Problem-based learning influences on female students' self-efficacy and critical thinking skills

by

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B.A., Pittsburg State University, 1988
B.S., Pittsburg State University, 2013
M.S., Pittsburg State University, 2017
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AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

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Abstract

Gender inequalities continue into the 21st century and STEM was a major area of emphasis. Educators need to focus on female students to build their self-efficacy and critical thinking skills. The purpose of this study was to determine if problem-based learning (PBL) improves female elementary students' self-efficacy and critical thinking skills. This case study based on Merriam examined how integrating PBL into the curriculum with STEM at the elementary level motivated female students towards selecting STEM careers while improving their self-efficacy and critical thinking skills. The PBL unit was developed to meet the NGSS Standards along with the Kansas Technology standards for students. The core idea of the unit was focused on shrinking our carbon footprint on the Earth with how humans and Earth interact together. A qualitative data analysis was conducted, and three themes were discussed during the findings stage. The analysis showed positive improvements for female students' self-efficacy and critical thinking skills with problem-based learning infused with STEM. Butler's feminist theory and Bandura's self-efficacy theory were evident with female students as improvement was apparent during the PBL.

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Dedication

I would like to dedicate this dissertation to my daughters, Reyna and Lauren Valenzuela, who have showed me how to persevere through any challenge put before me, as they have done. I would also like to dedicate this to my grandmother, Mary Jane (Duggan) Hood who believed in me and told me to reach for the stars. She always supported me in all that I did, and I am thankful for the talks we had in her house, during my college years. Finally, I would like to dedicate this dissertation to my husband, Mario Valenzuela, who has supported me along the way and believed in me. I love all of you, and I know grandma is watching from heaven.

Preface

Helping female students with their self-efficacy and critical thinking skills is what I believe in because I want them to be strong and believe that they can do anything! I believe their learning is our responsibility as teachers, but we must also believe that all students can learn.

Chapter 1 - Introduction

How Does Problem-Based Learning Influence Rural, Parochial Female-Elementary Students' STEM self-efficacy and critical thinking skills?

Gender inequalities continue into this century and are still evident in Science, Technology, Engineering, and Math (STEM) (Lockwood, 2020). Educators need to assist female students to become aware of their power to learn, to partake and be active in their learning, and to build efficacy so that they can succeed in STEM (Lockwood, 2020). The purpose of this study was to determine if problem-based learning influences Catholic rural female elementary students' self-efficacy and critical thinking skills in STEM. The term STEM is defined as science, technology, engineering, and math. STEM was discussed in public terms during President Barack Obama's state of the union address in 2011, and the president stated that administrators needed to train more teachers in STEM areas for the future (Obama, 2011).

Problem-based learning (PBL) is an excellent method to engage students and create interest in STEM (Misher, 2014), and utilizing PBL is an excellent motivator for female students in building self-efficacy and critical thinking skills. This case study examined how integrating PBL into the curriculum with STEM at the elementary level will influence female students' self-efficacy and critical thinking skills.

What is STEM?

Where does the term STEM come from? The National Science Foundation (NSF), termed the phrase STEM so students' critical-thinking skills could be enhanced (Sanders, 2009). The Industrial Revolution is where society saw the beginning of STEM as many innovations were created during this time, but not until the Morrill Land-Grant Act of 1862 did, society see education begin to embrace engineering. The Morrill Act (1862) required any state university that was granted land to create engineering degrees, because the government felt there was a need for inventors to be educated (White, 2014). Thomas Edison and Henry Ford utilized STEM aspects in their inventions, but they never attended college (Beals, 2012).

During World War II, the government utilized those educated inventors to assist them in the war effort (White, 2014). These brilliant individuals then collaborated and discovered that the military could use rubber for their vehicle tires, and a larger group of minds, including some from different countries, developed the atomic bomb (White, 2014). Together these individuals worked to assist the military in winning the war and helped to prove the need for STEM education (Judy, 2011).

History of STEM

STEM educational initiatives have become more prominent in the last 50 years, with science and technology having roles in international economics, power, and politics. For example, Sputnik was the beginning of the race to the moon between the United States (US) and the Soviet Union (USSR), which brought about the creation of the National Aeronautics and Space Administration (NASA), whose mission was to increase US space presence and utilize science and engineering to develop a space program (Dick, 2008). NASA has been a pioneer in many areas of technology and space throughout the years, but they have also developed STEM education initiatives for students with funding available through grants from NASA (NASA, 2012). NASA continues their efforts to improve STEM education today with improvements in teacher education and STEM initiatives for students.

Definition

STEM. STEM refers to the physical, biological, and agricultural sciences; computer and information sciences; engineering and engineering technologies;

> and mathematics. The social and behavioral sciences, such as psychology and economics, are not included, nor are health workers, such as doctors and nurses. College and university STEM faculty are included, when possible, but high school teachers in STEM subjects are not. While all of these workers are part of the larger scientific and engineering workforce, their exclusion is based on the availability of data. (Hill, et al. 2010, p. 2)

Major Shifts Influencing STEM Education

The first conceptual shift in STEM education was in 1862 when land grant universities were created and were required to include engineering degrees for future generations. Beals (2012) discussed previously, that inventors had been on their own with no formal education, for instance, Henry Ford, Thomas Edison, and Nicolai Tesla, and it had become clear to educators that formal instruction in engineering were needed. The belief was that if engineering was offered in the universities, then more inventors could receive education and support in research and design, and the benefit to the United States would be astronomical (Beals, 2012). The Morrill Act (1862) brought into being the concept of STEM education, and once universities implemented these new requirements, students were brought into the workforce with engineering degrees. Once these students entered the workforce, they then started to implement, design, and create new innovations that assisted the United States in growing into the future and thriving through the industrial revolution and beyond (Beals, 2012).

The next conceptual shift in STEM education occurred during World War II, the United States benefited greatly from inventors who helped in winning the war. The inventors also created and had many other ideas that were documented, and the NSF was created after the war to preserve all this information (Mervis, 2010). The government was making strides at creating

STEM education initiatives before STEM was discussed, and the education benefits of The Morrill Act (1862) were starting to become apparent. The inventions created during World War II, when American innovations were abundant, was often due to the creation of engineering degrees and STEM education in universities (Beals, 2012). Students were given the proper instruction in engineering and design, and they were able to assist in the workforce upon graduation. These individuals developed major innovations for the US, and they proved how much their degrees supported their endeavors (Judy, 2011). The government was certainly grateful for all they did for the country at a major time of need for innovations (Judy, 2011). The innovations were abundant in weaponry, transportation vehicles for our soldiers, and other products that helped in winning the war.

The third conceptual shift in STEM education occurred during the late 1950s and early 1960s when President John F. Kennedy announced that NASA would send the first man to the moon (Garber & Lanius, 2005). Our technology began to grow very quickly at this juncture in time, and society improved our technical knowledge as well. The United States was competing with the USSR to be first to the moon. Sputnik had initiated the space race signifying the Soviets were the first to put a satellite in orbit (Garber & Lanius, 2005). The race was then on to see who could put the first man on the moon. As the US raced towards this accomplishment, there were more ideas and inventions created along the way, all leading to more robust STEM education degrees along the way (Garber & Lanius, 2005). President Kennedy had begun the race towards STEM education by challenging NASA to be the first to the moon (Garber & Lanius, 2005). The number of inventions that came from the United States increased dramatically during the space race, and the United States still utilizes a great number of those innovations today (Kelly et al. 2012).

In 2001 another conceptual shift occurred when STEM education was created with problem-based learning for the curriculum in primary, middle, and high schools by the National Science Foundation (Mazuzan, 1994). The term STEM was created during this time, and educators started to learn what STEM included (Mazuzan, 1994). The NSF began using the term STEM in the beginning of 2000, and during President Obama's 2011 State of the Union Address, STEM was brought into the national spotlight (Obama, 2011).

While STEM education had been becoming a larger part of the school curriculum, President Obama was a major catalyst in wanting to have STEM included in the curriculum (Department of Education, 2016). He understood the need for STEM education to create more employable individuals in STEM careers down the road. Educators and congress were challenged to bring more STEM into the classroom and to find funding for STEM (Obama, 2011). Grants and scholarships were created to assist with funding, and many agencies and companies like, NASA, began initiatives to educate the next generation in STEM education (Garber & Lanius, 2005). The need to pay for the STEM initiative was a major priority, and everyone was coming up with new ideas on how to motivate the current generation towards STEM (Kelly et al., 2012). An even bigger concern was that there were a lack of females pursuing STEM degrees/careers. President Obama brought STEM into educational standards, focusing on bringing educators on board with instruction. He wanted students to be involved in STEM at all ages, because the thought was the more students are involved in STEM the more, they will come to enjoy it (Obama, 2011).

Finally, in 2018 President Donald Trump allocated money for STEM education and brought together a Presidential Commission on STEM education (Committee on STEM Education, 2018). A national report was created to assist educators moving forward to improve

STEM education (Committee on STEM Education, 2018). Today educators have many different ideas on how to incorporate STEM into education from in the classroom, to maker spaces, and implementing full STEM based schools (Department of Education, 2016). Some of our current students will be the first astronauts to go to Mars, and STEM curriculum will be a foundation to their success (Garber & Lanius, 2005)! STEM continues to evolve throughout education, and it is seen differently through each educators' eyes. Educators need to focus on building female students' self-efficacy and critical thinking skills in STEM. The lack of females in STEM continues to grow, and as educators, we need to discover the factors that will influence female students toward STEM (Hill, et al. 2010). Female and male titles were utilized during this study as biological identifiers for the subjects studied, and the study was not completed to expand on societal gender issues.

Problem: Why are Females Underrepresented in STEM

Three major factors influence why females are underrepresented in STEM: masculine cultures which keep females away; lack of experience in computer science, engineering, and physics during females' early years of schooling; and low self-efficacy for female students (Cheryan et al., 2017). Cheryan et al. (2017) found that more research was needed in the areas of STEM enjoyment and STEM anxiety regarding gender participation within STEM, and they pointed out that early involvement with STEM could motivate female students. As a nation we need to understand why female students do not pursue STEM degrees or careers (Cheryan, et al., 2017). Female students do understand STEM because they are able to problem-solve STEM lessons in schools (Hill, et al. 2010), but with STEM lessons educators can help female students gain self-efficacy, build critical thinking skills, and overcome any fears of science and math they may have (Kelly et al. 2012). Cheryan et. al. (2017) pointed out that more early involvement with STEM could be of assistance in motivating female students towards STEM, which is a viable theory for including problem-based learning (PBL) with STEM to give students the experience in the field. For this study, there is a possibility that educators can motivate female students with problem-based learning and build females' self-efficacy and critical thinking skills towards STEM.

Definition

> **Problem-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, et al., 2011, pp. 123-124).

Technology

Critical thinking skills were what educators were asked to build in students as the STEM initiative was instituted (Committee on STEM Education, 2018). Now, technology education has begun another shift toward integrating STEM education (Sanders, 2009), and an emphasis on engineering is also being asked for by the business world. As educators learn more about STEM, we need to understand that technology is not just computers, but technology includes many other areas: bio and medical, construction, engineering, electronics, manufacturing, and energy and power (White, 2014). There are many areas in technology that educators can assist students in learning and discovering about, and in some cases, it can be the beginning of a career pursuit (Hart, 2018).

There is now a need for clarification between technology education and educational technology (White, 2014). Technology education utilizes problem-based learning where students work with math, science, engineering and technology principles, and educational technology is where educators use technology to teach students (White, 2014). Universities are changing their labels in engineering to include engineering and technology education to clarify and make the shift away from educational technology (White, 2014). In STEM, educators need to continue to explore and motivate students towards these subjects (Hart, 2018).

President Obama expressed to all educators that STEM needed to be taught to all age groups (Obama, 2011). Educators became motivated and have integrated STEM into their lessons, but in some cases, STEM is not being utilized (Hart, 2018). Educational standards need to include STEM, so that teachers come on board as well. Administrators need to bring in professional development for educators on how to motivate female students, engage female students on their level, and to adapt STEM programs to female students.

