The Impact of Project-Based Learning Instruction on Anxiety, Confidence, and Academic Growth in the Applied Algebra Classroom

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Abstract

Student anxiety, confidence, and achievement in mathematics play a critical role in student success after high school. The purpose of this study was to investigate the differences in student anxiety, student confidence, and student achievement between students who received Project-Based Learning (PBL) instruction and students who did not receive PBL instruction in the Applied Algebra classroom. The Applied Algebra classroom was chosen for this study because historically this is the course where lower achieving math students are enrolled. The independent variables of interest in this quantitative study were Applied Algebra course format, where PBL was used as an instructional method and where PBL was not utilized as an instructional method; and student demographics, including gender (male, female), Individual Education Plan (IEP) status (had an IEP, did not have an IEP), socio-economic status (SES) (free/reduced, no designation), and ethnicity (White, non-White). The dependent variables were student anxiety in mathematics, student confidence in mathematics, and the change in mathematics academic growth using the Measures of Academic Progress (MAP) scores from fall to spring.

The results of the study indicated that confidence was higher in the PBL class. Anxiety and academic growth were not different based on class format. The demographics did not impact this finding with the exception that students with an IEP receiving PBL instruction reported lower mathematics anxiety than those with an IEP in the non-PBL class and they reported lower anxiety than students without an IEP in the PBL classroom.

This study has implications for district personnel and parents interested in considering alternative instructional approaches. The impact of these instructional considerations could include increasing overall student confidence in mathematics and reducing mathematics anxiety specifically for students with an IEP. Recommendations for future research include expansion of student sample size and the addition of other assessments to measure student achievement, student confidence, and student anxiety in mathematics.

Dedication

This work is dedicated to my family. First, to my husband, Rob, who without his support and continuous encouragement, this doctoral work would have never happened. Next, to my daughter Kala who showed me daily that her love and support of me during this process was unwavering. Finally, to my son, Jake, who showed me unconditional love during this journey even when I told him that I "could not go" this time. Jake shows me daily that the impossible is, in fact, possible. Yes, Jake, it is all possible.

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Chapter 1

Introduction

When considering the overarching goal of education, one would be remiss to not acknowledge the need for high levels of critical thinking by all students. Tiwari, Lai, So, and Yuen (2006) asserted that the 21^{st}-Century global society no longer sees the knowledge of obsolete facts as the ultimate goal for student learning, but rather the fostering of critical thinking at all levels of education. In an age and time of global awareness and problem solving serving as a critical trait for employment and future success, education must examine the way in which learning is achieved to produce students who can compete and thrive in a continually changing society (Assistant Superintendent of Teaching and Learning of District S, personal communication, March 23, 2017). However, helping students attain these levels of critical thinking are challenging while using our current approach to teaching (Assistant Superintendent of Teaching and Learning of District S, personal communication, April 13, 2017). Students must be provided the opportunity to engage in a multitude of 21^{st}-Century skills such as simulation, collaboration, reflection, and exhibition (Director of KC Rising, personal communication, May 5, 2017). The acquisition of these global problem-solving skills may be achieved through the implementation of Project-Based Learning (PBL) instruction.

PBL is defined as a student-driven, teacher-facilitated approach to learning (Bell, 2011). At the core of PBL is student inquiry and exploration based on an overarching idea, essential question, or problem. This level and skill of questioning creates independent thinkers and learners. In many ways, "students flourish under this student-driven, motivating approach to learning and gain valuable skills that will build a strong foundation for their future in our global economy" (Bell, 2011, p. 39). In the area of mathematics, students must gain the ability to think critically in terms of numeracy. Under the umbrella of mathematics, Algebra encompasses the "concepts, principals, and techniques" of all branches of mathematics (Huntley, Rasmussen, Villarubi, Sangtong, & Fey, 2000, p. 329). The skills and concepts students learn during Algebra set them on a progression for success in future math and life endeavors.

Algebra has been the heart of secondary school mathematics for many years. This class is essential for long-range success regardless of a student's future goals due to the critical numeric concepts that are learned in an algebra course (District S Math Coordinator, personal communication, June 11, 2017). The director of KC Rising (personal communication, September 15, 2017) shared that students gaining the ability to think critically and globally in mathematics potentially increase their chances of becoming marketable to employers based on the idea that through PBL instruction students learn the 21st-Century skills of simulation, collaboration, reflection, and exhibition. Understanding that the skills necessary for student success are grounded in 21st-Century competencies, the need to examine the steps in equipping students for this kind of future is necessary. As a result of this need, the combination of mathematical concept attainment, reduction in mathematics anxiety, increased confidence in mathematics, and critical levels of thinking generated by the implementation of PBL instruction in the mathematics classroom is the basis for this research.

Background

During the 2017-2018 school year, District S was a suburban district in Kansas that served 30,415 students of which 26% qualified for free/reduced lunch and 32% received special education (SPED) services (District S, Student Information System, (SIS), 2018). This suburban district had strong community support for all 53 schools operating in the district at the time of the study. This support is grounded in high expectations for student achievement. At the time of this study, this district had five comprehensive high schools. The two high schools chosen for this study had similarities in student demographics. Both high schools had student populations of approximately 2,200, the free/reduced percentage was comparable, the number of students receiving special services was similar, and finally, the ethnic make-up of the population was similar (District S, Student Information System [SIS] 2018). Additionally, both schools offered an Applied Algebra class. Due to the similarities in all these areas, School A and School B were chosen for this study.

During the 2017-2018 school year, students entering middle school in District S were afforded the opportunity to take on-level mathematics or an accelerated on-level mathematics course titled Math Plus. Once students enter high school, there are two mathematics curricular pathways available. Pathways include either taking Algebra or Applied Algebra during the student's freshman year (District S Mathematics Coordinator, personal communication, August 2017). In District S, the Algebra course is considered the accelerated course and Applied Algebra is considered the remedial course.

For the 2017-2018 school year, 32% of the students were placed in Applied Algebra (District S, Student Information System (SIS), 2018). The mathematics track leading out of Applied Algebra placed these students on a trajectory for consistent and continual remediation and support (District S Mathematics Coordinator, personal communication, August 2017). The curriculum of the Applied Algebra course followed the curriculum of the on-level Algebra course with remediation implemented for enrolled students.

Historically, students enrolled in Applied Algebra have lacked the skills to succeed in an on-level Algebra course (District S Mathematics Coordinator, personal communication, September 17, 2017). The critical thinking that is required of these students is vital to succeeding in the on-level track of mathematics. Additionally, students enrolled in this track of mathematics have lacked the interest, engagement, and confidence level to otherwise succeed in an on-grade level course (District S Mathematics Coordinator, personal communication, August 2017). To remedy low student engagement and confidence in mathematics, it was imperative that leaders in the district examine instructional shifts in this course.

The implementation of PBL introduced a strong pedagogical shift in classroom instruction. According to Krajcik, Czerniak, and Berger (1999), “this approach engages learners in exploring important and meaningful questions through a process of investigation and collaboration” (p. 27). PBL replaces the traditional approach to teaching and learning by placing the ownership on the learner. Utilizing the PBL approach for instruction, the teacher no longer completely provides the delivery of information. Through strategic planning and questioning, the traditional teacher becomes the facilitator of the classroom rather than the one imparting the details and the majority of the content. The PBL approach invites students to research and utilize their voice and choice regarding their learning and products of their learning (Frank & Barzilai, 2006). Since PBL promotes responsibility and independent learning, it offers multiple ways for students to participate and to demonstrate their knowledge. PBL instruction can also be matched to the various learning styles of students (Frank & Barzilai, 2006). Given that students enrolled in the Applied Algebra course lack critical skills in mathematics, PBL instruction provides the scaffolded instruction some students need.

An examination of the District S vision statement, *Students Prepared for Their Future*, illuminates that teaching in a way that impacts all students and their individual needs is essential. In District S, there is a commitment to supporting students and creating an environment for success beyond high school. Rogers, Gresalfi, Cross, and Trauth (2011) stated that “a PBL approach aims to situate the learning of basic disciplinary concepts within the context of real-world problems that students find relevant to their everyday life” (p. 6). This relevance creates the meaningful experiences that students need to find success and confidence in their capabilities.

Statement of the Problem

As mathematics scores continue to decline as students enter high school, the causes behind this downward trend must be examined (Kotok, 2017). Possible reasons behind the absence of mathematics success rest in students’ inabilities to accurately understand numeric processes related to mathematics. Additionally, the lack of student engagement, largely due to a lack of students connecting relevance to the content area, adds to this downward spiral. A student’s inability to think at this elevated critical level in mathematics creates a roadblock for student success beyond high school (Cheema & Kitsantas, 2014).

In District S, the trend of descending mathematics assessment scores is a concern. The high school MAP mathematics scores in District S continue to decrease or have shown no improvement for six years (District S Mathematics Coordinator, personal communication, August 2017). One potential solution to this lack of improvement is to increase student engagement and student connection to the relevance in the content area of mathematics.

