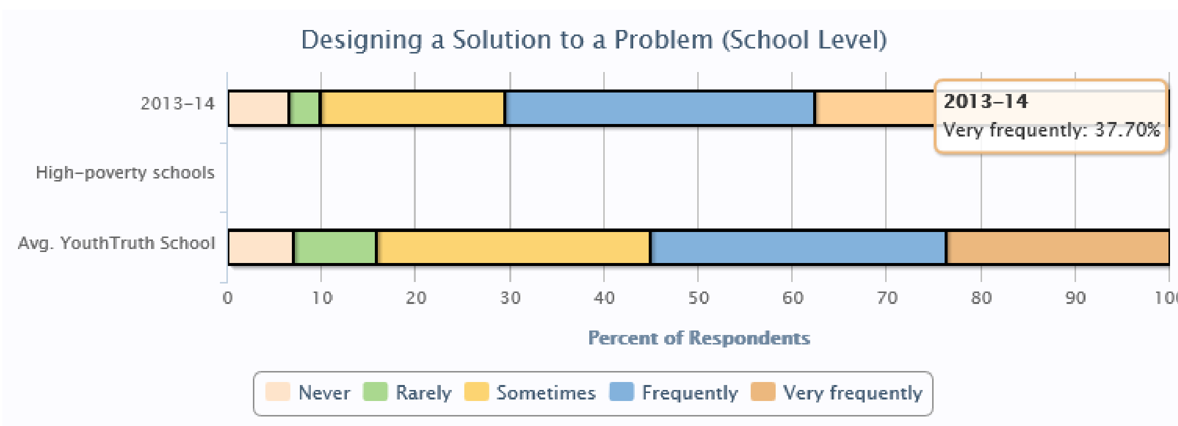
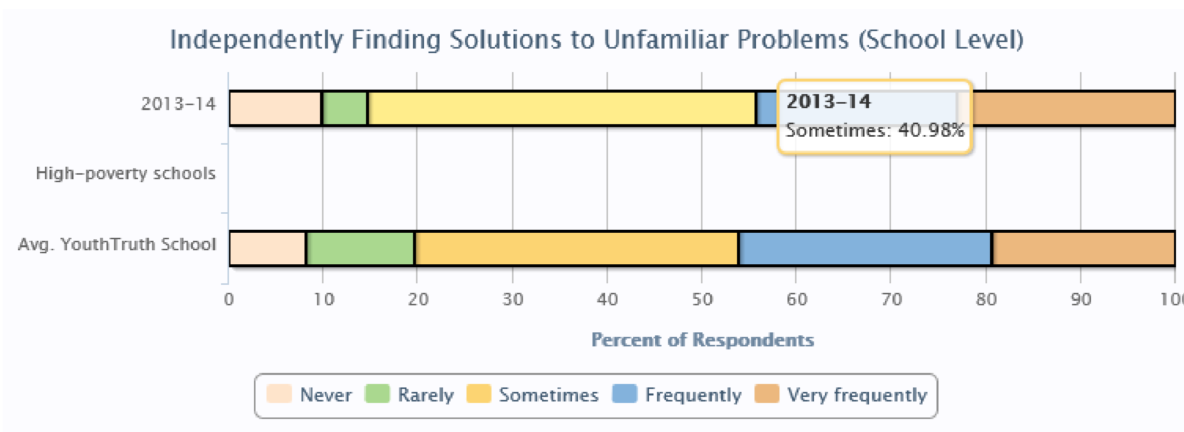


Figure 27. Working in Groups.

The PBL resource guide provided by the National Academy Foundation (2012) posited the best PBL designs drive students to apply new learning quickly and exercise important skills demanded by the workplace. This guide reinforces the concept of designing projects that compel students to apply what they have learned. Applied learning is one of Steinberg's (1998) Six A's for designing projects.

Students were asked how frequently they were able to find solutions and apply lessons learned in solving problems. When independently finding solutions to unfamiliar problems, students gave the favorable rating of 85.24% with YouthTruth schools favorable rating at 80.34%. Students stated they applied lessons from class to solve a problem with a favorable rating of 80.33. YouthTruth schools reported a higher favorable rating of 83.95% (Figure 28).



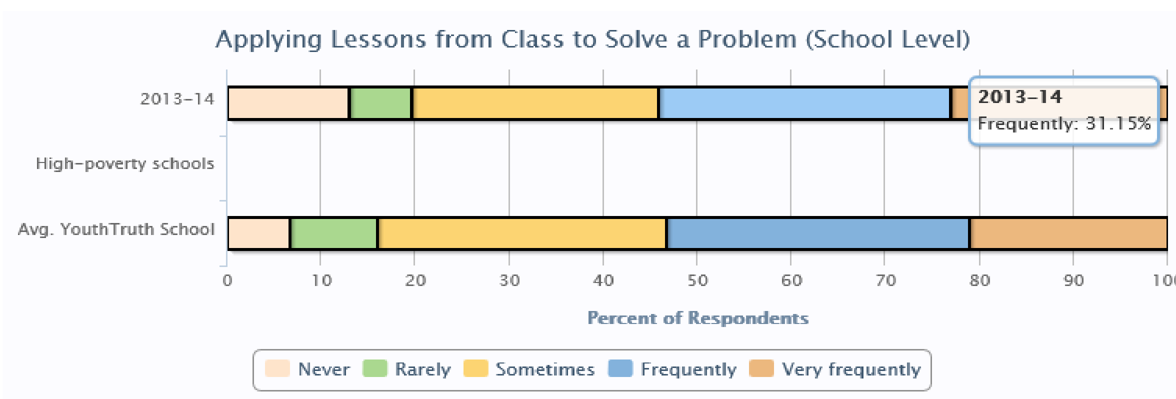


Figure 28. Application of Learning.

The entire survey data explained and answered Research Question 1: How does student engagement in PBL influence interest in STEM careers? The data presented students' perceptions pertaining to student engagement, PBL, and STEM careers. Students reported positively (61%) towards the academy getting them ready for college or a career. They conveyed being equipped to pursue college and careers. Student engagement (67%) was perceived as important and very evident within the school. The highest positive rating at the academy, as perceived by students, was academic rigor (73%). Students indicated they were challenged by their coursework and teachers.

Focus Groups

In December 2013, information was gathered from two student focus groups. Each student group member received prior approval from parents to participate and was randomly selected. The goal for this study was to include 24 students in the interview process. However, group one consisted of 12 students and group two consisted of 11 students. One of the students decided not to participate in the focus group.

Interview protocol and confidentially guidelines were clearly discussed before beginning each interview session. The focus-group sessions were completed during the students' lunches and during *lunch n' learn* sessions. The researcher utilized audio recordings for each session and a professional transcriber to guarantee accuracy (see Appendix L for the six interview questions).

Individual student interviews in this study were open-ended and conversational to allow for maximum freedom of discussion. Students had the freedom to answer or not answer a question. Efforts to ensure reliability of interviews were established by the researcher listening carefully and not allowing personal biases to influence the students' responses. No personal comments were given by the researcher to eliminate personal biases during the interviews. The length of each session was approximately 35-40 minutes.

This section will focus on emergent themes from student focus groups that answered Research Question 1: How does student engagement in PBL influence interest in STEM careers*?* Students were asked to explain how completing projects encouraged student engagement and how PBL increased their interest in going to college or to study STEM careers. One hundred percent of the 23 students stated working together and brainstorming ideas with others is an important part of learning in class and being engaged. The group further explained that working together on projects allowed them to share ideas, solve problems and monitor each other's work, and it was fun.

When providing student statements, they were not altered or *cleaned* in any way except for removal of name identifications. Each student (S) was given an alphabet code.

> SA: For me, completing projects helps me keep engaged in the class because I'm actually doing something to help myself with the subject and what I'm learning. And that way I'm not just sitting in class and doing a worksheet, but I'm really working.

> SB: It's kind of like everyone said – it's a collaboration and everything. It keeps you engaged and plus being able to see what you've accomplished in the timeframe that you have. . . . It just really keeps you wanting to keep working on it.

> SC: What keeps me engaged is having different parts of the project that you're responsible for and it gives you a job that you know that you will have to complete, in order to get a good grade on your project.

> SF: I think projects are more fun because you're with other people and not only can you get a lot of work done faster, but it seems like time goes by faster because

you're having more fun.

To further understand how the students perceived PBL, the students expressed their concerns or disadvantages for working in some groups. Three of 23 students (13%) stressed the concern of being in a group where they are the only one that does most of the work. Students were frustrated with other students not wanting to work while working on a group project.

Over 50% of the students advised that there should be a balance between *coaching* and *teaching*. The students wanted more help or direction with their projects and other class assignments from their teachers. Each class was designed to do classwork in pairs or collaborative groups. Teachers at the academy designed their classrooms to follow the Common Instructional Framework provided by North Carolina New Schools (NCNS, 2011). This framework included six components: collaborative group work, writing to learn, literacy groups, questioning, scaffolding, and classroom talk (NCNS).

> SD: I guess the worst part about project-based learning in my perspective is that with . . . some teachers will give you the work and you'll have the group and things like that, and you'll go and ask questions from other groups, come back to the teacher and she won't answer you.
>
> SC: The worst part is that sometimes you can get stuck in a group where you're the only one that does the work and then people take advantage of you when you do the work. That's my big deal.
>
> SE: I don't think . . . the helping part I don't think would be as bad if we had a different cycle of how we did things. Like in math, our cycle is we . . . say I don't understand something and (student) is in my group. I ask (student); (student) doesn't understand; I go up to another group. (Student) . . . (student) doesn't

understand. We can't figure it out. So we have to go up to the teacher; she gives us a slight hand and we still don't understand. It's just slight hand after slight hand.