The focus had been on STEM, but not until 2018 when President Trump supported initiatives with funding, did the shift by administrators asking for a larger focus towards STEM occur (Committee on STEM Education, 2018). STEM can be expensive and so educators began to pass on STEM because of the money factor, but there are cost effective ways through grants and bringing in community members to assist schools so the costs can be cut (Committee on STEM Education, 2018).

Females' decision-making process can be influenced towards STEM careers, and they need the support of their teachers, parents, family, friends, and their community to assist in this process. Public Service Ads (PSAs) have been circulating recently, and they show females in STEM careers, for instance video game designers, astronauts, pilots, and scientists, talking to young girls about STEM careers. Society needs to continue to show support to our younger female generations to motivate them through all areas of their lives. As a nation, we need to fill many open STEM positions and finding those factors that influence female students ages 12 to 18 to pursue STEM will address this need.

Reflections and Implications

The farther society goes into the future the more the United States is going to need innovators to create new ideas for our country and our world (Hart, 2018). Educators need to ensure that students are getting STEM education if not to just create better critical thinkers but to also develop the next generation of inventors (Committee on STEM Education, 2018). Society continues to move forward, but if the United States does not have people in the job market who can assist in new developments, our country will not continue to improve (Hill, et al. 2011).

Females are as competent as males at creating new ideas, and females have come up with some of the best concepts to improve our technology for instance: rocket fuel, bullet-proof fiber, space rocket propulsion system, space station batteries, laser cataract surgery, and stem cell isolation (Hill, et al. 2011). If society loses the ideas of part of a generation, we are losing out on a wealth of information. Educators must continue to pursue all avenues moving forward to ensure STEM is taught in our schools, and how to guarantee females' self-efficacy and critical thinking skills by improving them through PBL infused with STEM. A key perception for female students is there is a stereotype that only males are mathematicians and scientists, which needs to be eliminated moving forward (Judy, 2011). Utilizing PBL in early education should be a significant approach in generating future female leaders in STEM careers.

A big concern is the efficacy of educators, because they must believe that all students can learn (Misher, 2014). They must be supportive so that female students get the same motivators that male students receive, with motivators being “you can do this” or “you are smart.” If females are not believed to be able to learn, then they will pass on science and math skills (Hart, 2018). It must be a group effort to safeguard future innovators, leaders, and educators.

Purpose Statement and Research Questions

Studies are still needed on a range of topics dealing with STEM education, and the U.S. Department of Education (2016) stated that:

> STEM 2026 envisions high-quality, culturally relevant STEM learning experiences for every child and young person. In STEM 2026, students have access to and possess a sense of belonging in STEM and lifelong learning pathways that extend across formal and informal Pre-K–12 and higher education settings, including schools, science centers, and other STEM-rich institutions. STEM 2026 includes six interconnected components:
>
> - Engaged and networked communities of practice
> - Accessible learning activities that invite intentional play and risk
> - Educational experiences that include interdisciplinary approaches to solving “grand challenges”
> - Flexible and inclusive learning spaces
> - Innovative and accessible measures of learning
> - Societal and cultural images and environments that promote diversity and opportunity in STEM (p. 6)

STEM education, comprising these six core principles, holds promise to powerfully transform all students’ access to and engagement in STEM (Department of Education, 2016).

To assist in these recommendations, studies of female students' self-efficacy and critical thinking skills are needed, and this study was conducted to see if problem-based learning infused with STEM will influence female elementary students' self-efficacy and improve their critical thinking skills.

Research Question

The study focused on surveys, interviews, and observations to determine female elementary students' self-efficacy and critical thinking skills, and if problem-based learning infused with STEM influenced them. Based on the review of literature, this study sought to answer the question, how does problem-based learning influence rural parochial-elementary female students' self-efficacy and critical thinking skills?

Sub Questions

How do female students perceive themselves in the classroom?

What aspects of problem-based learning influence females' critical thinking skills?

Chapter 2 - Literature Review

Science, technology, engineering, and math (STEM) are part of a national crisis for businesses, and the job market is unable to fill the current need for STEM fields (Xue & Larson, 2015). Education has implemented STEM into the curriculum, but STEM needs to begin at the elementary school level to attain desires from female students for careers in STEM. If females are made aware of their abilities in STEM, educators assist in improving their self-efficacy (Lockwood, 2020). Many conclusions have been made through research on the lack of interest in STEM careers, however, a lack of research on problem-based learning (PBL) and how it influences female students towards STEM careers and the affect STEM has on female students' self-efficacy and critical thinking skills was discovered when reviewing the literature. This study will be conducted to determine those factors.

Why is STEM important?

As humanity continues into the 21st century, schools continue to focus on teaching and integrating STEM lessons into the curriculum in hopes of students selecting STEM careers in their futures (Tate, 2020). Yet, policy makers and scholars are concerned that a small STEM labor pool will not meet the demands of job growth currently (Mau & Li, 2018), and even more significant to the issue is that "women are less likely than men to pursue degrees in STEM" (Bishop, 2016, p. 2). President Obama started an initiative for STEM education during his presidency, and in June 2017, President Trump signed a presidential memorandum directing the Department of Education to make STEM and computer science education a top priority (Committee of STEM Education, 2018). President Trump has also signed legislation, the Inspire Women Act (2017), to urge NASA to involve women more in STEM, and the President has requested the National

Science Foundation to engage women more in inventing (U.S. Department of Education, 2016). Research has been completed on the need for STEM, but Bishop (2016) asserted the need for studies on the factors that influence female students towards STEM careers. By utilizing problem-based learning, the possibility exists to encourage and foster more females into the STEM pipeline, and "to ensure the long-term prosperity of our Nation, we must renew our collective commitment to excellence in education and the development of scientific talent" (National Science Board, 2010, p.1). Bishop (2016) and Lockwood (2020) also recommended research should be completed on our current programs in primary and secondary schools to see if students are being influenced towards STEM careers by educators through problem-based learning.

Finally, in 2018 President Donald Trump allocated money for STEM education and brought together a Presidential Commission on STEM education (Committee on STEM Education, 2018). A national report was created to assist educators moving forward in how to improve STEM education (President's Council of Advisors on Science and Technology, 2012). Today education has many different ideas on how to incorporate STEM into education from in the classroom, to maker spaces, to problem-based learning, and implementing full STEM based schools. Some of our current students will be the first astronauts to go to Mars, so humanity must plan for their futures with STEM curriculum (Garber & Lanius, 2005)!

STEM Integration

Research shows that STEM integration in elementary years is beneficial because students begin making choices about careers during early adolescence (Auger, Blackhurst, & Wahl, 2005), and this could assist in determining if female students' early exposure to STEM, would influence their career goals and their self-efficacy (Tate, 2020). Cheryan et al. (2017) also found that early involvement with problem-based learning infused with STEM motivated female students to pursue STEM careers. Honey et al. (2014) discovered that “integrated STEM programs can support development and maintenance of interest in STEM" (p. 67) especially if STEM programs begin during the primary years. Integrating STEM lessons into the curriculum is also beneficial to females because they learn better with hands-on activities and can build critical thinking skills (Kulturel-Konak et al., 2011). Kulturel-Konak et al. also proposed that utilizing real-life examples (problem-based learning) and working towards summer internships for women could be beneficial for females in selecting STEM careers and building their self-efficacy. Educators will need to understand that they influence their students, and the potential harm of stereotypical beliefs to their students (LeGrand, 2013). Female students will perceive their role-models, for instance, teachers, counselors, and parents as being very influential in their decision-making process about their careers (LeGrand, 2013). If STEM lessons can focus on developing students’ self-efficacy, educators can motivate their students towards STEM careers and build their critical thinking skills (LeGrand, 2013).

Problem-Based Learning as a Factor

Many factors have been linked through research that motivates students to select STEM careers: social identities, self-efficacy in math and science, familial background, gender, race, school engagement, and personal/psychological norms (Mau & Li, 2018), and research should focus on the factors that influence females towards their career decisions prior to postsecondary education. Recently, Schuster and Martiny (2017) discovered women do not aspire towards STEM careers because of gender stereotypes, and Cheryan et al. (2017) also stated that low self-efficacy also contributes to the female gender gap in STEM. A need for support from counselors in high schools is desirable because Mau & Li (2018) believed females have barriers to overcome before selecting a STEM career based upon a lack of confidence, to discrimination, and stereotypes. Bishop (2016, p.2) stated, “A specific need is to increase the number of women interested in pursuing STEM careers. The participation and persistence of women in STEM-related fields is a national concern.” Female students are making decisions on STEM careers prior to entering high school, and they are also academic achievers with high math scores (Bishop, 2016). If females’ interests in STEM are piqued in primary and middle school, they are more likely to pursue STEM careers (Sadler et al., 2012). Cheryan et al. (2017) found that there was a lack of experience for female students in computer science, engineering, and physics in their early schooling. Educators should focus on females in elementary grades to motivate them towards STEM, and Tate (2020) found that teachers believed integrating STEM career-related lessons was important in elementary and middle school. Once the stereotypes are shattered, more females will pursue STEM careers, and Hart (2018) further discovered that female students were more engaged in PBL lessons during self-discovery and improved their self-efficacy. By utilizing problem-based learning (PBL), teachers can be the driving force towards female students enjoying STEM and moving toward STEM careers, and they can assist female students in developing a growth mindset towards science and math that will keep them learning (Hill et al., 2010).

Educators utilize PBL to ensure students have real-world experiences and to develop their critical thinking skills (Hmelo-Silver, 2004). The implementation of PBL in the classroom has taken on several different plans from Hmelo-Silver (2004) with a three-step process of identifying the problem, self-guided investigation, and reporting; while Gallagher et al. (1995) have a five-step process of problem presentation, analysis of the problem, self-regulated learning, data organization, and solution presentation. Finally, Delisle (1997) suggests a sevenstep process with creating a proper environment, connecting with the problem, creating a structure, reviewing the problem, revisiting the problem, product creation, and evaluation (Rehmat, 2015). There are many different ideas on implementation, however, the guidance from the facilitator is crucial for PBL to be successful (Rehmat, 2015), especially in promoting STEM careers. Therefore, many educators will need professional development prior to implementing PBL in their classrooms (Koretsky & Hirshfield, 2017) to be effective facilitators.

Teacher's Role

As the classroom has evolved, so has the diversity of student populations and educators must be able to facilitate PBL and STEM lessons to culturally diverse students (Rehmat, 2015). Instructors need to be aware of the influence they possess over students, and how they could impact a students' decision-making about their career selections or how they are a role-model for students (LeGrand, 2013). By engaging the students and adopting PBL into their teaching repertoire, teachers will be able to motivate students through the learning process (Rehmat, 2015) and develop a higher level of critical thinking. Educators will need to integrate strategies where students will question, examine, engage, explore, and develop their own insights to real world problems in problem-based learning (Rehmat, 2015).

PBL influence in K-12

Elementary students are now being included in STEM lessons, and they are appreciating the knowledge (Rehmat, 2015). A quantitative study evaluated PBL and traditional instruction and discovered that 47% of 126 students in PBL classrooms improved their self-efficacy through the control of their learning beliefs (Rehmat, 2015). Further the study showed that 43% of 126 students also scored higher in reasoning scores, who were in PBL classrooms in comparison to students in traditional classrooms (Araz & Sungur, 2007).

Forrester (2004) listed the characteristics of PBL that increase their engagement and achievement, which included student independence, discourse, and active involvement that assist them in performing at a higher level. Liu, et. al. (2006) determined that middle-school students' self-efficacy towards science with technology was a predictor of higher achievement. Another study discovered utilizing PBL, infused with technology, increased students' science accomplishments and their self-efficacy towards learning science (Rehmat, 2015). While Simons, Klein, and Brush (2004) determined that effective PBL instruction with sixth graders increased their academic achievement and created a positive outcome for the students. Azer (2009), discovered that fifth, sixth, and seventh graders PBL knowledge was determined by students' gender, age, and first language. Overall, PBL was found to be an effective way to engage students (Rehmat, 2015).