Beginning in the fall of 2017, District S implemented a district focus on PBL. One of the five high schools, which opened in August of 2017, began as a full-scale PBL school. District S's commitment to relevance and engagement as it relates to student learning using PBL is exemplified in this school design. In addition, District S offered district-wide professional learning on PBL to teachers in 2017-2018. However, the impact of this training had not been evaluated. Therefore, it was critical to explore the influence of the PBL approach on student anxiety, confidence, and achievement in mathematics.

Purpose of the Study

There were three purposes for this study. The first purpose of this study was to determine if there was a difference in student anxiety and confidence in mathematics between students receiving PBL based instruction in the Applied Algebra classroom and students not receiving PBL based instruction in the Applied Algebra Classroom. The second purpose of this study was to determine if there was a difference in student growth from fall to spring on the MAP mathematics assessment between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction. The third purpose of this study was to determine if the differences between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction were affected by student gender, SES, IEP status, and ethnicity.

Significance of the Study

The results of this research could be valuable to school districts as they determine whether PBL instruction should be considered for implementation particularly in mathematics. School districts might find that PBL implementation has an impact on student learning compared to traditional mathematics instruction (Thomas, 2000). Teachers might find this work valuable as they consider a PBL methodology for teaching mathematics. Parents may find this research of value as they question the impact of PBL instruction on their student's assessment scores. This research would also be useful to teachers because the implementation of PBL and its effect on student stress and confidence in mathematics as well as student achievement was examined. Districts could also use this research in teacher preparation training in mathematics. University teacher preparation programs could add the PBL instructional framework training to their coursework. Finally, this study could add to the body of PBL research currently available with a focus on Applied Algebra.

Delimitations

Delimitations, as defined by Lunenburg and Irby (2008), are "self-imposed boundaries set by the researcher in the purpose and scope of the study" (p. 134). The delimitations set for this research project included:

1. The study was conducted in one Midwestern suburban school district.
2. Participants were high school students enrolled in an Applied Algebra class.

3. Teachers taught in two of the five high schools located in a Midwestern suburban school district.
4. The Measure of Academic Progress (MAP) was used to measure the mathematics growth of students enrolled in the Applied Algebra classroom.
5. A survey was used to measure student confidence and anxiety.

Assumptions

Assumptions, according to Lunenburg and Irby (2008), are “postulates, premises, and propositions that are accepted as operational for the purposes of the research” (p. 135). The assumptions that influenced this research include:

1. All MAP data retrieved from the Northwest Evaluation Association (NWEA) was complete and accurate.
2. Students completed assessments to the best of their ability.
3. Students honestly completed the confidence and anxiety survey items.
4. PBL was implemented with fidelity.
5. Mathematics concepts and curriculum were taught to the best of the teacher’s ability.

Research Questions

Research questions are a “directional beam for the study” (Lunenburg & Irby, 2008, p.126). Six research questions guided this study

RQ1. To what extent is there a difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra?

RQ2. To what extent is the difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in applied algebra affected by student gender, IEP status, SES, and ethnicity?

RQ3. To what extent is there a difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra?

RQ4. To what extent is the difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra affected by student gender, IEP status, SES, and ethnicity?

RQ5. To what extent is there a difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra?

RQ6. To what extent is the difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra affected by student gender, IEP status, SES, and ethnicity?

Definition of Terms

For accurate interpretation of this study's purpose and findings, terms specific to this research have been identified and defined. The following are provided for this purpose:

Applied Algebra. In this class, the critical areas in algebra deepen and extend understanding of linear and exponential relationships by contrasting with each other applying linear models to data that exhibit a linear trend. Students engage in methods for analyzing, solving, and using quadratic functions (District S, Program Planning Guide, 2018). This course includes the same content of an algebra course, but with an emphasis on the application of the material. Applied Algebra is recommended for the student with a lower mathematics aptitude.

Ethnicity. Information regarding a student's ethnicity is reported at the time of enrollment. Ethnicity choices include Asian, Black, Hispanic, White, Pacific Islander, and Multi-Racial (District S, 2005).

Individualized education plan (IEP) status. The U.S Department of Education (2007) defined an IEP as a written document developed for "each public-school child who is eligible for special education. The IEP is created through a team effort and reviewed once a year" (U.S. Department of Education, 2007, para. 3).

Mathematics anxiety. Ashcraft and Krause (2007) defined math anxiety as a feeling of tension, apprehension, or fear that interferes with math performance.

Mathematics confidence. Pajares and Miller (1995) defined math confidence as a feeling of self-assurance arising from one's appreciation of one's own abilities or qualities.

Measures of Academic Progress (MAP). The MAP is a suite of assessments which adjusts to each student's responses. The MAP is a personalized assessment experience that adequately measures performance Northwest Evaluation Association (NWEA, 2018).

Project-based learning (PBL). The Buck Institute for Education (2018) defined PBL as a "teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging, and complex question, problem, or challenge" (para. 2).

Rausch unit (RIT). The student's RIT score indicates the level at which the student was answering questions correctly 50% of the time on the NWEA MAP assessment (NWEA, 2018).

Socioeconomic status (SES). A student's SES is based on the identification of their free and reduced lunch status. This status is determined by the family income guidelines established by the National School Lunch Program (District S, 2005).

Organization of the Study

This research is presented in five chapters. Chapter 1 included the background, statement of the problem, the purpose of the study, the significance of the study, delimitations, assumptions, research questions, the definition of terms, and the organization of the study. Presented in Chapter 2 is the review of the literature. Chapter 3 includes the methodology related to this study. The results of the study are presented in Chapter 4. Chapter 5 includes a summary of the study, findings related to the literature, and the conclusions.

Chapter 2

Review of the Literature

This chapter outlines the rationale for the research on the impact of PBL on student anxiety, confidence, and achievement in the mathematics classroom. The need for such research is evident because of current mathematics assessment scores continuing to decline. With the exploration of teacher instructional practices as one source necessary for examination, there is a need to study pedagogical approaches to the teaching of mathematics. As a result, examining the impact of PBL, a nontraditional approach to mathematics instruction, is imperative in seeking an understanding of student anxiety, confidence, and achievement in mathematics.

Presented in this chapter is the literature pertinent to the research on PBL and its impact on students in the area of mathematics. First, the history of PBL along with both the support for this method and those who do not support PBL is examined. Next, the literature on mathematics anxiety, its causes, and recommendations for reducing it are reviewed. Third, mathematics confidence and student efficacy literature are reported. Finally, the impact of PBL on mathematics achievement is reviewed.

Project-Based Learning

The foundations of PBL have existed since the time of the great philosophers and teachers, Confucius and Aristotle. These iconic philosophers "modeled how to learn through questioning, inquiry, and critical thinking – all strategies that remain very relevant in today's PBL classrooms" (Boss, 2011, para. 3). Just like Confucius and Aristotle, Dewey, the founding father of public education, also endorsed an environment based on experience and student interest. However, "Dewey challenged the traditional view of the student as a passive recipient of knowledge, and the teacher as the transmitter of a static body of facts" (Boss, 2011, para. 3). Dewey saw education as a place for "active experiences that prepared students for ongoing learning about a dynamic world" (Boss, 2011, para. 3). Dewey's approach to learning serves as a foundation for the tenets of PBL. From Dewey to present day educational theories, high levels of learning for all students remains a strong edifying goal. Students of today might be entering a workforce filled with jobs that have not yet been created. Given this fact, the necessity for our students to be provided differentiated learning opportunities along with the opportunity to demonstrate their learning in a meaningful and relevant way is imperative. One pedagogical technique to create this meaningful student learning is through PBL instruction.

Boss (2011) also acknowledged Montessori as a contributor to this foundational pedagogical approach to instruction. Montessori demonstrated "that education happens not by listening to words but by experiences upon the environment" (Boss, 2011, para. 1). The present-day model of PBL has evolved from this strong foundation created by the early education experts. Today, PBL gives "students more choice when it comes to demonstrating what they know" (Boss, 2011, para. 3). PBL differs from a traditional project model where projects are "tacked on at the end of real learning, PBL is the centerpiece of the lesson" (Boss, 2011, para. 4). In the PBL model, students are working collaboratively, researching, analyzing, and creating a product for an authentic audience. Research has been conducted around this approach to understand how students learn best. Researchers of this movement concluded that "culture, context, and the social nature of learning all have a role in shaping the learner's experience" (Bell, 2011, para. 5).

Understanding that the learner's experience is paramount to student success creates increased support for the PBL instructional approach. Bell (2011) stated that overall, "these insights help to explain the appeal of PBL for engaging diverse learners" (para. 5).

Thomas (2000) examined the research surrounding the uniqueness of the PBL instructional model. He began with the fact that "PBL projects are central, not peripheral to the curriculum" (Thomas, 2000, p. 3). The project in the PBL delivery is the curriculum and the central teaching strategy. Thomas (2000) also reported that projects that follow traditional instruction are not examples of PBL, "no matter how appealing or engaging" (p. 3). He continued by sharing that PBL projects "drive students to encounter (and struggle with) the central concepts and principles of a discipline" (Thomas, 2000, p. 3). These concepts are all designed to provide students with the opportunity to deeply consider the important intellectual purpose of the research they are asked to pursue (Thomas, 2000). These projects must also involve constructive investigation and must be realistic and not simply school-like. The more relevant and investigative the projects are, the more the learning will be driven and engaged in by students. These projects must be created and delivered in the most authentic form possible and have the potential to be implemented in a real-life situation. Thomas (2000) reported that students taught in a PBL environment were more equipped to answer the more difficult, conceptual based, questions versus simply answering procedural mathematics questions.