SD: I guess for me especially for certain classes like math, we aren't necessarily being taught per se. We are learning, physically learning, but we are not being taught I guess. We're not being taught what we need to know to be able to pass the End-of-the-Year test. That's the big part for me about some subjects. Like, we get things and we get to learn about those and other things and we retain knowledge from them. But we're not being taught.

Even though they are, per se, coaches, they're still . . . have a role as a teacher. Teachers are supposed to teach. That's how I feel about it.

Researcher: So that's only in math?

SD: Not just math. It's really not just in math. We're being given work and we're supposed to do the work because we're students. We do and we ask for help from OTHER students and go back to the teacher and ask for help from whoever, guess. And we come back; no answer. No answer.

Students willingly discussed how PBL increased their interest in going to college and to study STEM careers. During this question, nine students wanted to share their beliefs. Nine of 23 students (39.1%) agreed that PBL at the academy has increased their interest or exposed them to possibilities of college and STEM careers. All 23 students were eager to share their future career goals. The top two STEM career interests were medical careers (30%) and engineering (20%).

SG: With me I've always kind of focused around one thing. And here at (academy) it has broadened my view.

SH: I feel like it's helped me see where my career is headed to. And I think that's really good.

SI: Because it helps you decide what you want to do. And what the classes you need to take to deal with that career.

SJ: It hasn't really increased my interest in studying STEM, but it has given me an open mind of what is what. And also, we haven't really gotten into the whole . . . I know I haven't really with the engineering besides the engineering design process, doing the projects and all that, which I understand. But maybe the job shadowing, that are about to begin or start would help us, might help us out a little bit more. I know I'm going to try to do Advanced Manufacturing – I have absolutely no idea what it is. But this might give me an idea, so the starting of job shadowing will help me maybe increase the good.

SE: I would say that it increases interest by increasing your ability to actually do that. Also not only because most careers are in some form harder that STEM curriculum because say like somebody wants to be a construction worker – you gotta go get a civil engineering degree. I came here and I wanted to go into construction work; I'd do a civil engineering degree, plus I already have the experience of going through the engineering design process and all that stuff that I'll need to actually put that into, so if I want to go to college course it's because I know I can do it a lot better.

SK: I think like the first week that I came to the academy just by the concept of it, and what I knew I was going to end up learning – I already knew what I wanted to do. And what I wanted to do and learn in college. So I could get to what I wanted to do in the future when I'm on my own. I think just as this has really helped me know what I want to learn specifically in college.

In November 2013, information was gathered from the teacher focus group. Each group member (nine teachers and principal) willingly signed consent forms to participate in this interview. The researcher received 10 teacher consent forms, but only nine agreed to participate in the teacher focus-group session. Interview protocol and confidentially guidelines were clearly discussed before beginning the session. The teacher focus-group session was completed after school for approximately 45-50 minutes.

The researcher utilized audio recordings and a professional transcriber to guarantee accuracy (see Appendix K for the six interview questions). Teachers had the freedom to answer or not answer a question. Efforts to ensure reliability of interviews were established by the researcher listening carefully and not allowing personal biases to influence the teachers' responses.

This section will focus on emergent themes from the teacher focus group that answered Research Question 2: How does teacher knowledge and perception of PBL influence PBL implementation? Teachers eagerly explained how utilizing PBL as a core instructional strategy continues to strengthen communication, collaboration, critical thinking, and creativity (4 C's).

This is the second year of the academy's existence. All nine teachers (100%) stressed they are still learning about PBL but believe PBL is an important strategy for the academy. All teachers believed PBL makes this academy stand out among other district high schools. They emphasized that PBL provided opportunities for students' authentic work to connect new learning to prior knowledge. They highlighted how PBL encouraged the students to make connections at a deeper level in what they are learning; not surface knowledge.

Many opportunities were offered to the teachers to enhance their knowledge about PBL. Teachers have received extensive professional development through HTH, North Carolina New Schools' organization/coaches, state-level STEM training, and summer externships.

One hundred percent of the teachers agreed that PBL was an important teaching strategy but not the only strategy; it was a different way of thinking, problem solving, and a great way to develop soft skills. The teachers agreed that PBL builds skills that are important in student presentations and for building collaborative teams.

Teacher statements were not altered or *cleaned* in any way, except for removal of name identifications. Each teacher (T) was given an alphabet code. Teachers eagerly described their feelings about implementing PBL.

TA: I think PBL takes advantage of the engineering design process, which regardless of the content, it's a scientific way of thinking – kind of like the scientific method where regardless of the project you have to research, and you have to brainstorm ideas to solve the problem. They have to create a prototype or a product of some sort . . . revise, revise, revise, revise. And they communicate their results somehow and that will transfer very well into a STEM field later in their life.

But it is *A* method. I think it is a good method. But I don't think it's the only method. I think it just needs to use the same components of providing students an opportunity to think through problems and solve problems creatively.

TC: I'll say that from all the business contacts and the meetings that we've had, all the business leaders have said that when they hire kids out of high school or college, they're missing all the soft skills. And doing group work and project-based learning helps them with their communication skills and becoming a leader and a facilitator and a recorder and has different roles for different students in a group. And it's teaching them to actually work with others. You can't work with everybody but you need to learn to get the project done, whichever role that you might have. . . . And now it's teaching kids to actually solve their own problems- so they created the workforce to be more prepared.

TD: I would like to reiterate what (teacher C) said. I DO think that with project-based learning it is a different way of thinking. I think lots of time with students, again for the past nine years have been lectured [to] and been chosen to just regurgitate that information – as opposed to look at a centralized program and understand how to work with others to solve that problem at hand without me giving the direct answer. And I think one thing that I've done interesting is that a lot of the students have become frustrated by that because they just want to be told: "Well, what's the answer? What's the answer? Just give me the answer." Well for them to come to understand, there may not always just be one answer or one fit. So I think just developing that type of thinking and those types of skills to think outside the box is one of the things that is one of the most important reasons to utilize PBL in the classroom.

As the teachers discussed their perceptions and PBL implementation, they also discussed student engagement and student interest in STEM careers. Student engagement was one of the focuses in all classrooms. Teachers agreed (100%) that they were constantly developing ways to encourage and promote student engagement. The statements that follow shed light on these sentiments:

TF: Student engagement. . . . Some of the things that we have been encouraged to do that I have found works really well is assigning specific group roles. And in letting students have different roles and different times. And to actively facilitate whatever is going on, making sure that you're interacting with the groups and having discussions at each small table throughout the timeframe of whatever it is that they're doing. But also touching upon what you were talking about a minute ago – making the students feel safe to take that risk.

TE: I think student engagement comes also from the structure from the day – that it's flexible and that they have a say in the norms and the setup of the classroom, and how they're going to respond to the instructional coaches. And that they go to the principal (CEO) and actually present what they would like to see. Not that they get everything that they ask for, which is relevant in and of itself – but that they those negotiating powers which are so useful in the workforce. And I also think that the lunch n' learns, but more importantly when they do project-based learning during the project, introducing real life scenarios and experts that are in the field, or just the environment. Like when they did the play to actually . . . language arts, to actually have a stage to perform on is so different than just performing a play in the classroom. And then like in finance when the banks actually came in and taught in class. And then like Career Day to explore a lot of different careers . . . so these opportunities that business brings to the table broadens their outlook on education.

TD: About student engagement . . . I think it answers the age-old question that the students have: "Well, when are we ever going to use this?" We're giving them prime examples through our lunch n' learns, through our various speakers, through their job shadowing; through their field trip experiences that they may

> have . . . they're seeing where they're actually going to use this information. And I think that takes that question out of account; when you get them engaged, when you get them to buy into that and they can see – or this is something that I'm actually going to need to work in the healthcare field or maybe in logistics, global logistics – whatever it might be. Then they really take ownership and initiative in that because they know it's something that they're going to have to have.

Doppelt (2009) cited challenges for teachers when implementing PBL. These challenges include transitioning from traditional instruction to PBL, classrooms appearing to be in disorder, designing and implementing projects were time-consuming, creating a balance with teaching and coaching to provide support, and designing authentic assessments.

Several challenges were reported by the teachers. Three of nine teachers (33.3%) reported that they were new to the academy this year and PBL was a huge learning curve. It was a balance from a traditional school setting (for several years) to the academy. The academy's flexible schedule, small staff (10) to teach two grade levels (freshmen/ sophomores=102 students) and integrating state guidelines/curriculum were constant challenges for the teachers.

Another challenge reported by the group was communicating to parents the philosophy and mission of the academy as it related to the implementation of daily lessons – not through lectures. It was difficult explaining the role of the teacher as a coach, who would facilitate the learning and lead the students through investigations to process knowledge at a deeper level.

Additionally, teachers agreed that when implementing PBL, grouping the students to make sure there was equal work distributed among all students proved to be a challenge. They stressed the importance in having the “right group dynamic” to create an atmosphere of professionalism, good work ethic, creativity and leadership. Teachers struggled in creating groups where the “shy students” would not hide behind the risk-takers and stronger leaders.

To answer Research Question 3, “What stages and challenges do teachers experience in attempting to implement PBL,” teachers provided their beliefs about challenges they faced during implementation.