PBL is an approach that uses group-investigation, collaborative learning, and the use of the internet for research and learning information regarding the presented problem (Shepherd, 1998). Students work in collaborative groups to work through a real-world problem, analyze the data, and brainstorm ideas to solve the problem. When utilizing PBL, instructors must create challenging activities that motivate students to use their cognitive critical thinking skills. The process is a way to motivate the learner to want to learn more and to determine a solution to the problem (Shepherd, 1998). By using problem-based learning an environment is created that students' self-directed learning promotes deeper understanding and develops skills for the workforce in the future. It becomes the role of the instructor to create a stronger understanding of STEM through PBL instruction (Farland-Smith & Tiarani, 2016). As educators, determining whether PBL can influence female students' choices towards STEM careers is a key factor we must continue to discuss.

Problem-based learning has been utilized globally for all academic levels to improve knowledge base with students (Rehmat, 2015). PBL has been proven to increase higher order thinking skills in students and expand reasoning as well (Rehmat, 2015). Researchers now need to examine if utilizing PBL can motivate female students towards selecting STEM career fields, to improve their self-efficacy, and develop their critical thinking skills.

Gaps in Research

Gaps in research exist in several areas of STEM education, including female students' involvement in STEM after high school, STEM for high school students, high school students STEM career interest, and elementary and middle school student participation in STEM (Bishop, 2016, p. 35). Maltese and Cooper (2017) stated that more research was needed on what specific experiences trigger STEM interest in female students. Mau and Li (2018) proposed as a research method using a multi-tiered method that not only included surveys but also utilizes observation and interviews with focus groups, which would examine problem-based learning with STEM and its influence on elementary female students.

Women involved in STEM careers

As women have improved the number of undergraduate degrees they hold versus men, they are still behind substantially in STEM degrees.

> Advanced Placement (AP) exam participation rates reveal stark divides among and across states. For example, girls represented just 22 percent of the approximately 50,000 high school students nationally who took the Computer Science AP exam in 2015 (U.S. Department of Education, 2016, p. 27).

Educators should focus on "increasing the interest and confidence of girls and women to pursue and succeed in STEM programs and careers" (U.S. Department of Education, 2016, p.30). The accomplishments of females in math and science are influenced by the factors around them, and with the correct motivations from parents and teachers, we can influence female students towards STEM careers. A recommendation would be to have "STEM education programs in elementary schools and middle schools in order to increase the number of females interested in STEM careers" (Bishop, 2016, p. 29), and a great way to implement those STEM programs would be with problem-based learning.

Theoretical Framework

The role of females has been socialized through the community in which they live, so that females' behaviors were labeled by society (Butler, 1988). Women do not establish their roles because society does this for them which in turn squanders their equity in life, equal pay, workload, and recognition at work and with family (Butler, 1988). Butler's feminist theory was how 'women' are labeled, but then the question could become what it means to be a woman (Butler, 1988). Women have been branded in social categories and culturally conditioned, but there was no separation from being oppressed (Butler, 1988). Butler (1988) continues by asking the question why label male or female, we should all be humans and all equal.

As female students are growing in their identities, their self-efficacy can be influenced by societal norms. By identifying gender roles, society places females into roles which they may not be willing to act (Butler, 1988), and society needs to allow female students to select their own roles in society to better perform at their capabilities. Bem (1981) explained that females can feel marginalized by society, and religion may also affect student attitudes when viewing STEM subjects (Michael, 2016).

If female students believe they are lacking in knowledge of STEM fields, they can develop a low self-efficacy towards STEM. Students failing at a task build low self-efficacy, and educators must contribute to the learning process to build up a students' self-efficacy. Students' attitudes can be affected by many factors from school, subjects, and their own personal feelings on how they will perform (Michael, 2016). Students can also struggle with refocusing on a STEM subject once they have failed, but students who are inspired by the subject area are more likely to continue in STEM (Michael, 2016). Bandura (1998) stated that students with self-efficacy will confront a problem with a different method than a student with low self-efficacy, and the difference being students with stronger self-efficacy accept the challenge to solve the problem. Studies have indicated female students with higher math and science self-efficacy will achieve better than students with lower self-efficacy (Bandura, 1998). LeGrand (2013) found that high school males retained a greater level of self-efficacy than females in physics, but that their self-efficacy was equal in math and chemistry subjects. Female students can be influenced by teachers and parents toward certain subjects, but when females were surveyed, they conveyed more self-efficacy towards life sciences (Baker & Leary, 1995). Female students seem to identify more with biological sciences and maintain a higher self-efficacy towards biology (Baker & Leary, 1995). Female students possibly identified more with life sciences because they can help people (Jones et al., 2000). The issue though is that female students who maintain low scores in math and science maintain low self-efficacy and will avoid any challenging tasks that they perceived as being too difficult (Hare, 2017). The National Science Foundation's (2010) research indicated female students were not as interested in STEM as male students. Michael (2016) also reported that female students lacked an interest in being a scientist because they did not see any relationships being formed. It had been shown that female students lost interest in STEM fields because of low science and math self-efficacy (Hare, 2017). All three of these studies from the National Science Foundation (2010), Michael (2016), and Hare (2017) discussed the fact that female students either lost interest in STEM fields or did not feel a connection or relationship, and female students needed to have a personal attachment or connection to the field. Therefore, so many females moved towards life sciences because they wanted or needed to assist people (Jones et al, 2000).

The art of mastering a skill was needed in PBL with STEM infused lessons, and by engaging female students, educators could build the confidence levels of their students and increased their self-efficacy (Jenson et al., 2011). By engaging in mastery skills, students would collaborate with each other, an important element of STEM, learn from each other, and lessen the fear of failing (Jenson et al., 2011). Another key to improving female students' self-efficacy would be to include female role models from STEM fields, so students can observe others succeeding in the field (Hare, 2017).

Lent et al. (1994, 2000) explained that a person's interest will be piqued when they have experienced that indicates how they can be successful and have a positive outcome. Thus, self-efficacy and a person's expectations may influence their decision making towards selecting a career (Lent et al., 1994). Butler (1988) stated that by working with social performances, gender reality can be achieved, and leaving gender behind to only see human beings would be the reality for the future. When promoting confident attitudes towards STEM, educators can foster enjoyment for STEM subjects and increase students' self-efficacy through motivation (Michael, 2016). By utilizing self-efficacy and feminist views, these theories may link a perspective as to how female students build their self-efficacy and improve their critical thinking skills.

Chapter 3 - Methodology

The study focused on how problem-based learning influenced female elementary students' self-efficacy and critical thinking skills in STEM. The students were all from the same parochial school located in rural Kansas. The researcher was also a teacher in this school and community, and the researcher had most of the students in class previously. The teacher had established rapport with students over an eight-year career at the school. As a result of the standing credibility and trustworthiness that existed between the researcher and students, all students were ready and willing to assist the researcher in all parts of the study. A qualitative case study approach was conducted utilizing Merriam's case study approach (Yazan, 2015).

Participants and Setting

This study targeted female elementary students in fifth grade and took place in the researcher's classroom within a rural, parochial school. The participants were selected as a result of the lack of studies on elementary level female students in STEM (Bishop, 2016). Mau and Li (2018) proposed a research style using a multi-tiered method which would examine problem-based learning with STEM and how it influenced elementary female students. All students selected were taught by the researcher, who utilized PBL instruction in her classroom. The participants and setting selection were based on convenience for this study.

Participants

The target population were female elementary students in fifth grade from a small school district in a rural, Midwestern community. The location and setting were chosen out of convenience as students attended the same school the researcher was employed at. There was a total of 16 female students within fifth grade, who were all asked to participate in the study. The students had a parental consent form that was required to be signed and returned for the students to participate in the study, and the students were also required to complete a self-assent form to participate in the study. The female students were between 10 and 11 years old, with 87.5% white and 12.5% Hispanic; additionally, 25% of the students were from low-income range and 75% from the medium to high income range. The number of fifth-grade students who participated in the study totaled 25, with 16 female students and 9 male students. The female students have interacted with STEM lessons in previous years, and were shown STEM careers in fourth grade, as such they held a basic understanding of STEM. They have all previously conducted STEM experiments in other grade levels at the school. Male students were also instructed at the same time as female students, completed the same self-assent forms, but were excluded from this study because of their gender.

The researcher was the teacher in the study and was a technology specialist for the school. The teacher had taught the female students involved in the study previously, following which the teacher moved to fifth grade where the study was conducted. The teacher holds a Bachelor of Arts in Elementary Education and a Master of Science in Technology Education (Technology Integration Specialist). The teacher is state certified to teach grades K-6 and had over nine years of teaching experience at the elementary level.

School Setting and Demographics

The study took place in a parochial school located in a rural Kansas community which is part of a parochial school district located elsewhere in Kansas. The administration had asked that STEM be integrated into all lessons, that all instructors utilized STEM at some point in their lessons. During the study both classes of fifth graders were taught the same PBL with STEM infusion. In prior years, the researcher had instructed all grade levels and utilized STEM within the curriculum. The elementary population is 239 students. There were 123 (51%) males and 116

(49%) females in the elementary school with 16 females in fifth grade. As the study was focused on female students in STEM, there was a total of 16 female students who participated.

Case Study

Merriam defined “case as a phenomenon of some sort occurring in a bounded context” (Merriam, 1998, p 27). A qualitative case study is “intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process or a social unit” (Merriam, 1998, p xiii). The qualitative case study approach used for this case study followed Merriam’s case study, this study also retained Merriam’s definition of “heuristic as enlightening the reader’s perspective of the phenomenon being studied” (Yazan, 2015, p 139).

Merriam combined sections of Yin and Stake creating guidelines a researcher needed to proceed through a case study (Yazan, 2015). Merriam included five steps to research design: literature review, theoretical framework, describing the research problem, defining research questions, and identifying the sample (Yazan, 2015) which was incorporated into the case study.

Research Design

The case study employed a qualitative data analysis including two surveys, interviews, and field notes from observations. For this study, a data analysis utilized the survey data prior to the interviews and combined field notes with the interview to begin the coding process. The coding process then developed the themes utilized in the findings section of this study.

The teacher presented the problem of climate change for the fifth-grade students to work through in a PBL environment. The teacher posed the question “How can you shrink your carbon footprint?” to students when discussing the overall problem of climate change. Following the presentation of the problem and question to be answered, discussion was held to address any questions students had, as well as to observe students’ understanding. Students were also encouraged to discuss with their classmates and collaborate as they worked to answer the more specific question in relation to climate change. Female students were then interviewed, and after the interviews, students were allowed to verify their transcripts and make any changes to their interviews prior to data analysis.

The study included a four-phase design: Pre-Instructional Phase, Instructional, Interviews, and Post-Instructional Phase. The pre-instructional phase included students completing a demographic and questionnaire form, an interest survey, and the S-STEM Survey. The instructional phase included a PBL lesson with STEM integration, student centered activities, group collaboration, and a discussion on STEM careers. The researcher performed classroom observations during PBL instruction and completed a field notes journal. The interview phase was developed for only the female students to answer open-ended questions, and it queried the students about their involvement with PBL and STEM careers. The researcher in this study was also the teacher for the PBL unit. The Post-instructional phase included students completing an S-STEM Survey, interest survey and a PBL questionnaire.