Solomon (2003) discussed PBL as a "central teaching strategy" (para.1). The PBL approach to teaching promotes effective learning through projects geared toward solving an over-arching question and exercises the idea of "teaching and learning designed to engage students in the investigation of real-world problems to create meaningful and relevant educational experiences" (Solomon, 2003, para. 1). He continued by discussing the aspect of the projects being, in part, interdisciplinary. Learners "gather information from a variety of sources and synthesize, analyze, and derive knowledge from it" (Solomon, 2003, para. 2). The value of this work by students lies in the fact that "learning is inherently valuable because it is connected to something real and involves adult skills such as collaboration and reflection" (Solomon, 2003, para. 2). This role is defined as guiding and revising rather than "to direct and manage, student work" (Solomon, 2003, para. 2). Gragert (as cited in Solomon, 2003), the director of iEARN, an organization that offers PBL projects that address local and national issues, believes that the idea of a solution that "'improves the quality of life on the planet' really speaks to kids" (para. 5). This meaningful level of engagement and high level of critical thinking pushes students to think and solve problems at a new, and more critical, level.

Hmelo-Silver and Barrows (2006) added that the PBL approach "requires students to become responsible for their own learning. The PBL teacher becomes a facilitator of student learning in the classroom, and his/her interventions diminish as students progressively take on responsibility for their own learning processes" (Hmelo-Silver & Barrows, 2006, p. 24). This varying role of the teacher is one that requires training and the acknowledgment that there must be a release of full control by the teacher of the imparting of knowledge and content. In the PBL approach, the students own and control their learning. The teacher in the PBL classroom "models good strategies for learning and thinking, rather than providing expertise in specific content" (Hmelo-Silver & Barrows, 2006, p. 24). Although PBL still calls for direct instruction to some extent, it creates an increased opportunity for the practical utilization of the instruction in a project or an authentic demonstration of learning. Hmelo-Silver and Barrows (2006) also specified that "as students become more familiar with PBL, facilitators can fade their scaffolding until finally, the learners adopt much of the teacher's questioning role" (p. 24.). In the PBL classroom model, the role of the student is elevated to one who discovers learning authentically and through inquiry whereas the role of the teacher is shifted to a facilitator.

Additionally, PBL is a well-known method for imparting thinking competencies and creating flexible learning environments. This topic was explored by Doppelt (2003) as he researched the impact PBL has on low-achieving students. Doppelt's (2003) research was conducted over a three-year period, and he concluded that low-achieving students showed an increase in college admittance requirements. He purported the idea that "routing low-achievers into low-learning tracks creates a vicious circle" (Doppelt, 2003, p. 255). The PBL approach takes what has traditionally been done in a classroom and targets specific changes that can be made to "promote pupils both emotionally and cognitively" (Doppelt, 2003, p. 255). Additionally, Doppelt (2003) reported four strategies that facilitate greater effectiveness in the learning environment: "defining goals for the pupils as well as teachers, changing the learning environment, carrying out original projects taking advantage of the pupils' special skills and abilities, and changing the assessment methods for project-based learning activities in a computerized environment" (p. 255). His findings signified that "PBL elevated pupils' motivation and self-image at all levels and achieved significant learning" (Doppelt, 2003, p. 255). He also related that "most of the low-achieving pupils succeeded with distinction in the same matriculation exams that the high-achievers did in the same school" (Doppelt, 2003, p. 255).

Doppelt centered his research on the theory of active learning. This theoretical approach puts the student at the center of the learning process. The common practice in this theory is the "emphasis placed on the activities of the individual learner that motivate learning processes that occur inside the pupil's mind for which he/she is responsible" (Doppelt, 2003, p. 256). These theories stake claim that students should be allowed to investigate and satisfy their own curiosity. Ultimately, the "transfer of responsibility should occur through a teacher who gives degrees of freedom for learning and changes the teacher's role from that of the lecturer to the role of tutor, guide, and partner in the learning process" (Doppelt, 2003, p. 256). This student-centered approach to learning creates authentic learning focused on student engagement and discovery.

Another beneficial instructional component of PBL is the teacher's ability to differentiate instruction and in turn support learning for all students. Dobbertin (2012) discussed the concept that differentiation within a PBL instructional framework supports learning for all students regardless of skill or ability.

> By maintaining a consistent focus on what students will learn, teachers develop a clear roadmap for success on grade-level expectations and, ultimately, on state assessments. Teachers must find ways to assess students' different entry points on the path to mastery of those expectations and to determine whether each student is progressing appropriately on the journey. The substantial amount of time teachers put into planning learning targets and differentiating activities pays off: More

> students succeed initially, and teachers have built-in opportunities to provide all learners additional support and challenges along the way, lessening the need for interventions later on. (Dobbertin, 2012, p. 69)

Based on Dobbertin's theory, providing students the opportunity to work at their own level within the PBL framework supports the expectation that teachers must meet students where they are in their mathematical skill development.

Comparable to the above research on student engagement and ownership, Creghan and Adair-Creghan (2015) examined the impact of PBL instructional practices on economically disadvantaged students. Often, disadvantaged students have low attendance and low motivation for attending school. These students do not connect the relevance of the learning to their everyday lives. The number of students who have lost connection with their education is staggering. Creghan and Adair-Creghan (2015) shared that in 2010 the U.S. Department of Education reported that approximately 3 million 16-24-year olds were not currently enrolled in school and considered dropouts. In 2003, Creghan and Adair-Creghan also observed that the National Middle School Association had indicated,

> If schools are going to meet federal and state standards and provide a comprehensive education for children, including those in poverty, they must provide curriculum and instruction that is challenging, and that meets both the needs and interests of students by keeping them engaged in learning. (para. 6)

The results of Creghan and Adair-Creghan's (2015) research indicated that the use of PBL instructional practices leads to higher attendance rates for economically disadvantaged students. This higher attendance rate might serve students well in the areas of engagement and ownership in their learning. PBL provides the opportunity for students to own their learning and grow in their inquiry-based approach to solving problems on a global scale, which can then be translated into meaningful local action.

The Buck Institute for Education (BIE) discuss their support for many of the 21st-Century efforts related to PBL. The BIE promotes and trains educators on the best practice research surrounding PBL instruction. One of BIE's mantras is that "PBL is an effective and enjoyable way to learn and develop deeper learning competencies required for success in college, career, and civic life" (BIE, 2018, para. 3). Their work is grounded in eight areas based on recent developments in education. First, they purport that PBL makes school more engaging by involving students in hands-on, real-world problems and scenarios. Second, according to BIE, the PBL instructional approach helps to construct success skills students need for college, career, and life by asking students to "work in teams, communicate ideas, and manage themselves more effectively" (BIE, 2018, para. 4). Third, the institute reports that the PBL approach supports the practice of teaching the standards that drive the curriculum and outline student learning. They contend that through the utilization of PBL, teachers are able to teach standards while using a relevant approach to instruction. The fourth area they focus on provides a multitude of opportunities for students to use technology, which assists in students' opportunities to collaborate more effectively and share work with audiences around the community and world. In the Buck Institutes' fifth area, they share that PBL works for educators as it creates a more enjoyable and rewarding teaching experience. Projects allow teachers to "work more closely with and actively engaged students doing high-quality, meaningful work and, in many cases, rediscover the joy of learning alongside their students" (BIE, 2018, para.7). Sixth, BIE reveals that the PBL approach connects students and schools with communities and the real world by allowing students to solve problems and address issues "important to them, their communities, and the world. Students learn how to interact with adults and organizations, are exposed to workplaces and adult jobs, and develop career interests" (BIE, 2018, para. 8). In many cases, parents and community members are closely involved with the projects in which students are engaged. Finally, The BIE shares that PBL promotes educational equity. This equity is grounded in the idea that students can create and work using their individual strengths. This pillar is grounded in the fact that all students deserve to experience a focused project and to experience the "powerful effect to help them reach their potential" (BIE, 2018, para. 9).

However, there are those who do not support PBL methodology as being as effective as the traditional approach to mathematics instruction. Kirschner, Sweller, and Clark (2006) discussed theories supporting the idea that guided or direct instruction is superior to PBL instruction. Kirschner et al. (2006) defined PBL as "unguided or minimally guided instruction" (p. 75). Using this definition of PBL, their theory is rooted in the claim that the effective classroom is one that is led by the content expert and all knowledge and factual information is imparted to students by the teacher. Kirschner et al. (2006) outlined that minimally guided instruction ignores how the brain works related to working memory and processes. Their discussion pointed to the fact that working memory and the cognitive structures of the brain must have all the information to begin all brain processes. Kirschner et al. (2006) also asserted that "learners must construct a mental representation or schema irrespective of whether they are given complete or partial information" (p. 78). Kirschner et al. (2006) continued by maintaining that "complete information taught will result in a more accurate representation and is more easily acquired" (p. 78).