> TB: Some challenges that I feel like I’m facing with PBL is a continued, I guess, confusion – like with parents. Parents are skill kind of…not concerned I guess, but parents are still . . . I mean it’s our second year in PBL and for our freshmen especially, parents are still trying to understand PBL. Again, that it’s different from traditional school.
>
> I just think it’s different. I mean, they’re just trying to adjust. Maybe not necessarily understanding, but just an adjustment to something different that they’re not used to, because their kids have been doing something else for 9 years.
>
> TJ: I’m new to PBL this year. Coming from a traditional high school to our school has been a learning experience. I think I had to learn some terminology. In fact, I was under the impression that part of PBL might be some hands-on – and that’s not necessarily always the case. The group dynamics, watching groups form, going through the process of group formation, learning students how to communicate effectively with one another and not shut down if they don’t get their way or if their ideas aren’t always used.
>
> TF: My MAJOR concern is timing and being able to balance how much time a project would take compared to the expense of number of standards that are in the

xxx curriculum. But one thing that I am trying to do differently this year is focus more on the concept of a project being their purpose for learning those individual standards and tasks, and presenting it at the beginning – and then that provides the reason for them learning.

TI: There are significant time restraints. We have learned that once we get into the process of starting a project and then finishing a project and we go through the reflective process, we realize that there are some ways that we could improve it for the following time that we do it or make some modifications. But we have a limited amount of time and a limited amount of resources to accomplish some of our goals, and because our day is shorter because of the nature of our transportation plan.

TG: The challenges that I face when implementing PBL is that parents have a lot of questions about the lack of grades in Haiku because it does take so much time for progress and projects to occur. And I guess my strategy of coping with that is that I email parents more frequently to give them updates of what's going on in our classroom.

TH: I'd just like to say that with several of the parents that I've talked to, I think they just needed reassurance. That truly the right thing IS happening. Because if you don't deal in the educational world, the only school you know is the way school was played when you were in school. So some of them just needed some reassurance that, yes, your student is doing what they're telling you.

Classroom Observations

The researcher observed 10 lessons utilizing the Observation Protocol (see Appendix C) during the months of October and November 2013. The researcher interviewed teachers and attended after school and executive/advisory team meetings. During the observations and meetings, the researcher received a short overview of the daily structure of the school, curriculum/instruction, student engagement, project assignments, and PBL. The researcher often was able to interview the teachers separately during this study.

To further answer Research Questions 2 (How does teacher knowledge and perception of PBL influence PBL implementation?) and 3 (What stages and challenges do teachers experience in attempting to implement PBL?), the researcher observed math, language arts, science, and civics/economics/history classes.

The purpose of the classroom observations was to gather descriptive information to supplement the interview data. Additionally, observational data were used to better understand interview feedback and used as probes in the interview.

The observation protocol was designed to observe three major areas: engagement, perceptions, and projects. The researcher used this protocol to observe several subareas such as student focus, verbal participation, student confidence, fun/excitement, individual attention, meaningfulness of work, rigorous thinking, performance orientation, teamwork skills, and projects. The protocol used a rubric ranging from very high to very low.

The observation process included ten 30-minute walk-throughs for English, math, science, and civics/history classes. The purpose of the walk-throughs was to observe if students focused on the learning activity, provided verbal participation, could describe the purpose of the lesson/project, found the lesson interesting/challenging, worked on complex problems while creating possible solutions, and demonstrated the ability to work in teams.

The protocol allowed the researcher to observe classroom expectations, the quality of student work, how students utilized/developed rubrics, the organization of group projects, and how the teacher provided coaching. These behaviors/activities were noted every 5 minutes during a 30-minute time period. Field notes were kept, including comments from student-student interactions, student-teacher interactions, and questions asked by teachers/students. The protocol provided a tool to observe student engagement.

Good teacher quality and good instruction is an important element in implementing PBL (Darling-Hammond, 2009). Darling-Hammond (2009) cited the following teacher qualities to be essential for good instruction:

> strong content knowledge and content pedagogy, an understanding of learners and how they learn, teach in a fair and unbiased manner, be willing and able to adapt instruction to help students succeed and strive to continue to learn and improve. (p. 2)

In the regular class time, the researcher observed the majority of students on task. Students worked in pairs or in groups to complete in-class assignments. Teachers coached and conferenced individual students as needed. Circulating and monitoring the students as they worked were strongly apparent in each class. High expectations were clearly observed with group leaders reiterating the class objective. Students were free to ask teachers questions only after first collaborating with group members.

Evidence was discovered that when the students were not working on projects, teachers made sure their classroom was a place of continuous learning. The teachers encouraged students to "engage in new patterns of thinking and to learn how to continually learn together" (Boss & Krauss, 2007, p. 31). Teachers created an atmosphere of collaboration and a process for sharing feedback.

During these class times, students were working in pairs or in collaborative groups of four. When working within a larger group, students were given jobs such as facilitator, time keeper, reader, reporter, etc. Norms were discussed and enforced. Students worked and moved freely to other groups as needed for help and clarification of class assignments.

During classroom observations, teachers demonstrated coaching and facilitating not only as students worked on projects but also during regular class time. In each class, teachers encouraged and pushed the students to think and support their answers. Students were encouraged to work together and keep each other on task. Guidelines and due dates appeared regularly as reminders as students entered assignments (in their *i-calendar*) on their personalized laptop.

Students did not work on projects each day; rather, projects were assigned throughout the year as teachers designed them around state standards. It was evident that each teacher planned and studied state standards and guidelines before teaching the lessons. The researcher was able to observe regular lessons and also students working on projects.

To better understand the implementation and challenges of PBL, the researcher first observed the classroom teacher or coach to understand their role. The National Academy Foundation (2012) suggested the role of the teacher is transformed during PBL, stating, "PBL transforms the role of the teacher from content provider to learning coordinator. Therefore, teachers spend less time lecturing and leading and more time planning, observing, listening, coaching, and facilitating" (p. 8).

One project that was observed was designed from the combined efforts of two teachers (History-Economics and Principles of Business/Finance). The primary objective of this project was for students to explore economic conditions of their county from the

1920s through the present day. This time period would include studying World War II and the Cold War through the present time. The students collected information from the local museum and were required to interview a person from each time period, creating an interview video. This interview process allowed students to connect to community members and leaders. Videos were made into a multi-media presentation, which were published at a display in the local museum for an authentic audience to view (Personal communication, November 8, 2013). The researcher was able to view these video presentations or artifacts, and students were very proud to share their presentations with the researcher.

This Civics/Economics/Business project included a collaboration rubric for students. This rubric provided assessment areas of responsibility for oneself, helping the team, and gaining respect for others. Students were also given a blog rubric. The assessment areas for the blog rubric were purpose, content, sources, and audience. Boss and Krauss (2007) stated, “blogs offer students space where they can reflect over time about what they are learning” (p. 96).

To plan for all projects, teachers presented their ideas to the staff during a tuning protocol. The tuning protocol was a way for teachers to receive feedback and fine-tune their projects. This “collaborative reflection assisted teachers in designing and refining their assessment systems and to support higher quality of student performance” (NSRF, 2012, p. 1). Teachers were given the opportunity to share with colleagues their rubrics and lesson objectives embedded with state standards for feedback.

One staff member gave their thoughts on the tuning protocol in the focus-group session:

TI: We incorporate content and standards in the tuning protocol that we use

> when we're planning projects. The non-negotiable that before projects are implemented; they have to go through a tuning protocol where the lead presenter will share what their ultimate goal was or their plan or some questions they're having. It offers an opportunity for other disciplines to see where there's some potential alignment to their standards so that multiple standards and multiple disciplines can be embedded into the same project and be assessed at the same time.

The tuning protocol at the academy entailed a comprehensive agenda following Steinberg's (1998) Six A's (authenticity, academic rigor, applied learning, active exploration, adult relationships, and assessments). Steinberg posited the Six A's were developed as a "self-assessment tool for teachers to help them consider whether the project they are planning addresses key dimensions of project-based learning for student success" (p. 25).

The project author completed a *project planner* which is similar to a lesson plan with specific guidelines or components. These guidelines included project title, overview of the project, enduring understanding (what would you like students to remember and understand a year or a decade later), driving question, products (what would you want students to do/write/create/build), learning goals, timeline/milestones, presentation (how will students present/exhibit their work), and strategies for meeting the needs of diverse learners. The project planners for various projects were collected by the researcher as artifacts.

Forty to 50 minutes were usually allowed for the tuning protocol. Roles were given to the teachers such as facilitator, time keeper, recorder, contributors, and project author(s) to keep anyone on task. The facilitator provided a brief overview of the project author's main goals, needs, and parameters. Ten to 15 minutes were given for each teacher to independently review the project plan, rubrics, and other provided documents with the guiding purpose of noting evidence of each of the Six A's. Fifteen to 20 minutes were given for a round-robin discussion of each target or *Six A's elements.* The project author responded to the information shared during the round-robin session, followed by a period for questions/answers from contributors or teachers. This format was followed for each tuning protocol to provide feedback and support. The researcher collected the agenda as an artifact.

The English/Language teacher designed a project for the students. This project addressed content in English, World History, Civics and Economics. PBL allowed for the integration of state standards in different subject areas.

In this project, students worked in groups to understand different ancient civilizations and their lasting impact on modern day American society. Each group conducted research on social classes, laws, religions, and the culture of their assigned society and answered the question, "How has this civilization made a lasting impact on America?" Students analyzed drama in different historical periods to understand how and why it was a way of preserving the culture. Each group was given the challenge of producing a 5-7 minute skit that answered those questions in a creative manner (Personal communication, November 8, 2013). The skits were performed at the local community college before an authentic audience on November 18, 2013.

As the students worked in groups on their skits, the researcher observed the students working in their assigned committees. Each committee had a leader to keep everyone on task. Committees assigned were publicity: creation; publicity: distribution; tech team; hospitality; actors; management; stage hands; and prop/set team.

The level of engagement was high as students designed their skits. Students were excited to present their play at the local community college. Larmer and Mergendoller (2012) stated, "interaction with an audience beyond their classmates and teacher ups the stakes for students, motivating them to do high-quality work" (p. 75). As the actors practiced their script, feedback was given by peers and the teacher. The teacher's role was clearly as a facilitator and coach as she conferenced and monitored throughout the lesson.