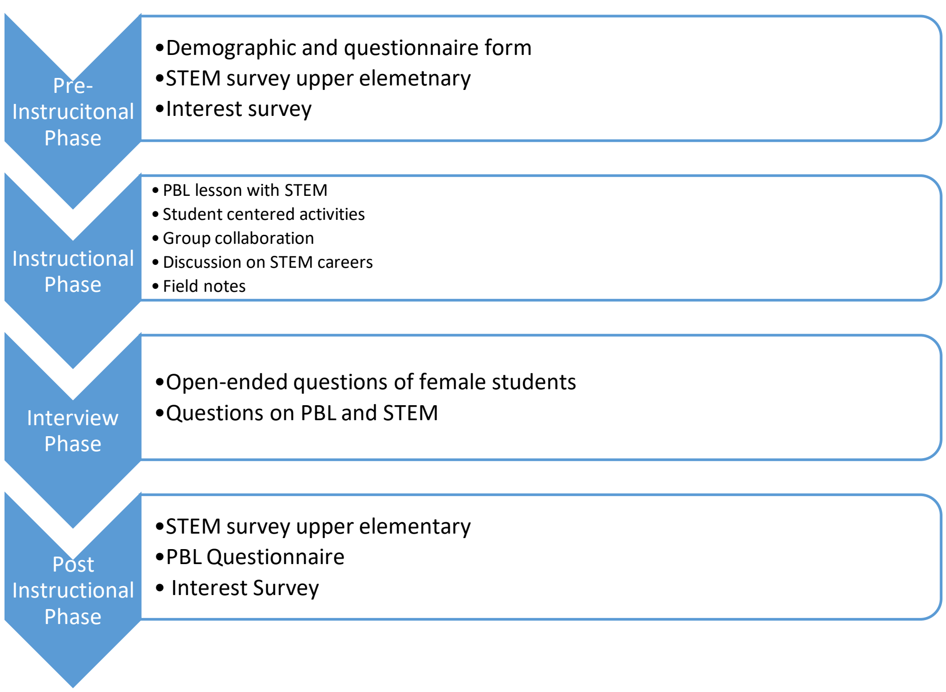

Figure 3.1 Pre/Post research design

PBL Unit Plan

The STEM infused problem-based unit was developed for the fifth-grade students with the PBL works website, and the unit plan can be found at this website https://my.pblworks.org/project/shrinking-our-footprints. The PBL unit was developed to meet the NGSS Standards (NGSS Lead States, 2013) along with the Kansas Technology standards for students (Waston, 2020). The core idea of the unit focused on shrinking our carbon footprint on the Earth, concentrating on how humans interact with the earth. The unit plan addressed the NGSS Standards, 5-ESS3-1 Earth and Human Activity: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment, the Kansas Common Core Mathematics Standards, 5.MD.2. Make a data display (line plot, bar graph, pictograph) to show a data set of measurements in fractions of a unit (12,14,18,116). Use operations (add, subtract, multiply) on fractions for this grade to solve problems involving information presented in the data display, 5.MD.5. Relate volume to the operations of multiplication and addition and solve real-world and mathematical problems involving volume, 5.NF.6. Solve real world problems involving multiplication of fractions and mixed numbers, *(e.g. by using visual fraction models or equations to represent the problem),* and Kansas Technology Standards (Watson, 2020). Student teams focused on one resource: water, garbage, electricity, or car fuel consumption. Teams researched information, such as the amount of water per minute of a shower or the number of miles per gallon used by a family car, and then they conducted home inventories to determine how much waste occurred within one week at home. Students graphed their individual families' use, and then determined goals to have for their families moving forward. The students then graphed how their plans assisted their families in lowering their carbon footprint on the Earth. They also utilized STEM and designed solutions for zero waste by creating presentations of their ideas.

Forms

Prior to the start of the PBL, students completed their assent forms that were previously signed by their parents at parent-teacher conferences. All forms were signed by parents, and the researcher had 100% participation from all students during the study. Students also worked on their demographic forms and interest surveys, which asked students about what careers they were hoping to pursue. Students were able to complete these forms quickly and without any issues.

Upper Elementary School S-STEM Survey

The Friday Institute for Educational Innovation (2012) created the S-STEM survey and was utilized to measure fifth grade students' thoughts concerning STEM for this study (Appendix 3.1). The validity of the content of the S-Stem survey was proven by a committee of five experts and ten educators prior to its release for use (Friday Institute for Educational Innovation, 2012). The tool included 37 statements: eight positions regarding math, nine positions regarding science, nine positions regarding engineering and technology, and eleven positions regarding 21st century skills. Participants answered questions using a five-point Likert scale with a score of one being a negative response towards STEM while a score of five was positive. Participants' scores on the S-Stem survey were a mix, but the participants may have been confused on the first survey as on the second survey there was less of a change in scores.

Classroom Observation

The researcher completed classroom observation by taking field notes in a journal during the study. During the classroom problem-based learning experience, the students and teacher were present and detailed notes were transcribed during each class period. The researcher kept detailed notes of each section of the unit plan from implementation, interaction with students, employment of the unit plan, and their part in the PBL experience. A field notes journal was utilized, and notes were taken on how often the students interacted in their groups, if there were questions for the instructor, any issues that group members had during collaboration, and how often students were off task. The journal was beneficial to the researcher by allowing for background information to be transcribed along with observations during the study.

Procedures

Once IRB approval was received, the study commenced during the fall semester of 2021 for 16 weeks. The fifth graders attended class with the instructor every day. All students were given the PBL instruction with STEM infusion, but the male students' data was not included in this study. The fifth graders received instruction on Mondays, Wednesdays, and Fridays. A breakdown of the plan of instruction is located below.

Table 3.1 Study Timeline for PBL and Interviews

Activity	Duration
Pre-Instruction Phase	Two class periods
• Assent Form	(2 weeks)
• Demographic Form	
• Interest Survey	
• S-Stem Survey	
Instructional Phase – Unit Plan	
• Explanation of PBL instruction	
• Problem discussion, students discuss how investigation will proceed	
• Students lead investigation, data collection, and plan	Eight class periods
• Discussion on STEM careers	(8 weeks)
• Field notes	
Interview Phase	Four class periods
• Open-ended questions of female students	(4 weeks)
• Questions on PBL and STEM	
Post Instructional Phase	Two class periods
• S-Stem Survey	(2 weeks)
• PBL Questionnaire	
• Interest Survey	

Pre-Instruction Phase

First, the assent forms were signed by all parents during parent-teacher conferences. The students then completed their assent forms, demographic forms, and interest surveys during their initial class period. During the next class period, the teacher explained the S-STEM survey, and the students completed the survey.

Instructional Phase

The teacher discussed how PBL instruction would occur and that the students would be leading their own knowledge growth. The problem was introduced as climate change while the specific question the students would be answering was phrased as "How can you reduce your own carbon footprint?" Students were then assigned to groups based on their area of interest, the four different areas students could choose from were food waste, gasoline, water, or electricity usage. Once in their groups, students then constructed questions they needed to ask to develop research on their main question. As the students worked towards answering their overall question, they discovered other websites to utilize for their research, and they shared this information with their classmates.

Students led their own investigations, planned, and set dates for their data collection, which was over a long Thanksgiving week break. Once students arrived back at school, they proceeded to improve their plans on shrinking their carbon footprints. The teacher had a small discussion on STEM careers upon their return, following which the students created graphs of usage for each family in their group. Students then began a collaboration on shrinking their carbon footprints, and as groups decided whether to present their plans by creating posters or Goggle Slides. During the instruction phase a field notes journal was employed by the researcher. Field notes assisted the researcher in the interview process as well and was an excellent benefit to the study.

Prior to winter break, students had practiced their presentations, and they presented to all 5th graders and their teachers. The students were all knowledgeable on their topics, and they had clear and concise presentations. They were able to answer questions from the audience and their teachers showing background knowledge. They also presented their plans to their families over Christmas break, and all students were able to persuade their families to work towards shrinking their carbon footprints.

Interview Phase

Fifth-grade female students completed an interview stage with the researcher. The researcher posed open-ended questions to the female students to determine if students were able to increase their self-efficacy during PBL instruction, if their critical thinking skills improved, and discuss how they felt about PBL and STEM careers. Female students discussed how they felt more confident in STEM, and some of the students discussed how their critical thinking skills had improved from the PBL instruction. Female students also discussed how the male students had influenced their learning and self-efficacy. The interviews were conducted by class, and the females from Classroom A were interviewed first followed by the females in Classroom B. Group interviews were conducted to help the students feel more comfortable and more willing to discuss their experiences. The interview questions are available in Appendix 3.2

Post-Instructional Phase

Students completed their final S-STEM survey after the completion of their PBL presentations, they also completed a PBL questionnaire on what their likes and dislikes were during the unit. The S-STEM survey was completed twice, as it was utilized as a pre/posttest for the students. The students completed it during a class period with the researcher reading the directions and questions to them, the researcher then allowed time for the students to select their answers and any questions students asked for clarification. The students were able to complete the post survey prior to the interviews. The interest survey was also completed for a second time to see if the female students' results had shifted from the initial interest survey.

Data Collection

Following Merriam (1993), interviews were conducted, field notes were written through observations, two interest surveys were completed, and two S-STEM surveys were collected for qualitative analysis both pre- and post-PBL (Yazan, 2015). An S-STEM survey was conducted to begin analysis of the participants prior to the interview stage, the survey is at Appendix 3.1. The survey was employed as a collection tool to see how many participants held established opinions about STEM. This data was then utilized in the interview stage to assist with the open-ended questions presented to the participants along with an interest survey, and the questions for the interview were listed in Appendix 3.2. Finally, PBL instruction was used with the fifth-grade students to determine if PBL would be of benefit in assisting female elementary students in building their self-efficacy and critical thinking skills in STEM. By utilizing PBL instruction, the researcher allowed students to commit to their own learning. The students became the knowledge base experts on carbon footprints, electricity, water, gasoline, and food waste, while they conducted their research by accessing websites selected by the instructor. Students then located other websites that were beneficial for their research, and they shared these websites with their peers. The instructor kept a list of websites for the students on Google Classroom and added to the list during the PBL.

Data Analysis

Utilizing a constructivist view, the researcher followed Merriam's suggestion of analyzing data while collecting at the same time (Yazan, 2015). A hand-written process was employed to manage the data during the study. A qualitative analysis was conducted of the data collected, and initial codes were created from the surveys, interviews, and field notes. The codes were then combined into themes and findings for the study which were listed below.

Table 3.2 Codes and Themes

Code	Theme: Improved Critical Thinking	Type	Code	Theme: Improved self-efficacy	Type	Code	Boys Affect Learning	
1.1	Yes: Conscious Realization	TAC	1.1	Creative Ideas	OBJ	1.1	Degrading	ATT
1.2	Yes: Conscious Realization	TAC	1.2	Observant	OBJ	1.2	Put us down	ATT
1.3	Yes: Conscious Realization	TAC	1.3	Supports our learning	OBJ	1.3	Ridiculed	ATT
1,4	Better Choices	TAC	1.4	Learned about environment	OBJ	1.7	Don't care	ATT
1.5	Know find answers	TAC	1.5	Nice being in charge of my learning	OBJ	1.8	Make jokes	ATT
1.6	Know find answers	TAC	1.6	Gained knowledge: Persevere	OBJ	1.13	Loud	ATT
1.7	Improved	OBJ	1.7	Make world better	ATT	1.14	Rushed	ATT
1.8	Gained Knowledge	OBJ	1.8	Groups: help us share knowledge	TAC	1.20	Don't listen	ATT
			1.9	Learned stop waste	TAC	1.22	Disagree with us	ATT
			1.1	Have more confidence	ATT	1.23	Frustrated	ATT
						1.4	Distraction	CON

1.5	Annoying	CON
1.6	No Help	CON
1.11	Don't share knowledge	CON
1.17	Know it alls	CON
1.18	Wouldn't take our ideas	CON
1.19	Think we aren't smart	CON
1.24	Side track easily	CON
1.25	Know technology	OBJ
1.10	Some quiet	OBJ
1.9	Some help (cousin)	EMO
1.26	Happy had no boys on team	EMO
1.21	Difficult	EMO
1.15	Uncomfortable	EMO
1.16	Make you feel bad	EMO
1.12	Done with them	EMO

Open-ended questions utilized in the study were developed to assist in further exploring the participants' thoughts, ideas, and fears about STEM careers. The questions also assisted in showing the self-efficacy of the participants. Following the interview an open dialogue took place, during which the female students added what they felt was important in PBL. This was beneficial to the researcher as it provided additional information or feedback that was not collected during the formal interview process. The collected data was coded by the researcher and analyzed to determine themes for the data in a more detailed manner. These detailed themes were evaluated and then combined into broader themes. The themes were able to answer the research question for this project and were as follows: improved critical thinking skills, improved self-efficacy, how males affect learning, careers in science/engineering, role models, and challenging subjects, and with the lack of data for some themes, the focus will be on improved critical thinking skills, improved self-efficacy, and how males affect learning.