Bennett (2016) shared his findings on the PBL instructional approach and reported on the work of "learning through REAL projects" which involved almost 4,000 students from 24 schools. The PBL research team for this study found "no clear impact on either literacy… or student engagement with school and learning" (Bennett, 2016, para 4). He also found that the effect on students with low SES was "negative and significant" (para. 4). Additionally, Bennett (2016) utilized the 2015 PISA results to support his theory that PBL was not as effective as direct instruction. He reported that the 2015 PISA results indicated that "the increase in the amount of inquiry learning that students report being exposed to is associated with a decrease in science scores (Bennett, 2016, para. 6). Bennett's (2016) findings on PBL provide contrasting information with the body of research surrounding the successful implementation of PBL.

Guido (2016) discussed five disadvantages of PBL instruction. The first discussion centered around the potential for lower student performance on assessments. He argued that students might not have the breadth of knowledge needed to achieve high assessment scores. This theory was focused on the idea that "problem-based learners develop skills related to collaboration and justifying their reasoning, many tests reward fact-based learning with multiple choice and short answer questions" (Guido, 2016, para. 25). He continued by sharing that although PBL engages a large percentage of students, other students may struggle due to immaturity, unfamiliarity with the topic, and lack of prerequisite knowledge. Third, Guido (2016) discussed that the challenge is often found in teachers not being fully prepared or trained in the nuances of PBL instruction. His discussion focused on the importance of teacher preparedness to implement PBL fully and successfully in the classroom. Moreover, Guido (2016) purported that the assessment of PBL “demands constant monitoring and note-taking” (para. 33). This continual progress monitoring and data collecting is a key component of PBL instructional methodology and could be overwhelming for teachers and students. Finally, Guido (2016) shared that within the PBL framework there are varying degrees of relevancy and applicability for students. If students divert from the objectives, they will miss critical instructional information. Furthermore, if students “veer away from the problem’s focus, they may experience unanticipated obstacles” (Guido, 2016, para. 40).

Schaffhauser (2017) discussed his theory that the claims surrounding PBL are “promising not proven” (para. 2). His theory centered around the lack of evidence for the achievement results that PBL claims to offer. Schaffhauser (2017) shared that the number of studies done on the effectiveness of PBL is small, and it is difficult to find “valid, reliable, and readily usable measures of the kinds of deeper learning and interpersonal and intrapersonal competencies that PBL aims to promote” (para. 2). He also found that the evidence is weaker in mathematics classrooms due to the low number of studies that have been done surrounding the effective PBL instructional implementation. Additionally, Schaffhauser (2017) discussed the instructional challenges associated with the implementation of PBL as teachers must grow accustomed to movement, ambiguity, and noise in the classroom. The theories of Schaffhauser (2017) support the utilization of a traditional method of mathematics instruction to promote student learning.

In conclusion, the PBL instructional approach to the teaching of mathematics can be one method of student engagement in the mathematics classroom. This approach offers not only engagement but also differentiation within the mathematics classroom. The PBL approach provides students the opportunity to think critically about solutions to problems outside of the four walls of the classroom. This collaborative, problem-solving approach to learning is what employers are seeking and how students must be prepared to perform. However, there is also evidence that calls into question the validity and reliability of PBL instruction. The argument for direct or traditional instruction is seemingly valid; however, it assumes that in a PBL instructional model that little to no information is provided to the student by the teacher. PBL does provide a balance between traditional and non-traditional instruction (Kirschner et al., 2006).

Mathematics Anxiety

One of the suggested factors challenging students in mathematics achievement is their anxiety in the content area. Richardson and Suinn (1972) defined mathematics anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). These feelings of anxiety can be a barrier to student success in the mathematics classroom.

Wigfield and Meece (1988) assessed cognitive and affective components of mathematics anxiety, relations between mathematics anxiety and other key mathematics attitudes such as beliefs and values, and gender differences in mathematics anxiety.

Wingfield and Meece (1988) referenced Liebert and Morris's (1967) research as they purported the "two components of test anxiety are worry and emotionality" (p. 67). Wigfield and Meece (1988) defined worry as being the "cognitive component of anxiety, consisting of self-deprecatory thoughts about one's performance" (p. 76). Wigfield and Meece (1988) defined emotionality as the affective component of anxiety, including feelings of nervousness, tension, and unpleasant physiological reactions to testing situations. Wigfield and Meece (1988) reported that these two components of anxiety are empirically distinct, though they are correlated, and that worry relates stronger than emotionality to poor test performance. Students who experience worry as their emotion during this interval of learning might have a more challenging time learning and retaining the concepts and skills in the mathematics classroom.

According to Godbey (1997), much of the anxiety that students experience can be largely due to their teachers' approach to teaching mathematics. Godbey (1997) stated, "instructors who are enthusiastic about the subject and really try to make mathematics fun will have more success with student comprehension" (p. 11). Teachers who adopt this awareness of making mathematics more enjoyable might provide a less stress-ridden environment that could, in turn, create a more relaxed environment for learning. She went on to state, "students will also find themselves looking forward to math class rather than dreading a dull presentation of mathematical facts" (Godbey, 1997, p. 9). She pointed to the fact that the essential learning for all students is centered around the approach and teaching style of the teacher in the classroom and his/her ability to create an environment for learning that focuses on enthusiasm for the subject and student engagement.

In research related to anxiety, Ashcraft and Krause (2007) discussed the impact of anxiety on the learning of mathematics. They explored the concept that mathematics anxiety "compromises the functioning of working memory when people do arithmetic and math" (Ashcraft & Krause, 2007, p. 243). Working memory plays a vital role in mathematical cognition and the retaining of information. The researchers shared, "the literature now supports a clear generalization concerning the important positive relationship between the complexity of arithmetic or math problems and the demand on working memory for problem solving" (Ashcraft & Krause, 2007, p. 243). To demonstrate the effect of anxiety on working memory, Ashcraft and Krause (2007) asked college-aged adults to complete several two-column mathematics problems. As the task grew more challenging and "with the working-memory demanding carry problems, the dual mathematics task was quite strong, and affected the high-anxious group the most" (Ashcraft & Krause, 2007, p. 246). They concluded that highly anxious participants, students who are already wasting working memory resources by attempting to decrease their own anxiety, struggle the most when attempting to learn a new skill or concept (Ashcraft & Krause, 2007). Examining anxiety further, several implications can be drawn including the fact that "math anxiety seems to influence cognitive processing in a straightforward way-working memory resources are compromised whenever the anxiety is aroused" (Ashcraft & Krause, 2007, p. 246).

Moreover, some correlations have been found between student anxiety and mathematics achievement. According to Ashcraft and Krause (2007), "the overall correlation between math anxiety and individuals' math achievement, as measured by standardized tests, is -.31" (p. 245). They went on to conclude that highly math-anxious students earned lower grades in the mathematics classes they took. Additionally, these students showed lower motivation to take more elective mathematics courses, and in fact took fewer mathematics courses (Ashcraft & Krause, 2007, p. 45). The results of this study supported the concept that as mathematics anxiety increases, mathematics achievement decreases. Also, the fact that students with heightened anxiety choose to not enroll in mathematics classes are ultimately less mathematically prepared for the demands of higher education or the workforce.

Curtain-Phillips (2017) supported the work of Ashcraft and Krause (2007) when she concluded that traditional mathematics classrooms cause anxiety for many students who struggle with failure. Curtain-Phillips (2017) reported that students learn best and with less anxiety when they are active rather than passive learners. To support student mindset about mathematics, Curtain-Phillips (2017) suggested that "a person's state of mind has a great influence on his/her success" (para. 7). As an essential component of her research, she addressed the fact that math is often associated with "pain and frustration" (Curtain-Phillips, 2017, para. 9). This pain and frustration that students experience often manifests into mathematics anxiety. Her main body of research focused on the different learning styles of students. To produce a population of more math-minded adults, we "must re-examine traditional teaching methods which often do not match student's learning styles and skills needed in society. Lessons must be presented in a variety of ways" (Curtain-Phillips, 2017, para. 11). As researchers continue to look for stronger connections for mathematics students, we must also contemplate the concept of reducing anxiety. One way to address this is to create relevant experiences for students to learn mathematics. According to Curtain-Phillips (2017), to learn mathematics, “students must be engaged in exploring, conjecturing, and thinking rather than engaged in the rote learning of rules and procedures” (para. 5).

Research has been conducted that supports the idea that often math anxiety stems from parental influence on their children. Quan-Lorey (2017) discussed the impact that parental views on mathematics have on the anxiety felt by their children. Parents who share their negative attitudes about their performance in math with their children could have an impact on how the child feels about their performance in math (Quan-Lorey, 2017). Parental impact on students is important to consider since “parents are the first adults a child encounters and is influenced by with regard to their development” (Quan-Lorey, 2017, p. 20). Moreover, parents who were not successful in mathematics as children assume that the skill is heredity and convey this negative presupposition to their children.

Quan-Lorey (2017) also reported on the role of the teacher and the teacher’s influence on mathematics anxiety in students. As the leaders of the classroom, the influence that teachers have on students is dynamic. Thus, teachers must be self-aware of their influence, both positively and negatively, when working on mathematics with students.