Students were given rubrics to guide their work and reflection. Rubrics included annotated bibliography, ancient civilizations note-taking guide, Socratic seminar rubric, ancient civilizations script rubric, and a group contract. The group contract was very effective in holding each group member accountable. Students were aware of the timeframe for this project (6-8 weeks) and the high expectations for a good final product.

Summary

Chapter 4 has provided the data and results of this research study. Students gave favorable feedback regarding student engagement and PBL. They strongly agreed that the academy provided the necessary skills for them to be college and career ready. Teachers clearly believed in the importance of implementing PBL, but there were challenges as they attempted to reach this goal. Chapter 5 discusses these findings, implications, and recommendations for further study.

Chapter 5: Discussion and Conclusions

Introduction

This case study explored the utilization of PBL and how it affected student engagement in the classroom and interest in STEM careers. This study was designed to understand the experiences teachers and students had when they participated in a project-based environment. Chapter 5 uses the data found in the study to draw conclusions and discuss implications in education and for further research.

Discussion

This chapter uses the data from Chapter 4 to answer each of the following research questions:

1. How does student engagement in PBL influence PBL in STEM careers?
2. How does teacher knowledge and perception of PBL influence PBL implementation?
3. What stages and challenges do teachers experience in attempting to implement PBL?

Data from this study provide information about student engagement at the academy as well as teacher perceptions and challenges encountered in attempting to implement PBL. A discussion of student engagement is presented first in this chapter. The remaining discussions include teacher knowledge and perception of PBL and challenges in implementing PBL.

Student Engagement

Lattimer and Riordan (2011) advised PBL can be an effective way to engage and inspire learners. The authors posited when PBL is taught correctly, it can energize students, staff, and school communities. Research completed by CELL (2009) stated that

PBL has a "positive effect on student content knowledge and benefits students by increasing their motivation and engagement" (p. 2).

The first research question dealt strictly with student engagement in PBL and the influence in STEM careers. This research utilized a survey provided by the YouthTruth organization, which included 67 student participants (65%).

In this study, students were compared to other regular schools that had participated in the YouthTruth survey. Students at the academy gave more favorable feedback regarding college and career readiness than engagement in school. Students had more favorable perceptions and beliefs of how the academy prepared them to pursue college and careers at the 74th percentile. Relative to other participating schools, the academy had a higher percentage of students who wanted to attend college. The degree to which students perceived themselves as engaged with their school and their education was at the 56th percentile. This percentile was at similar levels of engagement when compared to other participating schools.

Positive ratings were given in relation to student engagement in the YouthTruth survey. These positive ratings represented what proportion of student responses were positive, either agree (four) or strongly agree (five). When compared to YouthTruth participating schools, the academy students reported similar levels of student engagement. Both groups agreed more strongly that they took pride in their school work and that teachers' expectations at the academy made them want to do their best. The academy and YouthTruth participating schools agreed less strongly that they enjoyed coming to school most of the time and that they tried to do their best in class consistently.

Zulkosky (2009) stated, "according to the research of Bandura, self-efficacy makes a difference in how people feel, think, behave, and motivate themselves" (p. 94).

Self-efficacy can influence students' choices and increase or hamper motivation. Self-efficacy beliefs may determine how much effort students apply in an activity/project and how long they struggle with resilience to meet the challenge (Zulkosky). Throughout this study and within the survey results, academy students displayed a high level of self-efficacy. As the students in this study "mastered experiences, they fostered a feeling of confidence and an eventual feeling of self-efficacy" (Zulkosky, p. 96). Self-efficacy and building confidence may inspire the student's decision to experience a new activity (Zulkosky). This can be seen in the positive ratings listed below.

In summarizing the questions, in question 1, "I take pride in my school work," 75% of the students rated positive (agree/strongly agree). Students were self-conscious and confident about the quality of their work. It was important to them to produce quality work. Seventy-nine percent of the students gave a positive rating to question 2, "I try to do my best in school." Students demonstrated a strong effort when working in school. Students displayed a sense of self-efficacy with perseverance when taking pride in their work and when doing their best in school.

Fifty-two percent of the students reported a positive rating to question 3, "I enjoy coming to school most of the time." This rating supported students wanting to attend school and be a part of the academy. A positive rating of 69% was given to question 4, "my teachers' expectations make me want to do my best." Students agreed about the importance in meeting the challenge by the teachers to consistently do their best in school. There was a sense of efficacy in striving to meet the teachers' expectations to do their very best.

Fifty-six percent of the students reported a positive rating to question 5, "what I learn in class helps me outside of school." Students were confident in demonstrating their best in school and applying this knowledge to real-world experiences. David (2008) stated, "real-world problems capture students' interest and provoke serious thinking as the students acquire and apply new knowledge" (p. 80). Academy students confirmed the importance in meeting the obstacles to apply knowledge to real-world problems. Students' sense of self-efficacy guided them to commit to the challenges to meet the goals of all five questions.

The Pearson Foundation, Microsoft Partners in Learning, and Gallup partnered to measure 21st century skills combined with student engagement and aspiration in education. In May 2013, these findings about student engagement were released. Gallup (2013) stated, "In the students last year of school, those who often used 21st century skills are more likely to have had greater student aspiration and engagement. Student aspiration and engagement are positively correlated to work quality later in life" (p. 4). Increasing student engagement is one approach to energizing students to become active learners and to want to learn 21st century skills to be globally competitive for the future.

During the two student focus-group sessions, 23 students reported their perceptions about student engagement in PBL and STEM careers. All 23 students (100%) agreed that being engaged in projects is preferred more so than participating in completing worksheets and lectures. Engagement through projects allowed students to "reflect on their work and set goals for further learning, which provided an opportunity for students to set personalized learning goals" (Miller, 2012, p. 1). Four students (17%) conveyed that learning from lectures was a faster way to learn, but PBL was an effective approach to thoroughly understand the content.

Students indicated collaboration with other students while working on projects made it more interesting, gave support from their peers, and it helped them learn the content. Students were confident in being able to produce a product for display to an authentic audience. They believed the driving question was one tool that kept the students focused on their goal, and it motivated them to successfully complete their task. The driving question inspired the academy students to use the power to produce an effect and to work towards a goal with their peers. This helps to build self-efficacy when working with projects.

Thomas (2000) provided five criteria that identified a PBL project:

1. Projects are one central teaching strategy which allows the student to the learn curriculum concepts via the project.

2. Projects are focused around a "driving" question that motivates the students to learn the central concepts and principles of the curriculum.

3. Projects allow students to investigate, build knowledge and problem-solve.

4. Projects are student-driven, not teacher-led.

5. Projects are realistic while incorporating real-world connections and challenges. (pp. 3-4)

Thomas (2000) further stated, "If the central activities of the project represent no difficulty to the student or can be carried out with the application of already-learned information or skills, the 'project is an exercise,' not a PBL project" (p. 4).

During this case study, these five criteria were apparent and supported building an environment for PBL. Students were given the opportunity to work with the driving question, to investigate, explore, problem solve and work collaboratively as a team to create a product. The product was presented to an authentic audience. The researcher observed the students as they worked on a project. A majority (95%) of the students were consistently engaged as they worked on the project. Student leaders within each group worked to keep their team members on task. Students believed projects were one way they were engaged within the lesson.

Several student concerns were identified that may affect student engagement in PBL. Students wanted to work together as a team to receive a good grade and to complete their job within the project. Students encouraged everyone to do well to receive a good grade but admitted that sometimes several group members did not consistently work. They displayed a sense of responsibility and accountability for their teammates to do their best. However, students indicated that it was difficult to get some members of the group to work and “carry their load.”

More importantly, “collaboration is the norm in a project-based learning classroom” (Krauss & Boss, 2013, p. 32). Building positive group norms encouraged students to discuss how they would work together to develop positive group dynamics. Group dynamics were important to the students. They reported that sometimes the groups did not get along or work well together. It was difficult for them to work with some of their peers. Students were encouraged to discover ways to work effectively with all diverse teams. To enhance better group dynamics, encouraging team accountability and reinforcing conflict resolution strategies were needed to strengthen effective team collaboration (Larmer & Mergendoller, 2010).

The last concern involved receiving help from teachers. Twenty students (87%) indicated that when working in groups, teachers would not give them any answers to questions. They were frustrated with always asking group members and not knowing if their answer was correct.

There was a disconnect in this area for students and teachers. Students did not understand why teachers would not help them with questions and projects. Teachers wanted students to think and solve more problems on their own before asking questions. Continuous dialogue between students and staff was needed in this area.

To further answer the first research question, students discussed PBL and STEM careers. Ten students (43.4%) were willing to discuss how PBL increased their interest in STEM careers. PBL was one way the students believed they were exposed to new and possible STEM careers. These students agreed that attending the academy and learning through PBL had broadened their viewpoints about possible STEM careers.

There was self-efficacy and awareness about possible STEM careers. This high level of self-efficacy was seen as the students explained and demonstrated an interest in STEM careers. This level of confidence "opened their eyes" or heightened their awareness to other career possibilities that they may have not learned in a traditional setting. All 23 students eagerly indicated their career goals and strongly viewed themselves attending college. For them, PBL had encouraged them to make real-world connections and understand the connection between their classwork and future careers. Barron and Darling-Hammond (2008) cited, "students learn more deeply if they have *engaged* in activities that require applying classroom-gathered knowledge to real-world problems" (p. 1).