Positionality Statement

As a female and a mother of two daughters, the researcher wanted to investigate why females are lacking in STEM careers, and even more significant to the issue is that "women are less likely than men to pursue degrees in STEM" (Bishop, 2016, p. 2). By utilizing the feminist theory, the researcher has discovered that the focus was on empowering women that wanted it all, a career and family, and the emphasis was on blocking the stereotype about sex and gender (Fortman, 2017). By combining feminist theory with Bandura's self-efficacy theory, the focus was then utilized for this research. Concepts of self-efficacy are focused with a person's perception of how capable they are and their achievements (Bandura, 2006). Self-efficacy is an issue for female students who are continually told they cannot do something or that they do not have a high enough IQ. When observing this through the eyes of my daughters, I can see that the feminist theory interlocks with self-efficacy theory, and that my daughters and my female students are continuously fighting an uphill battle. Females are told they are not smart enough or they do not have the capabilities to do/play something, and it begins in elementary school. Females' self-efficacy must surpass the pressures of a male dominated area, STEM, and then they must prove to themselves and everyone else that they can be anyone they want to be. Self-efficacy derives from how humans are capable of development and adapting to change (Bandura, 2006), which will establish the focus of this study of how female elementary students' self-efficacy and critical thinking skills were influenced by PBL infused with STEM.

Chapter 4 - Findings

A qualitative analysis was conducted of female elementary students' self-efficacy and critical thinking skills in STEM and how problem-based learning influences these skills, along with the perception female students have of themselves in the classroom. The outcomes of the qualitative data analysis are below.

Analysis of S-STEM Surveys

A quantitative data analysis was conducted utilizing a pre- and post S-Stem survey which was administered to all participants prior to the PBL and afterward. The quantitative data was collected, analyzed, and evaluated by one researcher, and the researcher also analyzed t-tests and p-values for the data. The data was inconclusive, as such, the researcher determined that moving forward a qualitative analysis was required. The means of the October and December surveys were so close in proximation that no difference could be determined. Below are the t-tests and p-values for each section of the survey showing the inconclusive means, nothing was less than .05, in each section studied which included elementary science, engineering/technology, and 21st century skills. Tables 4.1, 4.2, and 4.3 were inconclusive for the research which would have shown how the female students gained knowledge in science, engineering/technology, and 21st century skills, but because the values were not less than .05 the results were too close to show any improvements in the female students' skills.

Table 4.1 T-Test Elementary Science

Two-sample t test with equal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
october	16	3.451381	.1219128	.487651	3.19153	3.711232
december	16	3.375	.1433981	.5735926	3.069354	3.680646
combined	32	3.413191	.0928321	.5251375	3.223858	3.602523
diff		.0763813	.1882173		-.3080097	.4607723

diff = mean(**october**) - mean(**december**) t = **0.4058**

Ho: diff = 0 degrees of freedom = **30**

Ha: diff < 0	Ha: diff != 0	Ha: diff > 0
Pr(T < t) = **0.6561**	Pr(|T| > |t|) = **0.6878**	Pr(T > t) = **0.3439**

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Table 4.2 T-Test Elementary Engineering/Technology

Two-sample t test with equal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
october	16	3.409731	.1589968	.6359871	3.070838	3.748625
december	16	3.340269	.2052449	.8209796	2.9028	3.777738
combined	32	3.375	.1278541	.7232522	3.11424	3.63576
diff		.0694625	.2596256		-.4607637	.5996886

diff = mean(**october**) - mean(**december**) t = **0.2675**

Ho: diff = 0 degrees of freedom = **30**

Ha: diff < 0	Ha: diff != 0	Ha: diff > 0
Pr(T < t) = **0.6046**	Pr(|T| > |t|) = **0.7909**	Pr(T > t) = **0.3954**

Table 4.3 T-Test Elementary 21st Century Skills

Two-sample t test with equal variances

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
october	16	4.068169	.1204053	.4816211	3.811531	4.324806
december	16	4.005675	.1017973	.4071891	3.788699	4.222651
combined	32	4.036922	.0777563	.439856	3.878337	4.195507
diff		.0624937	.1576709		-.2595133	.3845006

diff = mean(**october**) - mean(**december**) t = **0.3964**

Ho: diff = 0 degrees of freedom = **30**

Ha: diff < 0	Ha: diff != 0	Ha: diff > 0
Pr(T < t) = **0.6527**	Pr(|T| > |t|) = **0.6946**	Pr(T > t) = **0.3473**

Analysis of Interest Survey

The interest surveys were given to all 16 female students at the beginning of the PBL and afterwards to analyze any changes in thoughts or opinions the female students possessed following the conclusion of the unit. The survey asked students what their favorite subject was, what subject they needed help in, if they were confident in math or science, did they enjoy STEM, and what their career path would be. The data showed improvement in two areas: the students' best subject (math or science) and their decision on a career path in relation to STEM careers. The female students had a decrease in the number who needed assistance in math or science. The data is included in Table 4.4 Interest Survey Data below.

Table 4.4 Interest Survey Data

			Interest Survey			
	Best Subject	Subject need Help	Confident Math	Confident Science	Enjoy STEM	Career
Beginning of PBL	5	5	13	15	11	3
End of PBL	11	2	14	16	14	8
Improvement	up 6	down 3	up 1	up 1	up 3	up 5

Analysis of Focus Group Interviews Transcripts

The focus group was conducted at the end of the fall semester 2021 with 15 of 16 female students participating. Six major themes emerged from the coded data based on the following research questions: how does problem-based learning influence female elementary students' self-efficacy and critical thinking skills in STEM and sub-questions, how do female students perceive themselves in the classroom, and what aspects of problem-based learning influence females' critical thinking skills? The themes were as follows: improved critical thinking skills, improved self-efficacy, how males affect learning, careers in science/engineering, role models, and challenging subjects, but with the lack of data within a few themes, the three major themes that will be focused on were improved critical thinking skills, improved self-efficacy, and how males affect learning.

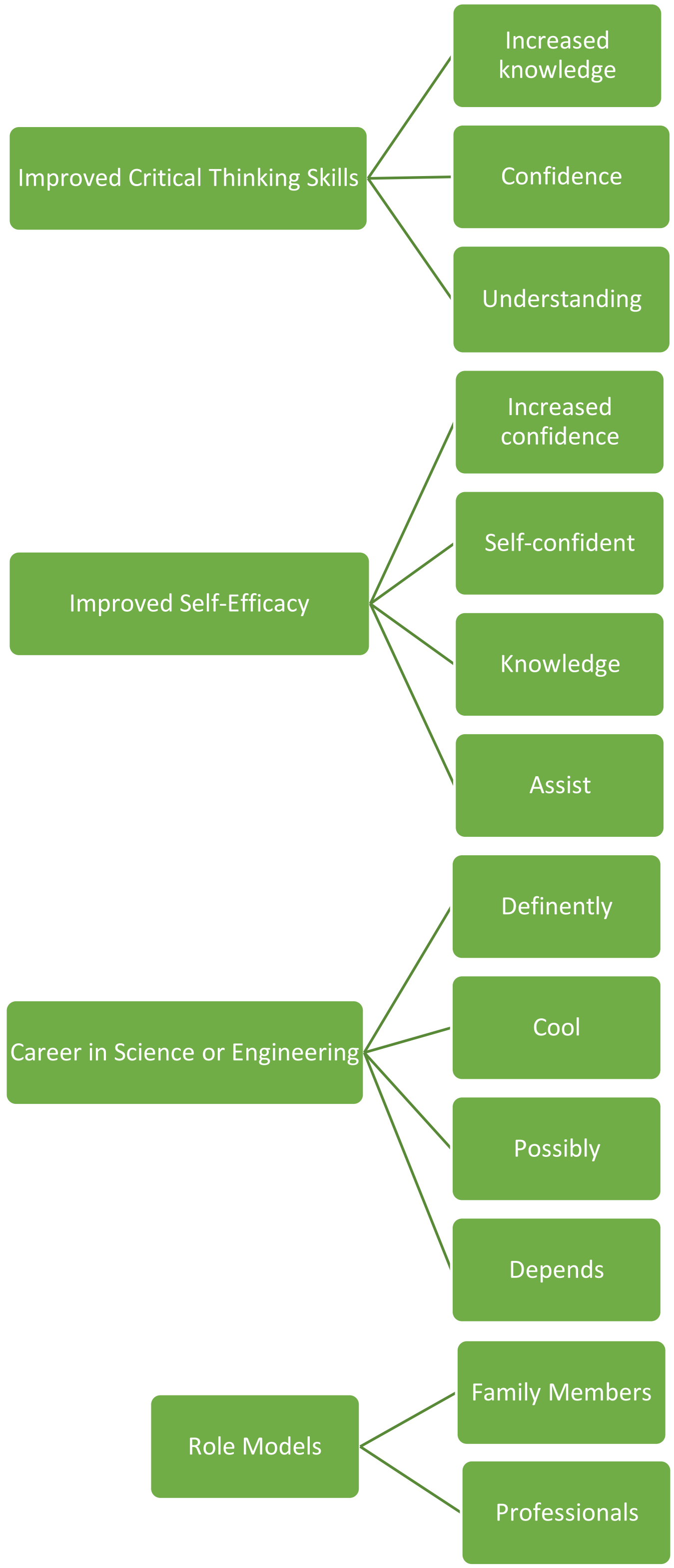

Figure 4.1 Themes (Positives)

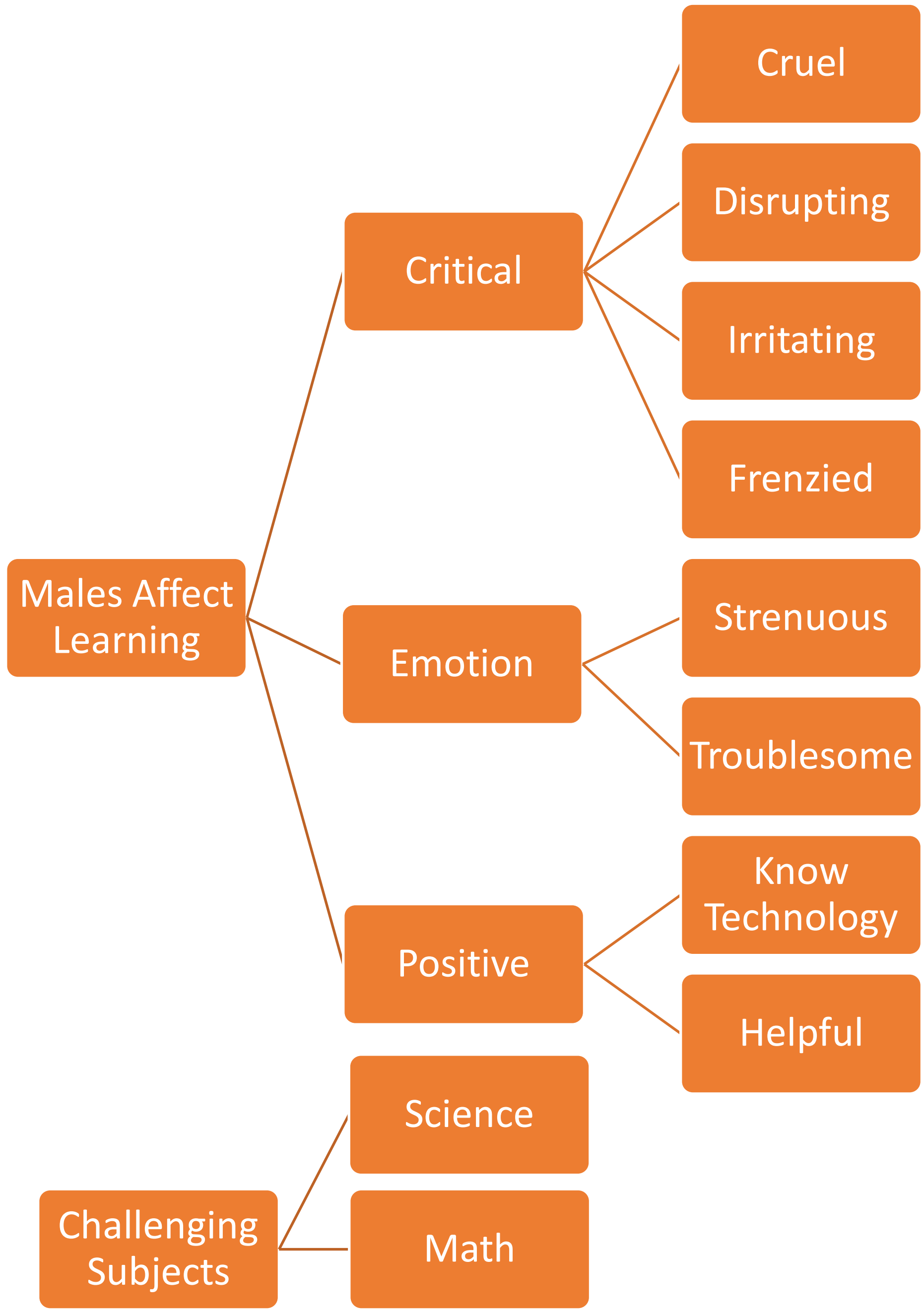

Figure 4.2 Themes (Negatives)