> With today’s schools filled with these teachers, the propensity of those who possess mathematics anxiety puts classrooms at a higher risk of having these feelings toward mathematics passed down from teachers to their students; thus, contributing to an unceasing cycle of mathematical disdain. (Quan-Lorey, 2017, p. 20)

In addition to the role of teacher influences on student attitude, Quan-Lorey (2017) also examined the impact of the instructional methods in the mathematics classroom. Quan-Lorey (2017) exposed the ineffective method of "chalk and talk" where the teacher "assumes an authoritative role where students work independently, and collaborative learning is scarce" (Quan-Lorey, 2017, p. 21). Unfortunately, these classrooms place a great deal of success on right and wrong answers versus learning for understanding (Quan-Lorey, 2017). This true understanding of concepts and skills is vital for the future of students. He reported on the current labor market and shared that many jobs require a mathematics or science background. Consequently, it is imperative to find a way to decrease mathematics anxiety and create a space where students desire to learn and have the desire to take more math courses.

Creating relevance and engagement in the processes of learning speaks to the power of the PBL approach in reducing student anxiety in mathematics. Students who experience math anxiety are more predisposed to failure and have a limited aspiration to continue their mathematics education. In addition to considering student anxiety in the area of mathematics achievement, we must also consider how math confidence and self-efficacy affects student learning in mathematics.

Mathematics Confidence and Mathematics Self-Efficacy

Hackett and Betz (1989) theorized the area of student self-efficacy and confidence in mathematics. They discussed "that mathematics self-efficacy is a situational or problem-specific assessment of an individual's confidence in her or his ability to successfully perform or accomplish a particular task or problem" (Hackett & Betz, 1989, p. 262). Additionally, they reported that a student's ability to understand mathematics and retain information in this area is important as it relates to the attainment of self-efficacy and confidence in the discipline. Self-efficacy and achievement work together as one can often be directly affected by the other. As student self-efficacy increases, student achievement increases, and as achievement increases student self-efficacy increases. Hackett and Betz (1989) purported that "mathematics self-efficacy contributed more significantly than sex, years of high school mathematics, ACT mathematics score, or mathematics anxiety to predicting the choice of a mathematics-related college major" (p. 262). The results of Hackett and Betz's research pointed strongly to the idea that self-efficacy is a strong indicator of student mathematics achievement. Through the demonstration of self-efficacy, students have an increased opportunity to gain confidence in mathematics.

In related research, Bandura (1994) supported the work of Hackett and Benz in the area of confidence and self-efficacy serving as a pivotal component in mathematical achievement. Bandura (1994) has been seen as the leading theorist on the relationship between self-efficacy and student achievement. His research focused on the four major psychological processes which affect human functioning. The first body of his research concentrated on the cognitive processes. The main construct of his theory is that self-appraisal of capabilities influences personal goal setting. The stronger the perceived capabilities are, the higher the goals and expectations are for the student. Along with this perception of perceived capabilities is the "student's ability to foresee ambiguities and uncertainties" (Bandura, 1994, p. 4). A person's ability to predict the failures that might occur as part of their executive functioning can prevent these moments from becoming setbacks that derail the journey in accomplishing a goal.

The subsequent cognitive process that Bandura (1994) outlined was the motivational process. This process is outlined in three forms of cognitive motivators: causal attributions, outcome expectancies, and cognized goals. Causal attributions center around the idea that if people see themselves as having high self-efficacy, they "attribute failure to insufficient effort" (Bandura, 1994, p. 5). Those with low self-efficacy "attribute a failure to low ability" (Bandura, 1994, p. 5). The third process is the affective process. In this process, a person's ability to cope affects how much stress and depression they experience in a threating or difficult situation. Bandura's (1994) continued by revealing that "anxiety arousal is affected not only by perceived coping efficacy but by perceived efficacy to control disturbing thoughts. Perceived self-efficacy to control thought processes is a key factor in regulating thought produced stress and depression" (Bandura, 1994, p. 6). This level of executive functioning is further discussed around the idea of biological systems, which are highly interdependent. "A weak sense of efficacy to exercise control over stressors activates autonomic reactions, catecholamine secretions and release of endogenous opioids. These biological systems are involved in the regulation of the immune system" (Bandura, 1994, p. 7). The control of the biological systems to regulate student executive functioning speaks to the influence of self-efficacy.

Finally, Bandura's (1994) theory focused on the selection process that is unlike the three processes already discussed. This process centers around a person's ability to choose and avoid those activities that would cause stress on some level. Bandura (1994) reported that "by the choices they make, people cultivate different competencies, interests and social networks that determine life courses" (p. 7). Through the ability to choose and cultivate, learners gain the confidence to manipulate their life choices. Bandura (1994) also reported that "the task of creating learning environments conducive to development of cognitive skills rests heavily on the talents and self-efficacy of teachers" (p. 11). Schools where "staff members collectively judge themselves capable of promoting academic success imbue their schools with a positive atmosphere for development that promotes academic attainments regardless of whether they serve predominantly advantaged or disadvantaged students" (Bandura, 1994, p. 11). The role of the teacher and the classroom is elevated and "in a personalized classroom structure, individualized instruction tailored to students' knowledge and skills enables all of them to expand their competencies and provides less basis for demoralizing social comparison" (Bandura, 1994, p. 12). Through strong instruction by the teacher and personalized learning for the student, student self-efficacy has the greatest opportunity to grow.

The results of Pajares and Miller's (1995) study aligned with the theories of Bandura (1994). Their study involved 391 students in providing three different self-efficacy judgments. These students were asked to solve tasks that revolved around math problems and choice of math-related careers. Pajares and Miller (1995) revealed that "students' confidence to solve mathematics problems was a more powerful predictor of their ability to solve those problems than their confidence to earn As or Bs in math-related courses" (p. 196). Additionally, Pajares and Miller (1995) found that student confidence to succeed in such mathematics courses was "more predictive of their choice of majors that required them to take many of the math-related courses on which they expressed that confidence" (p. 196). These conclusions further promote the theory that self-efficacy in mathematics is a strong indicator of whether a student will succeed.

Moreover, purposeful and strategic teacher training was found to increase mathematics confidence and self-efficacy in students. Siegle and McCoach (2007) researched self-efficacy theory. In this study, the researchers used a cluster-randomized pretest/posttest design. The schools that volunteered to participate had random assignments (Siegle and McCoach, 2007). The sample for this study included 872 fifth-grade students from 10 school districts located in six states across the Midwest. Teachers from both groups were questioned about their training related to student self-efficacy. Siegle and McCoach (2007) shared that self-efficacy judgments are based on four sources of information: an individual's past performance, vicarious experiences of observing the performance of others, the verbal persuasion that one possesses certain capabilities, and physiological states. In the first area, an individual's past experiences, Siegle and McCoach (2007) referenced the old adage, "nothing breeds success like success" (p. 281). The awareness that success in mathematics breeds more success in mathematics is just a portion of what their research unveiled. As the students in the control condition group experienced success, their confidence and motivation to continue learning was higher, and their confidence in taking risks grew.

Siegle and McCoach (2007) reported on the second source of self-efficacy, which involved students having the opportunity to see others like themselves fail or succeed. Students witnessing other students either succeeding or failing strongly affects their confidence in certain tasks. This approach could have adverse effects if students observe others comparable to themselves continuing to fail or be unsuccessful with tasks that are presented for them to complete. Students must learn to see failure as a learning opportunity and then see resilient behavior demonstrated following the failure.

The third source for building self-efficacy according to Siegle and McCoach (2007) is verbal persuasion. Verbal persuasion is only effective if the student feels that the person offering it is credible and trustworthy. If students do not feel as though the verbal persuasion is authentic, they may feel like they are being talked down to or patronized. The final form of building self-efficacy is physiological cues. Siegle and McCoach (2007) report that if a student has sweaty palms, a rapid heartbeat, or a dry mouth it can cause confidence to decrease. Student awareness of the physiological signs of anxiety might help them in not only identification but also the remedy for such effects. Siegle and McCoach (2007) reported that “feeling relaxed or excited before confronting a new situation may increase a person’s sense of efficacy toward the task he or she faces” (p. 282). Students gaining an understanding between feeling anxious and feeling excited is important in self-regulation and self-awareness. These areas of awareness could support students as they process their own feelings in the areas of mathematics confidence and self-efficacy (Siegle & McCoach, 2007).

Similar research on self-efficacy conducted by Khezri, Lavasani, Malahmadi, and Amani (2010) focused on self-efficacy being directly linked to how relevant tasks are perceived by students. They defined self-efficacy as “the main construct in Bandura's social- cognitive theory which refers to one's beliefs and judgments regarding his ability to accomplish specific tasks such as mathematics” (p. 943). This belief in one’s own abilities has been seen as the key to the success or failure of any given task. They also discovered that “high self-efficacy exerted a direct, positive influence on task value, mastery goals, performance-approach goals, deep approach, and mathematics achievement” (Khezri et al. 2010, p. 943). The researchers pointed out that students' self-efficacy creates change in their achievement goals: students with high self-efficacy adopt mastery and performance-approach goals while those low in self-efficacy tend to prefer performance-avoidance goals.