Promoting student engagement was also one of the focuses for the staff. One teacher explained that assigning students specific group roles and letting students have different roles at different times increased student engagement within the classroom. The teacher stressed the importance to actively facilitate what is going on in class, consistently interact with the groups, and having discussions at each small table throughout the timeframe. Creating an atmosphere where it was safe to take risks to collaborate and actively participate was essential.

Student engagement was encouraged through the structure of the day. The schedule was very flexible with no bells to start or end a class period. Teachers and students were free to structure each day as needed which promoted student engagement. Students were allowed to have a voice in the norms and the setup of the classroom. Students had the flexibility to present any suggestions to the principal for possible school improvements. Students were not guaranteed they would receive their requests, but they quickly learned how to negotiate and voice their opinions, which is important in the workforce. This gave the students a sense of empowerment towards self-direction and strong communication skills.

Teacher Knowledge and Perception of PBL

The second research question involved teacher knowledge and perception of PBL during implementation. Data for this question was received through classroom observations, artifacts, focus-group sessions, tuning protocol, and after-school meetings.

The researcher observed 10 classroom lessons. The teachers clearly shifted their role as teacher to coach. Teachers gave guidance as needed while monitoring the groups and providing individual conferences. One main focus was to make the classroom more student-centered and an environment for self-direction, problem solving, and critical thinking. Students were encouraged to take ownership of their learning on how they learned and how they expressed their learning. Students were given the opportunity to reflect on their work and to work collaboratively with peers. The majority of the students were consistently involved throughout the lessons.

During classroom observations, each subject area encouraged students to *think*, self-reflect, investigate, analyze, explore, and solve problems. Students were given the freedom to investigate and explore more into their inquiry. Students were pushed to think, which was uncomfortable for several of them. The students who were less independent searched for a guiding hand from the teacher and hoped for more answers instead of thinking through the process. Teachers pushed back with additional guiding questions to inspire them to think. The question guided them to an inquiry experience and to validate their answer to further build their knowledge. Boss and Krauss (2007) stated, "keeping a project moving requires teachers to support students on *their* learning journey . . . be flexible so you can adjust your teaching to address student needs" (p. 113).

During the observations, students were able to clearly discuss their purpose (guiding question) of the lesson or project and how they organized their work. Students took pride in having the freedom to move around in the classroom to collaborate with others. There was a broader range of learning opportunities throughout the lesson as the students engaged in real-world activities.

Students often worked independently, in pairs, or in larger groups. Teachers encouraged students to take responsibility for specific tasks within their group. Students were allowed to identify group/class norms to support effective teamwork. Clearly apparent was the *buy-in* from students and staff about PBL and the structure of the school. It was evident that the academy (school-wide) and each class embraced PBL as a core instructional approach to support/encourage high expectations.

In the observations, students were taught how to reflect and how to respond to feedback. They worked to refine and polish their work while collaborating with others. Each student could explain to the researcher what they were doing and why. They were comfortable using rubrics and putting their assignments into i-calendar (on their laptop). Rubrics were given to students in the beginning of the lesson/project so they would know the expectations and the specific content and soft skills for a grade. Most students were very articulate in explaining their work and/or their project.

During the observations, higher-order questions were asked by teachers. Whether talking to one student, a small group, or a large group, questions were asked that encouraged the student to analyze, evaluate, or compare. Students were given the role of researcher or investigator to discover the answers. Boss and Krauss (2007) cited, "you want students to come up with questions that will help them construct understanding . . . they have to go out and explore" (p. 116).

All teachers (9) agreed the academy's focus on PBL and STEM careers allowed the school to offer a new alternative among other high schools within the district. PBL assisted the staff in helping students make real-world connections with their learning. PBL provided a framework for teaching 21st century skills to prepare the students to compete globally. This approach generated interest in the content of the lesson in a creative way and promoted inquiry.

During the teacher focus-group session, five teachers willingly expressed their perceptions about PBL and significant reasons for using PBL at the academy. PBL inspired and allowed students to dig deeper, and it aroused their curiosity about the content and possible STEM careers.

They stated numerous business partners stressed the importance of having students equipped for the future workforce by demonstrating needed skills such as creativity, communication, collaboration, and critical thinking. Teachers emphasized that PBL was a new way of thinking for the students, which was needed to be productive in the business and real-world settings. The academy has agreed to utilize this approach to provide students an opportunity to think through problems and solve problems creatively.

In designing projects, teachers followed Steinberg's (1998) Six A's for assessing the purpose and expected outcome of the project. One teacher stated, "The development of the projects started at a very base level. They start with looking at the content, looking at the standards and seeing how we can make a project fit into the content – not the other way around."

The project planner served as a guide or lesson plan that was introduced during tuning protocols. During tuning protocols, teachers felt comfortable sharing their ideas and receiving feedback on how to implement the project. Teachers would like to find a protocol that would assist them reflecting a *post-project*. This would be valuable in assembling together to talk and reflect on how things went with the project and to receive suggestions for how to improve it for next year.

The teachers indicated that they are still learning how to effectively implement PBL. This is the academy's second year in existence. Teachers realized designating times for collaboration was essential to PBL's implementation. Weekly after-school meetings and tuning protocols allowed the teachers to share and fine-tune ideas. The academy has developed a nonthreatening environment for teachers to share and learn from each other.

To further support the implementation of PBL, the principal and school district strongly supported the entire staff receiving professional development. Teachers traveled to HTH in California to fully experience PBL. Teachers received state-level training on STEM subjects/careers and PBL. Local business partners worked with the academy to provide externships for teachers, internships for students, field trips, and guest speakers throughout the year. In addition, the staff and students were connected with local community/business experts. Business partners and the local community college continuously supported the efforts of the academy in the implementation of PBL to develop a needed workforce.

Challenges in Implementing PBL

The third research question involved the stages and challenges teachers encountered during the implementation of PBL. During the focus-group session, several challenges were discussed. Challenges given were time restraints/balancing their time, continuing to learn how to implement PBL, and explaining PBL to parents.

Time was the first challenge for teachers. Teachers indicated that it takes an abundance of time to provide adult-world connections within the lessons and to design projects to respond to the interests/needs of the students. One teacher stated, “A major concern is *timing* and being able to *balance* how much time a project would take compared to the expense of number of standards that are in the curriculum.”

With the emphasis on 21st century competencies and content, PBL addresses new CCSS (Boss, 2013). Teachers collaborated together to integrate the content and to follow CCSS. Time is required to teach needed skills before students can move to academic learning in PBL. Tuning protocols and numerous after-school meetings provided time for teacher feedback and collaboration. Teachers noted that they focused on student learning, supplying time for students to investigate/explore which required appropriated time to plan. Lattimer and Riordan (2011) posited that “PBL often fails when the emphasis falls too heavily on the ‘project’ element of the title rather than on the *learning*” (p. 1).

Having a shorter day due to their transportation plan also created time restraints. Students were bused from various high schools to attend the academy. The staff shared that they typically work with students throughout the instructional day, which limited their ability to engage in meaningful dialogue in a face-to-face environment to discuss content and alignment. Most communication with students was done virtually through emails and collaborative documents. More time was needed to reflect and to dig deeper into the projects and content/standards that could be incorporated.

The second challenge involved learning and understanding PBL. Teachers, especially first-year staff at the academy, were continuing to learn PBL. Working in a traditional school setting for several years required a shift in thinking for these teachers. There was a shift from the teacher role to coach. Additionally, giving students freedom within the class meant establishing strong classroom management skills. Relinquishing classroom control may create more student collaboration or a *noisy* classroom. For some teachers, this component may take additional time.

The terminology, concept, and framework of PBL were new for the teachers. They knew learning PBL was a continuous process and would need extra time. Consequently, there was a strong support system in place to assist and nurture newer staff members as each of them continued to learn more about implementing PBL.

The final challenge was communicating the components of PBL to the parents. Parents stressed their concerns in making sure traditional subject matter was being taught. Parents wanted reassurance that through completing projects, state content and standards were still being met. One teacher strongly reiterated, "We are not lecturing in front . . . loading information up front for students to memorize. Instead, students are doing *investigations* in order to internalize and have the information at a *deeper level*." It was emphasized that the principal and staff clearly discussed the mission and philosophy of the school with parents *prior* to the application and during the application process. Due to the school's philosophy and the emphasis on PBL, parents selected this academy for their children, but this continued to be a concern for the teachers.

CELL (2009) summarized a study that provided challenges teachers faced when implementing PBL. Such challenges included "creating projects were time-consuming, balancing giving students independence and providing support, designing authentic assessments and balancing giving students opportunities to explore their interests as they cover and integrate state standards" (p. 2). Teachers also struggled with shifting their role to a coach and creating an environment that empowered students to explore/ investigate their learning. This study reinforced the challenges and struggles of the teachers of the academy.

Future goals of the staff were given during the teacher focus-group session. The goals included continuing to provide a high quality and rigorous education, complemented with technical training at the community college that is embedded with real industry internship opportunities for students. The staff would like to continue to research and explore options where students are going to be able to interact with each other and with their instructional coaches in a non-face-to-face environment. They stated the next stage of their evolution was, "how do we make sure that students are still engaged in meaningful work that is relevant in an environment that might not necessarily model a classroom OR real-world industry? How do you model a project in advanced technologies or health science using a tool that we use potentially in an online learning environment that isn't used in advanced manufacturing or in health sciences?" Those questions will take time to answer but the staff is dedicated in doing what is best for students.

Discussions

The findings of this case study indicate that PBL encouraged student engagement and interest in STEM careers. Overall, participants of the survey rated positively on student engagement in the 56th percentile and 3.81 on a 1-5 Likert scale. Seventy-nine percent of the students stated they tried their best in school and took pride in their school work. Students believed they were challenged by the coursework and by their teachers with a ranking in the 57th percentile and a 4.00 rating. With a rating of 4.29 and in the 91st percentile, students believed the teachers wanted them to use their thinking skills, explain their answers, and not just memorize things.