The qualitative data was collected by analyzing the open-ended interview process (Appendix 3.2), an observation journal, kept by the researcher during the instruction phase, and two interest surveys (Appendix 3.3). The S-Stem survey was included but not utilized in this research (Appendix 3.1). A qualitative case study was utilized for this analysis. The design method was employed as all students interviewed shared and experienced the same phenomenon related to the PBL.

Critical thinking was defined as:

> the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. In its exemplary form, it is based on universal intellectual values that transcend subject matter divisions: clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth, and fairness. (Scriven & Paul, 1987, p 1)

Theme 1: Improved critical thinking

Female students critical thinking skills were improved during the PBL unit. During the coding process, three sub-themes developed, they were increased knowledge, confidence, and understanding. Though these themes were not represented in the definition, they were important for the female students to gain knowledge to ensure they would have the ability to apply what they had learned from the PBL. By gaining confidence and understanding, the female students were gaining the intellectual values required to successfully navigate the critical thinking process (Scriven & Paul, 1987).

Increased Knowledge

The female students gained valuable knowledge about STEM related fields and PBL throughout the study. Per the data collected during the interview stage, students identified improved critical thinking skills, with 50% of female students stating their critical thinking skills had been enriched during the PBL. As the researcher observed, the female students were more willing to assist in discussions and come up solutions for problems by the end of the PBL, a contrast to their behavior prior to the PBL which displayed a shyer or timid nature, as annotated in the field journal. The notes from the field journal showed an improvement for female students as the PBL progressed, and the female students were more willing than male students by the completion of the PBL to participate in class discussions. From the field notes journal, student 10 explained, “My dad spent over $300 dollars on gas during our Thanksgiving trip.” The male student in her group tried to blame the gas stations for increased prices, but student 10 explained that OPEC was the reason for gas prices increasing. A 10-minute discussion followed in order to explain OPEC and how oil prices are determined. It was noticeable that the female students were gaining knowledge and were more willing to interact in the classroom per the researcher’s field notes. Student 5 explained her critical thinking skills had improved, “I understand how to approach a problem much better, and I can work to solve an issue,” which was annotated in the field notes journal. Students 1, 6, 2, and 5 all had conscious realizations that they were now better at coming up with ideas to solve problems, which displayed an increased knowledge base and was annotated in the field notes journal, “We can work out problems now, and can solve an issue much easier.” As the researcher observed in the field notes, the female students did improve their critical thinking skills. By being more engaged in the class, the female students showed a development in their knowledge base.

Confidence

To the researcher, improvement was noticeable, per the field journal, that the female students' confidence levels had improved, with focused observation of a very quiet, shy student 8, who began to open-up and interact with others during the PBL. The female students increased their confidence while completing the PBL unit. Student 15 explained during the interview stage, "I know where to find information on websites, and I have gained knowledge." Student 12 explained, "I have learned how to make better choices," which she had also discussed during the interview stage. 15 of 16 female students gained confidence during the PBL, and the researcher was able to document this improvement during the interview stage. When asked if the students had gained confidence, all the students agreed, except for one who was absent. The female students' interest surveys also showed improved confidence levels by selecting math and science subjects as their best subjects increasing from 6 of 16 to 11 of 16. The female students also showed slight increases of 6.25% in confidence levels in their math or science subjects. With such results it is clear that the PBL unit improved students' confidence levels and also was beneficial in improving critical thinking skills.

Understanding

Female students retained the information given during instruction time. This improvement was made evident by how they gained a deeper understanding of STEM subjects through PBL, this in turn helped improve the students' critical think skills. The female students enjoyed learning through PBL as student 15 discussed per the interview stage, "it was fun learning this way, and I like being in charge of my learning." While documenting their progress, the researcher noted in the field notes journal that several students, 3, 5, 7, and 11, gained understanding and were more involved in the PBL by the students exclaiming, "NASA has a great website that even has ideas on shrinking our carbon footprints. We need to use this information and show the other groups what ideas they have." The interest survey also showed improved understanding for the female students in their math and science subjects by 11 of 16 female students believing these were their best subjects. The students have grown in their critical thinking skills.

Theme 2: Improved self-efficacy

Female students' self-efficacy improved during PBL instruction, and in fact, the qualitative data clarified that 10 of 16 female students improved their self-efficacy per the interest survey. The coding in this theme was separated into two different sub-themes: work ethic and confidence levels. Bandura (2006) defined as focused with a person's perception of how capable they are and their achievements.

Work ethic

Students improved their self-efficacy through their work ethic by being more observant than at the beginning of the PBL, supporting each other, gaining knowledge, participating, and being productive. The researcher was able to observe these improvements and document them in the field notes journal as evidence of students' improvement. The researcher documented in their journal that female students were discussing where they were locating information, sharing information, and locating answers quicker than in previous sessions of the PBL. Once female students became more aware of the information, they seemed to grow their knowledge base, which allowed for an improved self-efficacy, as student 12 noted during the interview stage, "in groups we are learning more, and we are able to share our knowledge. I didn't realize that I was learning so much until we went to create our presentations, and I just knew so much than before we began the PBL." Female students were enhancing their collaboration and work ethic skills during the PBL. The advancements in female students' work ethic assisted in improving their self-efficacy.

Confidence levels

The PBL enhanced the female students' confidence levels as they interacted more in discussions following the PBL than when the PBL first began, which was documented in the field notes journal. The female students increased their levels of confidence through determination, researching independently, and wanting to help the environment. Student 6 revealed, "I have located new websites for our research," and she shared these sites with everyone in the class, which the researcher noted in the field notes journal. Student 5 stated during the interview stage, "I have gained more confidence in myself, and I believe in myself." Student 3 explained, "I want to help keep us safe by cleaning up the environment," which was annotated in the field notes journal. Student 13 described, "I was having problems understanding the information, but I was able to find another website that explained the research to me where I was able to understand it better," which was documented in the field notes journal. The female students' interest surveys also showed improved confidence levels by selecting math and science subjects as their best subjects increasing from 6 of 16 at the beginning of the PBL to 11 of 16. The female students also showed slight increases of 6.25% in confidence levels in their math/science subjects. Obviously the PBL unit improved their confidence levels and was a benefit to improved critical thinking skills. The female students' self-efficacy greatly improved during the PBL.

Theme 3: Males affect learning

The female students wanted to discuss the male students at the end of the interview stage as they wanted their issues with the males heard. Once they began answering this question several themes appeared, however the most interesting theme was revealed by the qualitative data analysis through coding of how males affected the female students' learning. It was revealed that the males had a tremendous effect on the females' learning during the PBL unit, distracting the female students, not letting them speak, and the sometimes-malicious criticism from the male students. The PBL groups were determined by the students ranking their favorite group, and they could select from gasoline, trash, water, or electricity. The groups consisted of 4 groups evenly split by gender, 2 groups of 3 females and 1 male, and one group of 3 females, and while there were only nine males, they did have a visible impact on the female students.

Males being critical

Female students had reactions towards the males because the males were being critical of them with sub-themes of males being a disturbance by being off topic in discussions, and 13 of 16 of the female students believed the males were being critical of them from the interview stage. Student 8 stated, "the male in our group called me stupid, and said none of us knew what we were doing." Student 12 explained during the interview, "they have a lot of sidetracks," and student 6 stated, "they are just an annoyance." During the researcher's journal entries, it was noted that the males were easily distracted by other options on their laptops or even getting distracted by their surroundings, instead of completing their research. Student 7 revealed, "they are kind of like loud, and stuff like that, it can make me feel rushed and uncomfortable." Student 1 agreed, stating, "they just get distracted and are like, sometimes they just want to be annoying. They would also change what we had completed and that would be annoying." Student 5 described more of the male students' behavior, "they would make jokes that weren't even funny and get off topic."

The males were irritating and unaccepting of the females' ideas as they criticized anything they suggested. Student 1 explained during the interview, "they kind of made fun of us because we don't really know a lot about computers." Student 6 expanded, "we asked them how you make shortcuts, and they were like you don't know how to do that. You are just so weird." The males were irritating to the females because they would not assist them or share their knowledge, and this was evident from the researcher's journal because the males were told to assist the females by helping with technology and sharing their knowledge. Assisting the female students did not occur, because per the interview stage, students 1 and 6 explained, "we were teased, and told we didn't know technology, so why should the boys help us." The female students were not excited to have to collaborate when the males were so unaccepting of their knowledge and ideas per the field notes journal. Student 7 explained, "We were trying to brainstorm, and they were unaccepting of our ideas." Student 1 continued, "We created a character, and the males did not want to add it to the slides. A couple minutes later, we didn't do the character, and one of the males comes up with the idea to just like put a character in it." Student 15 added, "I was thrilled not to have any males on my team." Finally, student 8 revealed, "I did not like that we had one boy who thought he had all the ideas, and he wouldn't take any of our ideas." The researcher had not been made aware of these issues during the PBL, except for a couple of problems that were addressed, which included refocusing a male student who was off task, stopping an argument on how to proceed with a presentation, and not assisting the females in their group with technology. It was obvious that the males did not want any assistance from the females or to include any ideas from the females.

Emotions

In addition to the male students creating disturbances and general unrest among the female students there were also subthemes of a stressful environment and being irritating/unaccepting. The stressful environment for the female students centered in on the male students in their groups, the males were troublesome and stressful by not following the rules and continuously being off topic during the unit.

The males caused unrest with the female students, which student 10 explained during the interview, “it was hard because they would not listen to us or accept our thoughts.” Student 11 added, “I didn’t fully agree with the boys in my group, and then they just don’t want to listen because they feel they are the only one that’s correct. When I would not put their ideas on a slide they would get upset. It was frustrating at times.” From the interview stage, 15 of 16 female students felt the males were being troublesome or causing a strenuous environment for the females during the PBL, the final female was absent during the interview process. The female students were visibly and verbally upset by how the males treated them during collaboration.

The male students created a variety of problems by not following the rules of the PBL and not staying on task during the unit. They were disruptive on occasion which was discussed in the field notes, and the researcher noted that discussions occurred with several groups that consistently needed to be reminded to stay on task during the PBL needed to stay on task during the PBL. In one group a male student was consistently off task, noted by Student 2, “our boy said I’m just going to take six or I don’t have to do it. I told him he would still have to present, and it’s kind of like how all the males are, they just don’t want to help.” Student 7 agreed during the interview stage and stated, “you are trying to work and get this thing done, and they are just making some stupid joke. It’s just distracting.” It was clear that the male students required refocusing and needed to be monitored more closely; however, the researcher was not made aware of these issues until the interview stage, which followed the completion of the PBL.