Filcik, Bosch, Pederson, and Haugen (2012) also examined the effects of PBL on student self-efficacy. Their longitudinal study focused on student responses to survey questions and interviews. The study involved 92 students, 40 females and 52 males. Also, 39% of the students were eligible for free or reduced lunch which is a strong indicator of math under-achievement (Filcik et al., 2012). Students taught using a PBL approach, indicated that they “liked the new approach to learning because it was different and more exciting than the traditional method” (Filcik et al., 2012, p. 1472). In this study, the researchers discussed the two approaches in terms of benefits to learners. The approaches were content learning and motivation. Filcik et al. (2012) focused on self-efficacy and self-regulation in learning mathematics and discovered that the PBL teacher had to integrate several disciplines including art, history, and science into an authentic mathematics problem. The researchers concluded their report by sharing that students who experienced a PBL instructional framework were more engaged than their non-PBL counterparts (Filcik et al., 2012).

> Based on the surveys given at the end of the first year and in the beginning of the second year, there are clear positive changes in learning motivation of mathematics in PBL students. Specifically, students were using more learning strategies (i.e., elaboration and organization) and critical thinking. They were a little more self-regulated, setting more intrinsic and less extrinsic goals, and willing to seek help from their peers. They also showed a greater appreciation of

> the value of mathematics as well as higher self-efficacy in learning mathematics. (Filcik et al., 2012, p. 1472)

The research surrounding the impact of PBL instruction on student confidence and self-efficacy is prevailing. Students demonstrating confidence in their ability to perform in a mathematics classroom provides them with the confidence to succeed in other areas of their education as well. Students reporting a higher self-efficacy in mathematics shows they value math and are more open to the learning that the discipline requires of them.

Project-Based Learning and Student Achievement in Mathematics

An individual's ability to successfully compete in a global society largely depends on one’s ability to live in a world where mathematics is prevalent and necessary. However, a body of evidence suggests the mathematics achievement for our most striving or struggling students is even more critical. As our students begin to compete for employment, their ability to perform mathematic functions is vital. Mathematics achievement can be influenced by a variety of factors including but not limited to student mathematics anxiety and student mathematics confidence and self-efficacy.

Researchers have concluded that the implementation of PBL as an instructional method might have a profound effect on student achievement in mathematics. Erickson (1999) discussed the power of a classroom designed to teach mathematics in a way that “allows students to wonder why things are, to inquire, to search for solutions, and to resolve incongruities” (p. 516). Erickson (1999) maintained that students could “make connections between mathematical ideas that are familiar to them by solving new problems in a variety of different settings” (p. 516). Moreover, Erickson added that diverse populations of students have been successful in classes using the problem-based approach. Erickson (1999) found young women, English-as-a-second language students, and students at a variety of achievement levels "attain higher results on average in a PBL classroom than traditional mathematics classrooms" (p. 520). According to Erickson (1999), student success and motivation for learning in a PBL-based classroom is reported as promising and a way to promote student engagement and achievement for all students. Erickson acknowledged two challenges to this approach to mathematics achievement. One challenge is "keeping the character of the problem-solving tasks from changing after the students begin working" and the second challenge is "keeping the cognitive demands of high-level tasks from declining" (Erickson, 1999, p. 519).

Benbow and Stanley (1980) presented variability in mathematics achievement based on gender. In their study, data from over 10,000 males and females that had been collected by the Study of Mathematically Precocious Youth was used. The results of the data analysis indicated that there was a large "sex difference in mathematical aptitude observed in boys and girls with essentially identical formal educational experiences" (Benbow & Stanley, 1980, p. 1262). The authors went on to reveal that "a few highly mathematically able girls have been found, particularly in the latest two talent searches" (Benbow & Stanley, 1980, p. 1263). The talent searches focused on grade level students, both male and female, performing mathematical tasks including the SAT (Benbow & Stanley, 1980).

Roh (2003) concluded in the review of the effects of PBL instruction and implementation that "students become good problem solvers by learning mathematical knowledge heuristically" (p. 3). Because PBL instruction begins with a problem to be solved, “students in a PBL environment must become skilled in problem solving, creative thinking, and critical thinking” (Roh, 2003, p. 3). Using “PBL in mathematics classrooms provided young children with more opportunities to think critically, represent their own creative ideas, and communicate with their peers mathematically” (Roh, 2003, p. 3). In the traditional classroom environment, “students are allowed only to follow guided instructions and to obtain right answers, but not allowed to seek mathematical understanding. Consequently, instruction becomes focused on only getting good scores on tests of performance” (Roh, 2003, p. 4). As a contrast to this environment, Roh (2003) shared that the traditional way of looking at a productive classroom is seeing one that is well managed and where students follow “guided instructions to obtain right answers” (p. 3). However, this traditional approach does not necessarily allow students to “seek mathematical understanding” (Roh, 2003, p. 3). In this traditional classroom style, the focus is on earning high test scores versus true mathematical understandings of concepts and skills. Understanding that the goal of education is to produce critical thinkers in all areas of academics, the results of Roh’s review of PBL instruction supports the premise that learners must have opportunities to stretch their thinking to that of critical levels. It is in the critical levels of thinking that learners will most benefit and grow academically.

Hmelo-Silver, Duncan, and Chinn (2007) discussed their review of literature centering around the notion that PBL promotes student thinking in the complex domains. The learning in this approach is successful when extensive scaffolding and guidance are provided to facilitate student learning (Hmelo-Silver et al., 2007). This scaffolded approach to learning offers students a way to engage in complex tasks that might otherwise be beyond their present capabilities. Teachers play a significant role in the scaffolding of learning by creating mindful and meaningful tasks, which push students to think deeply. Hmelo-Silver et al. (2007) discussed the importance of students making errors during the exploration of PBL. The process of making errors created an increase in students' ability to create "more elaborate explanations compared to the sparse explanations of students in the traditional classroom" (Hmelo-Silver et al., 2007, p. 103).

Padmavathy and Mareesh (2013) examined the effectiveness of PBL instruction in the mathematics classroom. Their research was conducted using a pretest/post-test design. Two groups of 30 students participated in the study. One group received traditional mathematics instruction, and the other group received PBL instruction. Regarding mathematics achievement, the researchers focused on the hypothesis that "there is a significant difference between the pre-test scores and the post-test scores of the two groups" (Padmavathy & Mareesh, 2013, p. 48). The major finding from their study, based on pre and post-tests administered, indicated that students who were exposed to the PBL instructional method had higher achievement scores than those who were taught mathematics traditionally.

> The calculated t-value is found to be 5.20 which are greater than the table value 1.99 at 0.05 and the research hypothesis is accepted. Therefore, there exists a difference between conventional group and experimental group in their post-test. This shows a student who receives one-month problem based learning achieved higher results on achievement test than students in the control group. (Padmavathy & Mareesh, 2013, p. 50)

By adopting the PBL instructional method, the teacher can "create a number of creative thinkers, critical decision makers, [and] problem solvers which is very much needed for a competitive world" (Padmavathy & Mareesh, 2013, p. 50). In the competitive world our students might live, they might need the skills and competencies that PBL naturally provides as part of the learning process. Padmavathy and Mareesh (2013) also conveyed that a PBL approach provides greater opportunities for learners to learn the content with more involvement and increase the students' active participation, motivation, and interest. PBL leads the learners to have a more positive attitude toward mathematics and supports them in the process of "increase[ing] their achievement to a large extent which will, in turn, lead to long-term memory" (Padmavathy & Mareesh, 2013, p. 50). Their findings support the concept that the more active and engaged students are in their learning, the greater the retention of content information and in turn the greater the mathematics achievement.

Fatade, Mogari, and Arigbabu (2013) offered a theory that engagement in mathematics is the key to student achievement. Fatade et al. (2013) focused on the textbooks that are utilized in the teaching of mathematics. The researchers included 96 students in the study. Of the 96 participants, 54 students were in the control group and were not exposed to PBL instruction and 42 students in the experimental group were exposed to PBL instruction. Based on this research, Fatade et al. (2013) claimed the mathematics textbooks utilized were "repetitive and uninspiring in their content, and the students who are its victims are generally unable to transfer their skills from the textbook exercises to the problems of the real world" (p. 28). They shared that the strongest approach to teaching mathematics was to encourage the development of relevance, application, modeling, and problem-solving, which are all components of the PBL methodology. Furthermore, Fatade et al. (2013) reported that the challenge with the traditional method of teaching mathematics, which uses rote memory learning of facts, did not result in higher level thinking and problem solving by students.