Students expressed the importance of being college and career ready. They stated that the academy had helped them develop the skills and knowledge they needed for college-level classes with a ranking of 3.81 (66th percentile). Students believed the academy helped them to figure out which careers matched their interests and abilities with a ranking of 3.66 (84th percentile). Data revealed students believed the academy prepares them for college and/or careers and how to develop a career plan.

Students further discussed careers through their engagement in STEM education. All focus-group participants agreed that the academy had made them more interested in pursuing STEM careers (3.47) and increased their desire to work in a STEM field (3.37). Three point zero was the average strength of agreement on the Likert scale. The top two STEM career interests were medical careers and engineering.

Survey data supported student focus-group responses about student engagement and STEM careers. All participants in the focus group agreed that completing projects encouraged student engagement and their interest in STEM careers. Working together on projects allowed the students to share ideas, solve problems, and monitor each other's work, and it was fun. Three of 23 student focus-group participants (13%) expressed their frustration with other students not wanting to consistently work while working on a group project.

In the area of PBL, survey participants agreed that PBL encouraged them in their work. Students stated that they learned how to work well with others by participating in group projects (4.08) and learned more deeply with projects than with other types of assignments (3.81). PBL allowed the students to work with other students to design a solution to a real-world problem very frequently at 35% and 31% with teachers.

In completing projects, students reported over 65% that projects were the main way they learned in social studies, science, and English-language arts; math reported only 36%. Overall, students agreed that PBL increased engagement within the lessons and assisted them in learning content.

In the focus-group discussions, 50% of the students reported that there should be a balance between coaching and teaching. Students wanted more assistance from the teachers during classwork and projects. Students were frustrated and believed their teachers should teach just as much as they coach within each lesson. Students reported teachers did not give direct answers but answered questions with a question, guiding them to think.

In the classroom observations and teacher focus-group session, data revealed that the teachers were still learning PBL. Teachers emphasized that PBL was one instructional strategy that integrated content and supported developing skills such as communication, collaboration, critical thinking, and creativity. They agreed that PBL encouraged the students to dig deeper into the content, work collaboratively in groups, and to take ownership of their learning; but it was the teachers' strong core values about PBL that made the implementation of PBL a success.

Teachers stressed the implementation of PBL involved allowing students to think critically and solve problems independently or with a peer. PBL provided the tool for students to learn how to solve problems and not totally rely on the teacher for answers. Teachers understood the frustration students demonstrated from solving problems on their own. There may not always be one answer or one fit to a problem which teachers believed develops a new way of thinking. Teachers believed this is one of the most important reasons to utilize PBL in the classroom.

Teachers agreed they constantly focused on encouraging and promoting student engagement through group projects and class discussions. They stressed that as students made real-world connections, took ownership of their work, and understood the relevance of the work for future careers, engagement increased.

Classroom observations supported the findings from the teacher focus-group discussion. As students were able to dig deeper into understanding the concepts, students took ownership of their own learning. Students were engaged in the lesson and given tools to reflect on their learning. As the teachers' knowledge about PBL increased this year, teachers (100%) believed this helped with the implementation of PBL which also benefited the students.

A small percentage of students did not consistently participate in discussions or projects. There was a level of frustration that was seen by students who consistently completed their work or participated. Teachers and student-group leaders worked to get all students on task. High expectations were clearly observed with group leaders reiterating the class objective.

Findings indicated there were three challenges reported by the teachers. First, teachers stated it was time-consuming to design projects and balance the time for learning/implementing the CCSS. They discovered there was limited time to go through the reflective process after the project to make needed modifications. Teachers expressed being overwhelmed at times to meet all local and state guidelines and to create a PBL environment.

Second, teachers reported there was a learning curve to find a balance from working in a traditional setting (past years) to a PBL environment. Teachers realized there was a major transition from teacher to coach in a PBL setting. It was a shift not relying on textbooks and lectures but providing more coaching and modeling with less providing of answers. Within this learning curve, it was a challenge to empower students to take ownership of their learning and to push students to complete more in-depth inquiries.

Third, parents were still trying to understand PBL. Teachers were working to explain the transition from a traditional setting to a PBL environment. Even though this instructional strategy was thoroughly explained by the principal and staff at the beginning of the year, it still remains a struggle to explain how local/state requirements will be met. Teachers will continue to work hard in reassuring the parents that the students will be college/career ready.

Limitations of the Study

The limitations of a study provide useful parameters about possible weaknesses of a study which may affect results (Creswell, 2012). Providing possible limitations of a study allows researchers to measure the ability to generalize results that may be beneficial to other prospective researchers who seek to conduct a similar study. This case study of student engagement and interest in STEM careers through PBL was limited by the number of student participants. Sixty-seven students (65%) participated in this study and 10 staff participants. The STEM academy was a new school site with approximately 102 students. Accuracy of interviews was dependent upon how relaxed the participant felt during the interview process as well as if he/she trusted the researcher to accurately recall the facts and events.

This case study relied upon survey responses from 67 students regarding PBL, student engagement, STEM careers, college and career readiness, and academic rigor. A single observer (the researcher) conducted all observations (10) utilizing the Classroom Observation Protocol and interviewed the teachers. A short data collection period of 3 months was used for this study.

Recommendations for Further Study

Student engagement data provided correlating trends between students and teachers. Both groups agreed that student engagement was very essential and PBL as an instructional approach provided opportunities for student engagement and interest in future careers. PBL did yield students developing deeper learning of academic content and a stronger desire to learn. PBL encouraged college/career readiness through competencies (4 C's) that developed through projects. Projects consisted of research beyond the classroom which allowed students to learn from community/business experts from various career fields.

Teacher observation data were collected through 10 observations in 4-5 weeks. More observation time could yield better data about the implementation of PBL. A future study, which is designed to record the entire process of creating/presenting projects, would return additional data. This study was designed to collect data on one to two projects during a brief 2-month window. Conducting a longitudinal study of the implementation of PBL over the course of an entire school year would provide data over time, which this study could not do. In addition, having a larger number of students in a larger school may also provide additional data about the implementation of PBL and student engagement/interest.

It is recommended for the academy staff to continue to strengthen the culture for students to better understand the role of teaching and coaching. Students must understand the importance of discovering and justifying their answers. It may be frustrating for the students to stretch their thinking and learn from their peers by analyzing their work and working collaboratively, but this is needed. Students expand their skills and think critically when they "practice decision making and deductive reasoning when exposed to examples from real-life situations" (Stix & Hrbek, 2006, p. 2). Creating a culture that promotes students investigating their answers and solving problems will create a culture for high-quality work. The academy should continue to provide additional time for students to reflect and revise their work.

As students produce their products, the academy should locate additional spaces in the school or community to display student work. Providing additional spaces for student work will continue to provide a sense of self-efficacy and pride. This is important when nurturing a PBL environment.

Summary

This study sought to investigate student engagement and interest in STEM careers through the implementation of PBL. Teachers and students agreed that PBL made a difference in the academy and heightened awareness of student engagement and interest in STEM careers. Insights related to possible perceptions students and teachers may have had about PBL were uncovered. Information was provided on possible challenges that teachers face when implementing this instructional approach.

Additionally, PBL was more popular with students and teachers than traditional methods. PBL enhanced student learning and engagement, and PBL was an effective strategy for developing 21st century skills to prepare students for future careers or college at the academy.

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Appendix A

STEM Academy Courses, Year 1 and Year 2

STEM Academy Courses, Year 1

2012-2013 Cohort (Current Students) 9th Grade Year	2013-2014 Cohort (Incoming Freshman) 9th Grade Year
English I Honors	English I Honors
Common Core Math I	Common Core Math I or Common Core Math 2 Honors
Physical Science	Physical Science
Microsoft Word, Power Point, and Publisher	Principles of Business and Finance
Principles of Business and Finance	Civics and Economics Honors
Physical Education and Health	Physical Education and Health
ACA 115: Study and Success Skills (Community College)	ACA 115: Study and Success Skills (Community College)

STEM Academy Courses, Year 2

2012-2013 Cohort (Current Students) 10th Grade Year	2013-2014 Cohort (Incoming Freshman) 10th Grade Year
English 2 Honors	English 2 Honors
Common Core Math 2 Honors	Common Core Math 2 Honors or Common Core Math 3 Honors
Biology Honors	Biology Honors
Civics and Economics Honors	Microsoft Word, Power Point, and Publisher
World History Honors	World History Honors
Scientific Visualizations I	Scientific Visualizations I
2 courses at Community College aligned with career pathway (OPTIONAL) ONE each semester	2 courses at Community College aligned with career pathway (OPTIONAL) ONE each semester

Appendix B

Crosswalk between Constructs, Measures, and Research Questions

Concept	Measure	Research Question (s)
Student engagement in PBL influencing interest in STEM careers	Classroom Observation, survey, focus groups	1
Teacher knowledge and perception of PBL implementation	Classroom observation, Teacher Focus Group/Tuning Process/PLCs	2
Stages and challenges teacher experience in implementing PBL	Classroom observation, teacher focus groups	3

Appendix C

Classroom Observation Protocol

Project-Based Learning Observation Protocol

*Adapted from International Center for Leadership in Education Checklist (2009)

Date: **Class:** **Time:**

Project Name:

ENGAGEMENT

	Very High	High	Medium	Low	Very Low
Consistent Focus All students are focused on the learning activity with minimum disruptions.	☐	☐	☐	☐	☐
Verbal Participation Students express thoughtful ideas, reflective answers, and questions relevant or appropriate to learning. A balance between student centered vs. teacher centered classroom.	☐	☐	☐	☐	☐
Student Confidence Students exhibit confidence and can initiate and complete a task with limited coaching and can work in a group.	☐	☐	☐	☐	☐
Fun/Excitement Students exhibit interest and enthusiasm and use positive humor.	☐	☐	☐	☐	☐

PERCEPTIONS

	Very High	High	Medium	Low	Very Low
Individual Attention Students feel comfortable seeking help and asking questions. *Question to Ask:* What do you do in this class if you need extra help?	☐	☐	☐	☐	☐
Clarity of Learning Students can describe the purpose of the lesson/project/ unit. This is not the same as being able to describe the activity being done during class. There is more time for student work (80%) and 20% direct instruction. *Questions to Ask:* What are you working on? What are you learning from this work?	☐	☐	☐	☐	☐
Meaningfulness of Work Students find the work interesting, challenging, and connected to learning. *Questions to Ask:* What are you learning? Is this work interesting to you? Do you know why you are learning this?	☐	☐	☐	☐	☐
Rigorous Thinking Students work on complex problems, create original solutions, and reflect on the quality of their work. Students utilize what they know to construct new knowledge while making choices. *Questions to Ask:* How challenging is this work? In what ways do you have the opportunity to be creative? What opportunities do you have to receive feedback and refine work?	☐	☐	☐	☐	☐
Performance Orientation Students understand what quality work is and how it will be assessed. They also can describe the criteria by which their work will be evaluated. *Questions to Ask:* How do you know you have done good work? What are some elements of quality performance?	☐	☐	☐	☐	☐

	Very High	High	Medium	Low	Very Low
Teamwork Skills Students demonstrate the ability to work in teams while showing good communication, collaboration, creativity and critical thinking skills.	☐	☐	☐	☐	☐
Students demonstrate kindness and politeness when providing honest and positive feedback within their groups.	☐	☐	☐	☐	☐
Students reflect on their contribution to groups.	☐	☐	☐	☐	☐
Teacher Teacher discussed rubrics/expectations for the project with all students and assessed students' knowledge throughout the project process. This process incorporates co-constructed teacher/student rubrics.	☐	☐	☐	☐	☐

Questions to Ask: Did the teacher provide coaching questions to facilitate reflective conversation and student thinking during their projects? Did the teacher provide supportive feedback to encourage student thinking and dialogue within the student groups?

Project Time Line

Weeks	Strategy	Time Frame	Comments
☐ Week 1	Students set short/long-term goals, collect data		
☐ Week 2	Students are grouped based on data collected, analyze data, assess results		
☐ Week 3			
☐ Week 4			
☐ Week 5			

**Adapted from International Center for Leadership in Education Checklist (2009)*

Overall Comments:

Appendix D

Classroom Observation Protocol Approval Letter

International Center for
Leadership in Education
Rigor, Relevance, and Relationships for ALL Students

August 13, 2013

Pam Misher
3602 Fieldgate Rd.
Greensboro, NC 27406

Dear Ms. Misher:

Thank you for contacting the International Center for Leadership in Education regarding your dissertation, in which you'd like to reference Dr. Richard D. Jones' *Student Engagement* Teacher Handbook, specifically the "Student Engagement Walkthrough Checklist."

As we discussed, we are happy to grant you this permission. We do ask that you please ensure that we are given proper attribution in both your citations and also under the checklist in the following form:

© International Center for Leadership in Education

Sincerely,

Kris Ross
Managing Editor

1587 Route 146 ▪ Rexford, NY 12148 ▪ www.LeaderEd.com
P: (518) 399-2776 ▪ F: (518) 399-7607

Appendix E

Youth Truth Survey

YouthTruth®
STUDENT SURVEY

Project-Based Learning and STEM Questions, 2013-14

The following questions focused on Project-Based Learning and STEM education provide targeted student feedback on these two additional topics as a complement to the themes covered in YouthTruth's ***Overall School Experience*** survey (student engagement, academic rigor, relationships with teachers, school culture, and college and career readiness).

Project-Based Learning

1. During the past month, how often have you done the following? *(Never, Once or twice, A Few Times, Every Week, Every Day, or Almost Every Day)*
   - Discussed real-world issues that need solutions with other students
   - Discussed real-world issues that need solutions with your teacher
   - Worked with other students to design a solution to a real-world problem
   - Revised a project with other students to make it better
   - Revised a project with your teacher to make it better
   - Shared or presented your project(s)

2. How strongly do you agree or disagree with the following statements? *(Strongly disagree, Somewhat disagree, Neither agree nor disagree, Somewhat agree, Strongly agree)*
   - In school, I can find solutions to problems that I haven't been taught how to solve
   - Outside of school, I think about how to solve problems using lessons I learned in class
   - The projects that we do in school help prepare me for careers that interest me
   - The projects that we do in school help prepare me for college
   - I care more about what I'm learning when I fell like I'm solving a real-world problem
   - I learn lessons more deeply with projects than with other types of assignments
   - I have learned how to work well with other students by participating in group projects
   - Doing projects makes me a better student (for example: I get better grades, I understand the subject better)

3. Are projects the main way you learn in the following subjects? *(Yes, No, I'm not sure)*

- Math
- English/Language Arts
- Science
- Social Studies or History

STEM

1. How strongly do you agree or disagree with the following statements? *(Strongly disagree, Somewhat disagree, Neither agree nor disagree, Somewhat agree, Strongly agree)*

    - In the future, I see myself becoming a scientist, engineer, mathematician, or working with technology
    - I would choose to take additional courses in math or science even if they were not required
    - My teachers make connections between what I learn in my math, English, social studies, and science classes
    - I will use what I learn in math and science classes once I've graduated from high school
    - My school has made me more interested in pursuing a career in math, science, technology or engineering
    - I understand how math, science, technology and engineering are used in various careers

2. Have you taken part in any of the following experiences? *(Yes, No, I'm not sure)*

    - Participating in an internship
    - Hearing from professionals who have visited my school
    - Having a professional mentor
    - Attending field trips or summer camp
    - Participating in science, technology, engineering or math competitions or fairs
    - Other (please specify)

If so, how helpful have these experiences been to you in understanding how math, science, technology, and engineering are used in various careers? *(Very Unhelpful, Somewhat Unhelpful, Neither Helpful nor Unhelpful, Somewhat Helpful, Very Helpful)*

3. During this school year, how frequently have you engaged in the following activities either in or out of school? *(Never, Rarely, Sometimes, Frequently, Very frequently)*

    - Participated in hands-on group projects that involve building or designing
    - Worked with a group to design a solution to a problem
    - Independently found a solution to a problem that I haven't been taught how to solve
    - Applied lessons I've learned in class to solving a problem

- Worked with students and community groups to address issues in my community

4. I use technology in school to do the following activities *(Not at all, Monthly, Weekly, Daily)*
    - Create a digital portfolio
    - Conduct simulations
    - Analyze data
    - Design solutions to problems
    - Conduct research
    - Share ideas, questions, and issues with other students online
    - Other (please specify)

5. I use technology outside of school to do the following activities *(Not at all, Monthly, Weekly, Daily)*
    - Create a digital portfolio
    - Conduct simulations
    - Analyze data
    - Design solutions to problems
    - Conduct research
    - Share ideas, questions, and issues with other students online
    - Other (please specify)

Appendix F

YouthTruth Partnership Letter

YouthTruth
STUDENT SURVEY

July 8, 2013

To Whom It May Concern,

YouthTruth is pleased to be partnering with Doctoral Candidate Pam Misher and Yadkin Valley Regional Career Academy to implement the YouthTruth Student Survey during the 2013-14 school year.

The version of the YouthTruth survey to be implemented at Yadkin Valley Regional Career Academy will gather student feedback on topics such as student engagement, relationships with teachers, STEM education, and project-based learning.

The data collected will be shared both with Ms. Misher for use in her doctoral research, and with the school to inform ongoing planning and improvement. Specific terms and conditions will be set forth in the following brief agreements, to be signed before the survey is administered this fall:

- YouthTruth Registration and Client Agreement, a 2-page document to be signed by the school principal acknowledging the school's participation in the YouthTruth survey, and
- YouthTruth Data Sharing Agreement, a 2-page document to be signed by YouthTruth and our research partners.

Please don't hesitate to contact me with any questions.
Sincerely,

Jen Vorse Wilka, Manager

jenw@youthtruthsurvey.org
415-391-3070 ext. 109
100 Montgomery St. Suite 1700, San Francisco, CA 94104

www.youthtruthsurvey.org

Appendix G

Principal Confirmation to Participate in Research

Dear Principal,

A research project titled, “Project-Based Learning in a STEM Academy: Student Engagement and Interest in STEM Careers” is being conducted to help students and teachers in the classroom. This case study is designed to learn about the experiences teachers and students have when they participate in a project-based learning environment.

Random Assignment
Students will be randomly selected to participate in this study. All classroom teachers have agreed to participate in this study.

Data Collection
Your assistance is needed to collect the appropriate permissions to conduct this research from parents, students, and teachers, and to assist the researcher in collection of data during the study period. These data will include a student online survey, to be administered once near the end of the first semester; teacher reflections collected afterschool during the tuning process/PLCs and focus-group interviews with teachers and students who participate in the program.

Time Needed
Researcher will observe classrooms one day a week for 4-6 weeks. Researcher will also attend afterschool tuning meetings/teacher work sessions. Students will take an online survey for approximately 20-30 minutes. In addition, selected students for the focus groups will meet with the researcher for two 30-minute sessions to discuss the survey/projects.

Benefits
The expected benefits associated with your participation is the data collected from the impact of PBL on student engagement and student interest in STEM careers that may be helpful for students and teachers.