Positive

During the interview stage 3 of 16 female students explained how some of the males were helpful during the project, providing some data of positive opinions that had formed of a few of the male students. The positive theme also had two subthemes: some of the males were quiet and helpful, in addition to which they understood technology and kindly explained to the female students when they were confused or unsure. Student 5 stated, “like some of the males are somewhat helpful,” and student 14 added, “they do know technology.” Only three female students discussed how the males were helpful during the interview, and the researcher noted on occasion that a couple of the male students did assist the females with technology issues. However, it does appear that the males would have been seen in a more positive light if they had followed the examples of their peers and worked with the female students instead of against them.

Conclusion

Though having inconclusive results from the S-STEM survey data, after evaluating the data from student interviews, observations/journal entries, and interest surveys, the qualitative data shows positive improvements on self-efficacy and critical thinking skills with problem-based learning. The student interviews show that female students are inspired when they can collaborate with each other and discuss their plans and ideas. Students enjoyed being able to work through real-world situations and to critically think through the problem to come up with a solution.

Chapter 5 - Discussion

Introduction

The number of female students pursuing careers in science or math is not increasing; however, by offering problem-based learning to rural, parochial-elementary female students teachers can assist in improving female students' self-efficacy, critical thinking skills, and possibly promote a connection to STEM careers in the future. Utilizing PBL helps students to learn and improve, and problem-based learning is a unique way to see female students advance their skills and learning (Tate, 2020). This study was conducted to answer the following questions:

1. How does problem-based learning influence rural parochial-elementary female students' self-efficacy and critical thinking skills?
2. How do female students perceive themselves in the classroom?
3. What aspects of problem-based learning influence females' critical thinking skills?

Summary of Findings

The purpose of this study was to determine if problem-based learning in a fifth-grade classroom would improve rural parochial-elementary female students' self-efficacy and critical thinking skills. The data answers the researcher's questions from two interest surveys, focus group interviews, and classroom observations. Mau and Li (2018) proposed a research method which utilized a multi-tiered method in regard to surveys but also including observation and interviews with a focus group, which was accomplished during this study while examining problem-based learning infused with STEM. This study has worked through this multi-tiered method and come to the following conclusions.

Self-efficacy and critical thinking skills

Female students perceived that their critical thinking skills improved, and that they gained knowledge during the PBL unit. Per the data collected during the interview stage, 8 of 16 female students stated their critical thinking skills had been enriched during the PBL. As the researcher observed, the female students were more willing to assist in discussions and come up with a wider range of solutions for problems by the end of the PBL in contrast to the beginning of the study. The interest surveys also showed an increase in the females' feelings that their best subjects were math/science. It was noticeable that female students were gaining knowledge and were more willing to interact in the classroom per the researcher's field notes. Butler (1988) indicated the need to allow female students to select their own roles so they can perform at their highest capabilities. Thus, by allowing the free thinking associated with the PBL, the female students' critical thinking skills were enhanced, and an improvement was also observed for female students in STEM subject areas from the PBL. Female students flourished during the research phase of the PBL, and the female students grasped their role in the unit with improved willingness to participate and a deeper level of understanding.

During the survey, student 5 explained her critical thinking skills had improved, and students 1, 6, 2, and 5 all concluded that they were now better at coming up with ideas to solve problems. As the researcher observed in her field notes, the female students did improve their critical thinking skills during the PBL, and they were more willing to raise their hands and answer questions. Jenson et al. (2011) explained that educators can build female students confidence levels which will increase their self-efficacy, and by being more engaged in the class, the female students show more confidence in themselves and their answers.

By allowing the female students to decide from multiple options with the PBL, the students were able to select the topics they wanted to learn about and have experiences, this led to positive outcomes and as a result, the female students' confidence increased (Lent et al, 1994, 200). To the researcher it was noticeable, per the field notes journal, that female students' confidence levels had increased by focusing observation on the very quiet, shy Student 8, who began to discuss and interact with others during the PBL. Improving the female students' confidence levels was a benefit to improved critical thinking skills, which can then bring female students towards the selection of career in STEM (Lent et al., 1994).

Female students were retaining the information they were studying for the PBL, and it was obvious from how they gained understanding of STEM through the PBL, which helped improve their critical thinking skills. The female students enjoyed learning through PBL as Student 15 discussed, "it was fun learning this way, and I like being in charge of my learning." While documenting their progress, the researcher noted in the field notes that several students, 3, 5, 7, and 11, gained understanding and were more involved in the PBL by discussing and giving ideas during the PBL. By allowing female students to select their own roles during the PBL, the researcher was able to allow the free thinking of female students, allowing them to display their true capabilities without restriction (Butler, 1988). As such, it is clear the female students have grown in their critical thinking skills throughout the PBL.

Female Students' Perception

Bandura (1998) explained that as individuals gain self-efficacy the more their belief in themselves improves, allowing them to strive for academic success. Female students' self-efficacy improved during the PBL instruction, and the qualitative data showed more specifically 10 of 16 female students improved their self-efficacy once the post-PBL interest survey was given. As with Bandura (1998), students displayed their improved self-efficacy through their work ethic as they were more observant, supportive of peers, and perceptive of valuable, new knowledge. These changes were observed by the researcher and the annotated in the field notes journal, allowing the researcher to have visible proof of improvement. The researcher documented in their journal that female students were discussing where they were locating information, sharing information, and locating answers quicker than in previous sessions. Once female students became more cognizant of the information, they seemed to cultivate and share their knowledge, which allowed for an improved self-efficacy. Student 12 noted during the interview stage, “in groups we are learning more, and we are able to share our knowledge,” which shows an enhancement in their collaboration and work ethic skills.

Confidence levels

The PBL displayed enhanced the female students’ confidence levels because they interacted more in discussions, not just during the PBL but all subject areas. The female students improved their confidence levels by being more self-confident, gaining knowledge, and wanting to help the environment. Student 6 revealed, “I have located new websites for our research,” and she shared these sites with everyone in the class, which the researcher noted in her field notes journal. The female students increased their confidence level by persevering, learning to be more independent in the classroom, and wanting to help the environment, which was noted in the field notes journal by the researcher. The female students’ self-efficacy greatly improved during the PBL.

The female students’ level of commitment to their research increased when faced with a real-world problem. Hart (2018) revealed in their study that students who were engaged in PBL during self-discovery reached self-efficacy, and by evaluating the findings of this study, it shows a strong correlation to Hart (2018) as female elementary students' self-efficacy and critical thinking skills improved during this PBL. The advancements in female students' work ethic and confidence levels assisted in improving their self-efficacy, and as such justifies Bandura's theory on self-efficacy. Female students were actively working to improve throughout the PBL.

While they understood their new roles in the PBL, female students gained self-efficacy in solving the real-world problem, which Bandura (1998) discussed was beneficial to improved self-efficacy. Bandura (1998) explained that students with stronger self-efficacy will confront and accept the challenge to solve the problem, and the female students did thrive in this environment during the PBL. By linking the theories of Butler and Bandura, it can be justified then that the PBL was beneficial to improving self-efficacy and confidence levels. The advancements in female students' work ethic assisted in improving their self-efficacy.

Influences

The female students were adamant that if the males were not part of the PBL, they would have had an easier time completing tasks. It was revealed during this part of the interview that the male students had a tremendous effect on the females' learning during the PBL unit, which was also noted in a few instances in the field notes the researcher took. As Butler (1988) stated, educators need to allow students to select their own roles, so they can perform at their capabilities, and when males become critical the females become frustrated.

Males being critical

Female students had negative reactions towards the male students as the males were being critical of them, and 13 of 16 females during the interview stage believed the males were being rudely critical of them. Student 12 explained, "they have a lot of sidetracks," and student 6 stated, "they are just an annoyance." Within the researcher's journal entries, it was noted that the male students were easily distracted by other options on their laptops, in addition to which they would distract themselves quickly with their surroundings rather than focusing on their research. Student 7 explained, "they are kind of like loud, and stuff like that, it can make me feel rushed and uncomfortable." Student 1 agreed stating, "they just get distracted and are like, sometimes they just want to be annoying. They would also change what we had completed and that would be annoying." Student 5 further expanded, "they would make jokes that weren't even funny and get off topic."

In the female students' eyes the male students were being irritating and unaccepting of the females' ideas by being critical. Student 1 explained, "they kind of made fun of us because we don't really know a lot about computers." Student 6 expanded, "we asked them how you make shortcuts, and they were like you don't know how to do that. You are just so weird." The male students were irritating to the female students because they would not assist the females or share their knowledge. This was also observed from the researcher's point of view, annotated in the field notes, as the males were consistently told to assist their female classmates by helping them to better understand technology or share knowledge obtained in their research, unfortunately, this did not happen. This does, however, support Bandura's theory (1998), showing how women's roles are squandered by society, generally as the males remove equity as they do not believe females to be equal to them and therefore do not deserve to share the same space with the males.

The female students were not excited to have to collaborate when the males were so quick to disregard their knowledge and ideas. Student 7 explained, "We were trying to brainstorm, and they are unaccepting of our ideas." Student 1 continued, "We created a character, and the males did not want to add it to the slides. A couple minutes later, we didn't do the character, and one of the males comes up with the idea to just like put a character in it." Student 15 added, "I was thrilled not to have any males on my team." Finally, Student 8 revealed, "I did not like that we had one boy who thought he had all the ideas, and he wouldn't take any of our ideas." The researcher had not been made aware of these issues during the PBL, apart from a few situations that were addressed as a full class during the unit. It was obvious that the males did not want any assistance from the females or to include any ideas from the females, displaying at a young age just how females' influence and behavior is viewed by society (Butler, 1988).

Emotions

There were also additional difficulties the female students had to face when working with male students, while it has been established that the males created a stressful environment there were specific difficulties observed by the researcher and discussed with female students in the final interview. These difficulties, as expressed by the female students, were the male students cause problems by not following the rules of the assignment as well as consistently being off topic throughout the unit. While discussing the stressful environment the male students created Student 10 explained, "it was hard because they would not listen to us or accept our thoughts." Student 11 added, "I didn't fully agree with the boys in my group, and then they just don't want to listen because they feel they are the only one that's correct. When I would not put their ideas on a slide they would get upset. It was frustrating at times." From the interview stage, 15 of 16 female students felt the males were being troublesome or causing a strenuous environment for the females during the PBL, Student 16 was absent on the day of the final interview. The female students were clearly upset by how the males treated them during what was meant to be a collaboration.

The male students were troublesome by not following the rules of the PBL and staying on task during the unit. The male students were disruptive on occasion which was discussed in the field notes, and the researcher was forced to refocus several groups that were not on task many times. Student 2 had the following to say about the male student in her group, “our boy said I’m just going to take six or I don’t have to do it. I told him he would still have to present, and it’s kind of like how all the males are, they just don’t want to help.” Student 7 had a similar experience, stating, “you are trying to work and get this thing done, and they are just making some stupid joke. It’s just distracting.” It was clear the males needed to be refocused and more closely monitored; however, the researcher was only made aware of these incidents at the end of the PBL and did not have the opportunity to make such adjustments during the unit. Per Bandura (1998), educators need to allow female students to select their own roles so they can perform at their capabilities, and it would be beneficial to allow female students to work together to observe how they would progress in the unit.

Positive

There were a few positive opinions about male students who were not rude, critical, or disruptive, with 3 of 16 females discussing during the interview how some of the males were helpful. Student 5 stated, “like some of the males are somewhat helpful,” and Student 14 added, “they do know technology.” Only two female students discussed how the males were helpful, and the researcher noted on occasion that two of the male students did assist the females with technology issues in the field notes. A few males were more accepting of the females and therefore were more willing to assist with technology and listen to the female students’ ideas about the project. This phenomenon could be understood by utilizing Butler (1988) to form a theory that at some point gender will be ignored and they will simply be peers, equal. However, it was also noted by both the female students and the researcher that it would have been far more helpful and beneficial for all if the rest of the male students followed their lead.