In related research, Ajai, Imoko, and O'kwu (2013) examined both the traditional method of teaching mathematics and teachers implementing a PBL methodology. Their study took place in Nigeria utilizing intact classes that were randomly assigned to experimental and control groups. The 447 students were assigned to either the experimental group, those exposed to PBL instruction, or to the control group, those taught traditionally. The students and schools were selected through multistage sampling. The researchers utilized the non-randomized pre-test and post-test control group type of quasi-experimental design. The results of their research indicated that the experimental group outperformed their counterparts who were taught using the traditional method of teaching mathematics. The researchers recounted that a student who is exposed to the PBL method of learning was "more likely to possess a more meaningful in-depth knowledge of the content area" (Ajai et al., 2013, p. 133). The investigation revealed that the difference between the pre-test and the post-test mean scores for the students taught using the PBL method was higher than the mean gain for students exposed to the traditional instructional method (Ajai et al., 2013). Additionally, these students were able to organize their thoughts and ideas in such a way that created an organizational structure that promoted the acquisition of the basic practical skills of mathematics. Moreover, the PBL approach fostered deeper understanding through the utilization of social negotiations students utilized with PBL team members. Students afforded the opportunities for collaboration were allowed the chance to compare and evaluate their understanding of the content through conversations with others. Ajai et al. (2013) concluded that students who were exposed to a PBL methodology were provided the necessary skills to make meaning of mathematics while utilizing collaboration and critical thinking necessary for future student success.

The ultimate goal of classroom instruction is student learning, and the unwavering objective of student learning is achievement. The impact of strong student engagement through the implementation of PBL instruction promotes the theory that the PBL approach advances student achievement. As educators attempt to find ways to make learning meaningful and engaging, they may want to consider PBL instruction to engage learners and advance student achievement.

Summary

This review of the literature provided an overview of the contributing factors to student success in the mathematics classroom. Specifically, this section included the pedagogical framework and instructional practices of PBL, the examination of student mathematics anxiety and self-efficacy, and finally, student achievement in the PBL classroom. The research is clear that highly engaging and purposeful instruction has a strong impact in the mathematics classroom. PBL instruction, lowering student anxiety, and building student confidence and self-efficacy are all factors to consider when examining ways to improve student achievement in mathematics. Chapter three contains the research design, selection of participants, measurement, data collection procedures, data analysis and hypothesis testing, and the limitations of the study.

Chapter 3

Methods

This study was designed to explore the impact of PBL on students enrolled in an Applied Algebra course. The first purpose of this study was to determine if there was a difference in student anxiety and confidence in mathematics between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction. The second purpose of this study was to determine if there was a difference in student growth from fall to spring on the MAP mathematics assessment between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction. The third purpose of this study was to determine if the differences were affected by gender, SES, IEP status, and ethnicity. This chapter includes the methodology utilized in the study including the research design, selection of participants, measurement, data collection procedures, data analysis and hypothesis testing, and the limitations of the study.

Research Design

The research design for this study was quantitative. Specifically, a quasi-experimental research method was utilized as participants were either receiving PBL instruction or were not receiving PBL instruction. Creswell (2014) stated that a quantitative research design "is an approach for testing objective theories by examining the relationship among variables" (p. 4). The independent variables of interest in this study were Applied Algebra course format and student demographics including gender (male, female), IEP status (had an IEP, did not have an IEP), SES (free/reduced, no designation), and ethnicity (White, non-White). The dependent variables were mathematics anxiety, mathematics confidence, and MAP mathematics growth from fall to spring.

Selection of Participants

The population for this study included students enrolled in Applied Algebra at two high schools in District S. The schools and their demographics were presented in Chapter 1. In District S, an Applied Algebra teacher at High School A implemented PBL instruction, and an Applied Algebra teacher at High School B taught the course without using PBL instruction. At the time of the study, the demographics of the two high schools were very similar. The schools had similar SES, IEP, and ethnicity ratios. The sampled participants had both a fall and spring MAP mathematics score and completed the survey related to mathematics anxiety and confidence. When data were missing for any of the participants, those participants were not included in the hypothesis testing for that particular variable or variables.

Measurement

The instruments utilized in this study to measure the dependent variables including student anxiety in mathematics, student confidence in mathematics, and student growth from fall to spring on the MAP mathematics assessment are detailed in this section. These instruments were a student survey consisting of 13 items and the NWEA mathematics MAP assessment. These two instruments provided the data necessary to measure the variables specified in the six research questions and 15 tested hypotheses. To ensure anonymity, students were assigned subject numbers which were used to merge the survey, assessment, and demographic information for each student.

Prior to the survey administration, the researcher requested permission to utilize the Abbreviated Math Anxiety Scale (AMAS) (see Appendix B) to measure student mathematics anxiety. Permission to use the AMAS was granted to the researcher by Dr. Melissa Hunt on February 7, 2018 (see Appendix D). Additionally, the researcher requested permission to utilize the Student Attitude Survey (SAS) (see Appendix A) to measure mathematics confidence. Permission to use the SAS was granted to the researcher by Dr. John Trapper on January 22, 2018 (see Appendix C). The nine items from the AMAS and the four items from the SAS were combined to form one survey that was administered to the participants in this study. The results from these 13 items produced the data needed to address RQ1 - RQ4.

The first four items on the survey (SAS items) were used to measure student confidence in mathematics and were used to address RQ3 and RQ4. The next nine items on the survey (AMAS items) were used to measure student anxiety in mathematics and were used to address RQ1 and RQ2. To measure student achievement in mathematics, which addressed in RQ5 and RQ6, the fall to spring growth on the NWEA MAP mathematics assessment was utilized. Finally, to measure the independent variables, class format (RQ1-RQ6), student gender (RQ2, RQ4, RQ6), IEP status (RQ2, RQ4, RQ6), SES (RQ2, RQ4, RQ6), and ethnicity (RQ2, RQ4, RQ6) were used.

Abbreviated Math Anxiety Scale (AMAS). The AMAS was the instrument used to measure student math anxiety for the variables in RQ1 and RQ2. The AMAS was developed by Hopko, Mahadevan, Bare, & Hunt (2003) at the University of Tennessee at Knoxville. The AMAS contains nine items measured on a 5-point Likert-type scale. The possible student responses to these items were *1-Strongly Disagree, 2- Disagree, 3-*

Neutral, 4-Agree, and *5-Strongly Agree.* Students responding with 1-S*trongly Disagree* would be experiencing low anxiety in mathematics and students responding with a 5-*Strongly Agree* would be experiencing high anxiety in mathematics. A sample item from the AMAS survey is “Thinking about an upcoming math test one day before makes me anxious” (Hopko et al., 2003, p. 180). A student’s anxiety in mathematics score was calculated by adding the responses to the nine items. Based on student responses to the items, a student’s anxiety score ranged from 9 to 45. The AMAS has strong convergent validity and strong test-retest reliability based on the significant correlations between scores from two administrations of the Math Anxiety Rating Scale-Revised (MARS-R) the AMAS (r = .85), the AMASlma (r = .70), and the AMASmea (r = .81) (Hopko et al., 2003, p. 180). The use of the nine items from the AMAS provided the data needed for this study to measure student anxiety in the area of mathematics.

Student Attitude Survey (SAS). The instrument adapted for this study to measure student confidence in mathematics as specified in RQ3 and RQ4 was the Student Attitude Survey (SAS). This survey was “constructed under a principled assessment design approach using items selected from a variety of established instruments” (Mislevy, Steinberg, Almond, Haertel, & Penuel, 2003, p. 1). The SAS survey was built around the work of the F-S, Fennema and Sherman’s attitude survey. The survey was originally created to “measure changes in attitude and motivation of students participating in mathematics at the middle and high school level” (Brookstein, Hegedus, Dalton, Moniz, & Tapper, 2011, p. 1). Four attitudes are examined in the SAS survey: Attitude 1: Deep affect: Positivity towards learning mathematics and school; Attitude 2: Working collaboratively and related affect; Attitude 3: Working privately; and Attitude 4: Use of technology. On the original SAS survey, there are 18 items listed for response; however, survey items 1-4 were designated as measures of student confidence by the authors of this survey, and thus the only ones from the complete survey that were utilized in the current study. The SAS item responses are formatted with a 5-point Likert-Type scale. For this survey, the item responses were *5-Strongly Agree, 4-Agree, 3-Neutral, 2-Disagree,* and *1-Strongly Disagree.* Two of the items utilized from the SAS were recoded to achieve accurate measurement of confidence for this research. Item 2, "In the past I have not enjoyed Math," and Item 5, "When I see a math problem, I am nervous" were recoded so that the 1 to 5 responses were reversed 5 to 1. After the recodes, the sum of the four items, between 4 and 20, provided confidence data for the research. If students showed confidence in mathematics, the score for these four items would be high, if students showed a lack of confidence, the scores for these four items would be low.

The SAS has a number of similarities to the Fennema-Sherman (F-S) Mathematics Attitude Scale (Fennema & Sherman, 1976). The F-S survey has undergone extensive research on the reliability and validity of its measures (Fennema, Wolleat, Pedro & DeVaney Becker, 1981; Kimball, 1989; McLeod, 1994). The confidence items from the SAS showed the highest level of concurrence with the F-S survey items. Trapper (2011), the creator of the SAS, reported moderately strong evidence for the validity of the four confidence subscale items.

NWEA MAP Mathematics Assessment. The NWEA MAP mathematics assessment is a computerized adaptive test used to measure student performance in mathematics based on his or her academic level, independent of grade. The content and length of the test vary for each student because of the adaptive nature; however, each test is approximately 52 questions. The MAP test includes a variety of question types, such as multiple choice, fill in the blank, and drag and drop answers. The MAP was designed using these assessment types to ensure a clear assessment of a student's ability to think critically in the area of mathematics (NWEA, 2018).