Please sign below for your consent of this study.

Principal Signature:

____Date:_______________

Principal Name (please print):

____

Contact Phone #: ____

E-Mail: ____

Appendix H

Educator Informed Consent to Participate in Research

Dear Educator:

A research project is being conducted to learn about the experiences teachers and students have when they participate in a project-based learning environment. If you consent to participate please sign this form and return to your principal by Friday, October 18, 2013.

You should be aware that you are free to decide whether or not to participate, additionally you may withdraw at any time without affecting your relationship with the school, district, or researcher.

Purpose of the Study
The purpose of this study is review closely the impact of project-based learning on student engagement and student interest in STEM careers.

Participation Involvement
This study will begin in October 2013 and will continue throughout the school year. Teachers will engage in the following activities:

- Research Components: Teachers will be asked to help administer the student online survey which is approximately 30 minutes. Additionally, teachers will be asked to participate in focus-group discussions.

Confidentiality
All data will be kept strictly confidential, and no names will be used when reporting the results of the study. No data or focus-group discussions will be used in supervisory evaluation in any way.

Benefits
The information that we gain through this study may help us to better understand student engagement through project-based learning.

You may contact Pam Misher at phmisher@uncg.edu for further questions.

If you consent to participate in this study, please sign below and return to your principal by October 18, 2013. A copy of this form will be given to you for your records.

Teacher Signature: ____________________________________ Date: _____________

Pam Misher, Doctoral Student
Gardner-Webb University

Appendix I

Parental Informed Consent

Dear Parent/Guardian,

A research project is being conducted at your child's school to learn about project-based learning. This consent form will give you the information you need to help decide whether or not to allow your child to participate in the project.

Purpose of the Study
The purpose of this study is to learn more about the experiences teachers and students have when they participate in a project-based learning environment.

Participation Involvement for your child
This study will begin in October 2013 and will continue throughout the school year.

Students will be given an online survey, asking about student engagement and their interest in STEM careers. The will take 20-30 minutes to complete and will be given in the fall. In addition, several students will participate in a focus-group discussion. Your child will be told that he or she may choose not to participate in our study at any time, and may choose not to answer any question on the surveys.

Confidentiality
All data, including your child's responses on the survey, will be kept strictly confidential, and no names will be used when we report on the results of the study. None of their answers will be used in grading or evaluation in any way.

Benefits
The information that we gain through this study may help us to better understand student engagement through project-based learning.

For further information
If you have any questions about the study, you may contact Pam Misher at phmisher@yahoo.com.

If you consent to allow your child to participate in this study, please sign below and return it to your child's teacher by October 18, 2013. A copy will be given to you for your records.

Parent/Guardian's Signature_________________________________ Date____________

Parent/Guardian's Name (Please Print)____

Pam Misher, Doctoral Student, Gardner-Webb University

Appendix J

Student Assent Form

(To be read aloud as well as provided in writing)

A research study is being conducted to learn about the experiences students have when they participate in a project-based learning environment.

As part of this project, students will

1) Complete an online survey asking about your beliefs, goals, and experiences with student engagement, STEM and project-based learning. This survey will take 20-30 minutes to complete and will be given once in the fall.
2) Participate in focus-group discussions. *(Students selected randomly)

All information, including your responses on the survey and focus-group discussions, will be kept strictly confidential. No names will be used when reporting the results of the study.

Participation in this research is entirely voluntary. You may refuse to participate or withdraw from the study at any time without consequences. No grades will be given during this process.

If at any time you have questions regarding the study or your participation, you may contact Pam Misher at phmisher@yahoo.com.

You will receive a copy of this page to keep for your records.

• I understand the information provided, and I agree to participate in this study.

Student Signature:

____ Date:____________

Student Name (please print):

____

Human Sciences Research Council (HSRC) Staff Statement

1. Participation in this research is entirely voluntary. You may refuse to participate or withdraw from the study at any time without consequences.

2. If, during the course of the study, significant new information becomes available which may affect your participation, it will be provided to you.

3. Any information that personally identifies you will not be voluntarily disclosed or released without your separate consent, except as required by law.

4. If at any time you have questions regarding the study or your participation, you may contact Pam Misher at phmisher@yahoo.com.

I understand the information provided, and I give my consent to be included in this study. I understand that I can ask any questions about the study by emailing Pam Misher at phmisher@yahoo.com.

Educator Signature:

____Date:______________

Educator Name (please print):
____

Contact Phone #: ____

E-Mail: ____

Human Sciences Research Council (HSRC) Parent Statement

1. Participation in this research is entirely voluntary. You or your child may refuse to participate or withdraw from the study at any time without consequences.

2. If, during the course of the study, significant new information becomes available which may affect your participation, it will be provided to you.

3. Any information that personally identifies your child will not be voluntarily disclosed or released without your separate consent, except as required by law.

4. If at any time you have questions regarding the study or your child's participation, you may contact Pam Misher at phmisher@yahoo.com.

I understand the information provided, and I give my consent for my child to be included in this study. I understand that I can ask any questions about the study by contacting Pam Misher at phmisher@yahoo.com.

Parent/Guardian Name (please print):

____

Student's Name (please print):
____

Contact Phone #: ______________________________

E-Mail: ______________________________________

Parent/Guardian Signature:

____Date:_________

IMPORTANT: RETURN THIS FORM BY Friday, October 18, 2013

Appendix K

Focus-Group Interview Protocol for Teachers

As participants arrive they will sign the sign-in sheet to record attendance of the group participating in the focus group.

Introduction script:
You have been implementing project-based learning (PBL) and guiding the students with their projects. In an effort to better understand the impact and successes/challenges of PBL the researcher would like to ask you to respond to a series of questions. This interview should take about 30 minutes.

All responses will be held confidential. No individual participant will be identified in the analysis of this interview. The researcher will be transcribing your responses as well as audio recording this session to guarantee accuracy. You will be given a transcript of your responses and if there are statements that were inaccurately recorded or information you feel uncomfortable sharing, it will be removed from the research study.

Script:
During this interview you will respond to 6 questions. Please provide as much detail in your responses as possible.

1. What are the challenges you face when implementing PBL? What teaching/coaching strategies are you doing differently from last school year?

2. How do you handle parents wanting a traditional approach (more direct instruction), than incorporating projects into the lesson?

3. Why is it important to utilize PBL in a STEM school? What are the most important reasons for using PBL in the classroom?

4. What strategies do you use to promote (a) student engagement, (b) student interest in STEM careers?

5. How do you develop the assessments for the projects? What do you use to assess the projects; example portfolios, student peer reviews etc.?

6. How are you incorporating content and standards into project-based learning? Any time restraints?

Appendix L

Focus-Group Interview Protocol for Students

As participants arrive they will sign the sign-in sheet to record attendance of the group participating in the focus group.

Introduction script:
You have been participating in project-based learning (PBL) and learning how to design and present your project. In an effort to better understand student engagement in PBL and your interest in STEM careers, the researcher would like to ask you to respond to a series of questions. This interview should take about 30 minutes.

All responses will be held confidential. No individual participant will be identified in the analysis of this interview. The researcher will be transcribing your responses as well as audio recording this session to guarantee accuracy. You will be given a transcript of your responses and if there are statements that were inaccurately recorded or information you feel uncomfortable sharing, it will be removed from the research study.

Script:
During this interview you will respond to 6 questions. Please provide as much detail in your responses as possible.

1. How does completing projects encourage you to be engaged in class?

2. How has project-based learning assisted you to master the learning objectives/goals than through a traditional setting?

3. What is the best/worst part about project-based learning?

4. How has working in groups on projects assisted you in learning Science, Technology, Engineering, Math subjects?

5. How has project-based learning increased your interest in going to college to study STEM careers?

6. What would you change in your classroom, if anything that would assist you in learning more about STEM subjects and/or completing projects?

Appendix M

Focus-Group Consent/Sign-In Form

I understand that feedback is being collected about my participation experience in the project-based learning research. The purpose of this focus group is to gain a better understanding of the impact of the experiences teachers and students have when they participate in a project-based learning environment. I also understand that anything I say in this group will remain confidential. My signature below indicates my willingness to participate in this focus group.

Name	Name
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________
______________________	______________________

Appendix N

Superintendent Confirmation to Participate in Research

Dear Superintendent Mock,

A research project titled, "Project-Based Learning in a STEM Academy: Student Engagement and Interest in STEM Careers" is being conducted at the STEM Academy to help students and teachers in the classroom. This case study is designed to learn about the experiences teachers and students have when they participate in a project-based learning environment.

Random Assignment
Students will be randomly selected to participate in this study. All classroom teachers have agreed to participate in this study.

Data Collection
Your assistance is needed to collect the appropriate permissions to conduct this research from parents, students, and teachers, and to assist the researcher in collection of data during the study period. These data will include a student online survey, to be administered once near the end of the first semester; teacher reflections collected afterschool during the tuning process/PLCs and focus-group interviews with teachers and students who participate in the program.

Time Needed
Researcher will observe classrooms one day a week for 4-6 weeks. Researcher will also attend afterschool tuning meetings/teacher work sessions. Students will take an online survey for approximately 20-30 minutes. In addition, selected students for the focus groups will meet with the researcher for two 30-minute sessions to discuss the survey/projects.

Benefits
The expected benefits associated with your participation is the data collected from the impact of PBL on student engagement and student interest in STEM careers that may be helpful for the principal, students and teachers. The data collected will be helpful in developing STEM careers within the district.

Please sign below for your consent of this study.

Superintendent Signature:

____ Date:_________________

Superintendent Name: (please print):

____

Contact Phone #: ___________________ Email Address: __________________