Limitations

The first limitation was the fact that the study was limited to a single STEM unit plan as if multiple units were taught a wider range of data would have been analyzed. Another limitation was that the study was contained within a single parochial school in one grade level, as multiple grade levels would have, again, provided a wider range of data. The fifth-grade students shared the same teacher, resources, and curriculum which influenced their interests. The students also shared similar demographics with similar race and socio-economic background. The final noted limitation lies with the fact that the study was conducted with self-reported data from the surveys of the female students.

Recommendations for research

The research behind problem-based learning has grown, and studies have revealed many facts. The background of this study indicated that males do have an influence on females during collaboration. A suggestion can be made for a study where the groups are separated by gender to observe how the groups learn without influence of the opposite gender, and more specifically how female groups can improve their self-efficacy and critical thinking skills without the influences of their male counterparts. In relation to the importance of this study, separating by gender would also help to display the different ways the genders think, at the end of which discussion could happen about the differences and similarities in thoughts between the genders. The females in this study agreed that they would have had a better learning environment without the males in their groups, thus with a study separating the males and females, more detailed conclusions could be drawn from this type of study. Teacher observation was limited to a 16-

week observation window, by extending the timeframe to the second semester better data could be collected. By collecting data over the entire school year, data could be collected in different areas by separating the groups by gender and then by combining genders to compare the overall differences. In addition to these benefits, collecting data from a larger number of students would provide a wider range of data from performing the PBL.

Utilizing PBL instruction is beneficial for all students and assists them in developing their critical thinking skills. PBL is an excellent method of instruction for students to gain knowledge on working through and solving real-world problems (Misher, 2014). Additionally, studies could be conducted on how students work and solve these real-world problems while having fun. Students can become frustrated with trying to solve real-world issues and PBL allows them to thrive in situations where they feel they are more in control of what they're learning.

Conclusion

Butler's (1988) feminist theory and Bandura's (1998) self-efficacy theory combined to display how female students' critical thinking skills and self-efficacy improved during the PBL unit. Butler's (1988) theory indicated how educators need to allow female students to select their own roles in the classroom which would then allow them to perform at their capabilities. Additionally, by allowing the free thinking associated with the PBL, the female students enhanced their critical thinking skills and revealed an improvement with increased knowledge held by female students in all STEM subject areas. Bandura (1998) theorized that students with stronger self-efficacy accepted a challenge to solve a problem more frequently, which was revealed by how the female students in this study gained self-efficacy. The association between Butler and Bandura brought to light the fact that feminist theory and self-efficacy theory are interconnected in this study of female students' critical thinking skills and improved self-efficacy.

Students greatly enjoyed problem-based learning, and the PBL was an effective strategy for improving students' 21st century skills. PBL allowed students to find answers to real-world problems and understand how to utilize science, engineering, and math in their lives. Students enjoyed overseeing their own learning and could advance through the material at their own pace. By utilizing PBL in the classroom, instructors could facilitate more learning in an educational environment, and made math, science, and technology less intimidating for female students. Female students increased their self-efficacy through PBL, this also allowed them to utilize their critical thinking skills in a method that students enjoy far more than studying math and science problems from a textbook all day. Professional development would need to be introduced in schools to ensure all teachers know the process of PBL. Even if only a few of the teachers from a school attended professional development on PBL they would be able to return and act as trainers for their co-workers. PBL was enjoyed by the students and staff during this study and proved that it will be beneficial for all teachers and students moving forward in the 21st century.

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Appendix A - Appendix A.3.1 S-Stem Survey

Student Attitudes Toward STEM (S-STEM) Survey

Upper Elementary School Students (4-5th grades)

Last Updated March 2014

Appropriate Use
The Upper Elementary School (4-5th) S-STEM Survey is intended to measure changes in students' confidence and efficacy in STEM subjects, 21st century learning skills, and interest in STEM careers. The survey is available to help program coordinators make decisions about possible improvements to their program.

The Friday Institute grants you permission to use these instruments for educational, noncommercial purposes only. You may use an instrument as is, or modify it to suit your needs, but in either case you must credit its original source. By using this instrument you agree to allow the Friday Institute to use the data collected for additional validity and reliability analysis. The Friday Institute will take appropriate measures to maintain the confidentiality of all data.

Recommended citation for this survey:
Friday Institute for Educational Innovation (2012). *Student Attitudes toward STEM Survey-Upper Elementary School Students*, Raleigh, NC: Author.

The development of this survey was partially supported by the National Science Foundation under Grant No. 1038154 and by The Golden LEAF Foundation.

The framework for part of this survey was developed from the following sources:

Erkut, S., & Marx, F. (2005). *4 schools for WIE* (Evaluation Report). Wellesley, MA: Wellesley College, Center for Research on Women. Retrieved April 5, 2012 from http://www.coe.neu.edu/Groups/stemteams/evaluation.pdf

Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook*, 2010-11 Edition.

This project received support from The Golden LEAF Foundation.

DIRECTIONS:

There are lists of statements on the following pages. Please mark your answer sheets by marking how you feel about each statement. For example:

Example 1:	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I like engineering.	○	○	○	○	○

As you read the sentence, you will know whether you agree or disagree. Fill in the circle that describes how much you agree or disagree.

Even though some statements are very similar, please answer each statement. This is not timed; work fast, but carefully.

There are no "*right*" or "*wrong*" answers! The only correct responses are those that are true *for you*. Whenever possible, let the things that have happened to you help you make a choice.

PLEASE FILL IN ONLY ONE ANSWER PER QUESTION.

This project received support from The Golden LEAF Foundation.

Math

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. Math has been my worst subject.	○	○	○	○	○
2. When I'm older, I might choose a job that uses math.	○	○	○	○	○
3. Math is hard for me.	○	○	○	○	○
4. I am the type of student who does well in math.	○	○	○	○	○
5. I can understand most subjects easily, but math is difficult for me.	○	○	○	○	○
6. In the future, I could do harder math problems.	○	○	○	○	○
7. I can get good grades in math.	○	○	○	○	○
8. I am good at math.	○	○	○	○	○

Science

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
9. I feel good about myself when I do science.	○	○	○	○	○
10. I might choose a career in science.	○	○	○	○	○
11. After I finish high school, I will use science often.	○	○	○	○	○
12. When I am older, knowing science will help me earn money.	○	○	○	○	○
13. When I am older, I will need to understand science for my job.	○	○	○	○	○
14. I know I can do well in science.	○	○	○	○	○
15. Science will be important to me in my future career.	○	○	○	○	○
16. I can understand most subjects easily, but science is hard for me to understand.	○	○	○	○	○
17. In the future, I could do harder science work.	○	○	○	○	○

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Maximizing the Impact of STEM Outreach
Science, Technology, Engineering and Mathematics

THE WILLIAM & IDA FRIDAY INSTITUTE FOR EDUCATIONAL INNOVATION
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Engineering and Technology

Please read this paragraph before you answer the questions.

Engineers use math and science to invent things and solve problems. Engineers design and improve things like bridges, cars, machines, foods, and computer games. **Technologists** build, test, and maintain (or take care of) the designs that engineers create.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
18. I like to imagine making new products.	○	○	○	○	○
19. If I learn engineering, then I can improve things that people use every day.	○	○	○	○	○
20. I am good at building or fixing things.	○	○	○	○	○
21. I am interested in what makes machines work.	○	○	○	○	○
22. Designing products or structures will be important in my future jobs.	○	○	○	○	○
23. I am curious about how electronics work.	○	○	○	○	○
24. I want to be creative in my future jobs.	○	○	○	○	○
25. Knowing how to use math and science together will help me to invent useful things.	○	○	○	○	○
26. I believe I can be successful in engineering.	○	○	○	○	○

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21st Century Learning

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
27. I can lead others to reach a goal.	○	○	○	○	○
28. I like to help others do their best.	○	○	○	○	○
29. In school and at home, I can do things well.	○	○	○	○	○
30. I respect all children my age even if they are different from me.	○	○	○	○	○
31. I try to help other children my age.	○	○	○	○	○
32. When I make decisions, I think about what is good for other people.	○	○	○	○	○
33. When things do not go how I want, I can change my actions for the better.	○	○	○	○	○
34. I can make my own goals for learning.	○	○	○	○	○
35. I can use time wisely when working on my own.	○	○	○	○	○
36. When I have a lot of homework, I can choose what needs to be done first.	○	○	○	○	○
37. I can work well with all students, even if they are different from me.	○	○	○	○	○

Your Future

Below is a list of types of work that you could do when you are older. As you read about each type of work, you will know if you think that work is interesting. Fill in the circle under the words that describe how interested you are in doing that when you are older.
There are no "*right*" or "*wrong*" answers. The only correct responses are those that *are true for you*.

	Not at all Interested	Not So Interested	Interested	Very Interested
1. ***Physics:*** *People* study motion, gravity and what things are made of. They also study energy, like how a swinging bat can make a baseball switch directions. They study how different liquids, solids and gas can be turned into heat or electricity.	○	○	○	○
2. ***Environmental Work:*** *People study how nature works. They study how waste and pollution affect the environment. They also invent solutions to these problems.*	○	○	○	○
3. ***Biology:*** *People* work with animals and plants and how they live. They also study farm animals and the food that they make, like milk. They can use what they know to invent products for people to use.	○	○	○	○
4. ***Veterinary Work:*** *People who prevent disease in animals. They give medicines to help animals get better and for animal and human safety.*	○	○	○	○
5. ***Mathematics:*** *People* use math and computers to solve problems. They use it to make decisions in businesses and government. They use numbers to understand why different things happen, like why some people are healthier than others.	○	○	○	○
6. ***Medicine:*** *People* learn how the human body works. They decide why someone is sick or hurt and give medicines to help the person get better. They teach people about health, and sometimes they perform surgery.	○	○	○	○
7. **Earth Science:** People work with the air, water, rocks and soil. Some tell us if there is pollution and how to make the earth safer and cleaner. Other earth scientists forecast the weather.	○	○	○	○
8. ***Computer Science:*** People write instructions to run a program that a computer can follow. They design computer games and other programs. They also fix and improve computers for other people.	○	○	○	○

	Not at all Interested	Not So Interested	Interested	Very Interested
9. ***Medical Science:*** *People study human diseases and work to find answers to human health problems.*	○	○	○	○
10. **Chemistry:** People work with chemicals. They invent new chemicals and use them to make new products, like paints, medicine, and plastic.	○	○	○	○
11. ***Energy/Electricity:*** People invent, improve and maintain ways to make electricity or heat. They also design the electrical and other power systems in buildings and machines.	○	○	○	○
12. ***Engineering:*** *People* use science, math and computers to build different products (everything from airplanes to toothbrushes). Engineers make new products and keep them working.	○	○	○	○

About Yourself

1. How well do you expect to do this year in your:

	Not Very Well	OK/Pretty Well	Very Well
English/Language Arts Class?	○	○	○
Math Class?	○	○	○
Science Class?	○	○	○

2.

	Yes	No	Not Sure
Do you know any adults who work as scientists?	○	○	○
Do you know any adults who work as engineers?	○	○	○
Do you know any adults who work as mathematicians?	○	○	○
Do you know any adults who work as technologists?	○	○	○

Appendix B - Appendix B.3.2 Interview Questions

What is your hardest subject in school and why do you believe this is true?

How do you feel about being a scientist in the future?

After completing our PBL, how do you see yourself with engineering now?

What type of engineer would you like to be in the future?

What type of inventions could you create for use in our community?

Who are role models in your life that you would like to be like when you grow up?

How have your critical thinking skills improved while completing this PBL?

Do you feel more confident after completing the PBL?

Would you like to add anything about this PBL that you believe would be helpful?

How has it been working with the boys?

Appendix C - Appendix B.3.3 Interest Survey

1.	Student Name			
2.	What is your race? White Hispanic Black Other			
3.	What is your best subject?	Yes	No	Unsure
4.	What subjects do you need help?	Yes	No	Unsure
5.	Are you confident in math?	Yes	No	Unsure
6.	Are you confident in science?	Yes	No	Unsure
7.	Do you enjoy STEM?	Yes	No	Unsure
8.	What career path do you want to take?			