According to NWEA (2018), student scores are reported using the Rasch Unit (RIT) scale. The RIT scale is an equal-interval scale. Each RIT point is stable and means the same value for every grade group; this makes it possible to use the scale to measure individual academic progress for every student. Each RIT score indicates a point on a continuous scale of learning. The scores are not to be used as target scores, but as benchmarks of a student's academic skill level. Given that the MAP assessment is taken on a computer, once the student completes the assessment, scores are immediately available to both teacher and student.

> Questions on the MAP receive their RIT values after being tested on thousands of students across the United States. Responses to items throughout a student's test are used to produce the final RIT score for that student. The numerical (RIT) value given to a student predicts that at that specific difficulty level, a student is likely to answer about 50% of the questions correctly. Results are scored across an even interval scale, meaning that the difference between scores remains consistent regardless of whether a student scores high or low. The consistent even interval scale reinforces that grade level is not a factor. (NWEA, 2018, p. 5)

Student mathematics academic growth specified in RQ4 and RQ5 was measured by subtracting the fall MAP RIT score from the spring MAP RIT score.

NWEA MAP has a strong test-retest reliability. NWEA's reliability is based on a more accurate approach which blends test-retest and a type of parallel form of reliability. The second test that is administered is very similar in structure and content but differs in difficulty. According to NWEA (2011), most coefficients are in the mid-.80s to low .90s even when the tests are administered with several months between administration. In the area of validity, NWEA ensured validity by "carefully mapping existing content standards from a state into a test blueprint" (NWEA, 2011, p. 4). The majority of the evidence for validity for the MAP assessment comes in the form of concurrent validity. Concurrent validity answers the question "how well do the scores from this test reference the (RIT) scale in this subject area correspond to the scores obtained from an established test that references some other scale in the same subject area?" (NWEA, 2011, p. 5). NWEA MAP assessments have strong concurrent validity and reliability scores falling in the mid-.80s (NWEA, 2011). Given the strong reliability and validity of the NWEA assessment module, the MAP assessment was utilized for this study to measure student achievement in mathematics. The study utilized the difference between fall and spring math MAP RIT student scores as the measure of mathematics achievement.

Demographic Variables. For RQ2, RQ4, and RQ6, four demographic variables were measured. The first variable examined was student gender. Gender was determined by student self-reporting during school enrollment and then downloaded from Synergy, the Student Information System (SIS) used in District S. The next variable was IEP Status (had an IEP or did not have an IEP) which was also downloaded from the student information system in District S. The third variable was socioeconomic status (SES) (free/reduced, no designation) was also measured based on information available from

Synergy. The final variable measured was ethnicity (White, non-White) and was also stored in Synergy. The non-White category included Black, Asain, Pacific Islander, and Hispanic ethnicities and an option for students to respond with more than one ethnicity.

Data Collection Procedures

The research began by requesting and gaining approval for the utilization of both the SAS from Dr. John Trapper (see Appendix C), and approval for the utilization of the AMAS from Dr. Melissa Hunt (See Appendix D). Once the approval for the use of the surveys was obtained, the researcher submitted the district research proposal (see Appendix E) form and a research support letter from Dr. Susan Rogers, the dissertation advisor (see Appendix E). The completed form and letter from the dissertation advisor were electronically mailed to the Director of Assessment and Research of District S on January 28, 2018. District S approved the research proposal on March 1, 2018 (see Appendix F). The researcher then submitted the District S Research Proposal form to the Institutional Review Board (IRB) at Baker University on March 27, 2018 (see Appendix G). The Baker University IRB approved the research project on March 28, 2018 (see Appendix H). After IRB approvals from both District S and Baker University were obtained, the anxiety and confidence survey (see Appendix I) was administered to participants during their Applied Algebra class on April 26 and 27, 2018. The participants were assigned a participant number to use during the completion of the survey. The participant numbers were assigned to match survey and archived data while at the same time prevent the personal identification of students.

The MAP mathematics data was requested from District S's assessment and research department. The Student Information System (SIS) utilized in District S is

Synergy. The MAP data was collected and presented to the researcher on June 13, 2018. Once the data was received, student names were replaced with the participant numbers assigned during the survey administration. Once the data was collected and merged, the data were examined for accuracy before being imported into IBM SPSS Statistics Faculty Pack 25 for Windows to complete the statistical analysis.

Data Analysis and Hypothesis Testing

This study involved the use of quantitative methods of data analysis. The quantitative analysis focused on six research questions, listed below, each followed by the corresponding hypothesis or hypotheses, and the data analysis. In this section, the research questions and hypotheses for the study as well as the statistical analysis to test each hypothesis are included.

RQ1. To what extent is there a difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra?

H1. There is a statistically significant difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra.

A two-factor analysis of variance (ANOVA) was conducted to test H1 and H2. The two categorical variables used to group the dependent variable, student anxiety in mathematics, were PBL instruction status (receiving, not receiving) and gender (male, female). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for gender, and a two-way interaction effect for PBL instruction status by gender. The main effect for PBL instruction status was used to test H1. The level of significance was set at .05.

RQ2. To what extent is the difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra affected by student gender, IEP status, SES, and ethnicity?

H2. The difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student gender.

The two-way interaction effect for PBL instruction status by gender from the first ANOVA was used to test H2. The level of significance was set at .05.

H3. The difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student IEP status.

A second two-factor ANOVA was conducted to test H3. The two categorical variables used to group the dependent variable, student anxiety in mathematics, were PBL instruction status (receiving, not receiving) and IEP status (has an IEP, does not have an IEP). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for IEP status, and a two-way interaction effect for PBL instruction by IEP status. The two-way interaction effect for PBL instruction status by IEP status was used to test H3. The level of significance was set at .05.

H4. The difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student SES.

A third two-factor ANOVA was conducted to test H4. The two categorical variables used to group the dependent variable, student anxiety in mathematics, were PBL instruction status (receiving, not receiving) and SES (free/reduced, no designation). The two-factor ANOVA can be used to test three hypotheses including a main effect were PBL instruction status, a main effect for SES, and a two-way interaction effect for PBL instruction status by SES. The two-way interaction effect for PBL instruction status by SES was used to test H4. The level of significance was set at .05.

H5. The difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student ethnicity.

A fourth two-factor ANOVA was conducted to test H5. The two categorical variables used to group the dependent variable, student anxiety in mathematics, were PBL instruction status (receiving, not receiving) and ethnicity (White, non-White). The two-factor ANOVA can be used to test three hypotheses including a main effect were PBL instruction, a main effect for ethnicity, and a two-way interaction effect for PBL instruction status by ethnicity. The two-way interaction effect for PBL instruction status by ethnicity was used to test H5. The level of significance was set at .05.

RQ3. To what extent is there a difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra?

H6. There is a statistically significant difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra.

A fifth two-factor ANOVA was conducted to test H6 and H7. The two categorical variables used to group the dependent variable, student confidence in mathematics, were PBL instruction status (receiving, not receiving) and gender (male, female). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for gender, and a two-way interaction effect for PBL instruction status by gender. The main effect for PBL enrollment status was used to test H6. The level of significance was set at .05.

RQ4. To what extent is the difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra affected by student gender, IEP status, SES, and ethnicity?

H7. The difference in student confidence in mathematics between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction is affected by student gender.

The two-way interaction effect for PBL instruction status by gender from the fifth ANOVA was used to test H7. The level of significance was set at .05.

H8. The difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by IEP status.

A sixth two-factor ANOVA was conducted to test H8. The two categorical variables used to group the dependent variable, student confidence in mathematics, were PBL instruction status (receiving, not receiving) and IEP status (has an IEP, does not have an IEP). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction, a main effect for IEP status, and a two-way interaction effect for PBL instruction status by IEP status. The two-way interaction effect for PBL instruction status by IEP status was used to test H8. The level of significance was set at .05.

H9. The difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student SES.

A seventh two-factor ANOVA was conducted to test H9. The two categorical variables used to group the dependent variable, student confidence in mathematics, were PBL instruction status (receiving, not receiving) and SES (free/reduced, no designation). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for SES, and a two-way interaction effect for PBL instruction status by SES. The two-way interaction effect for PBL instruction status by SES was used to test H9. The level of significance was set at .05.

H10. The difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student ethnicity.

An eighth two-factor ANOVA was conducted to test H10. The two categorical variables used to group the dependent variable, student confidence in mathematics, were

PBL instruction status (receiving, not receiving) and ethnicity (White, non-White). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for SES, and a two-way interaction effect for PBL instruction status by ethnicity. The two-way interaction effect for PBL instruction status by ethnicity was used to test H10. The level of significance was set at .05.

RQ5. To what extent is there a difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra?

H11. There is a statistically significant difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra.

A ninth two-factor ANOVA was conducted to test H11 and H12. The two categorical variables used to group the dependent variable, growth on the MAP mathematics assessment, were PBL instruction status (receiving, not receiving) and gender (males, females). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for gender, and a two-way interaction effect for PBL instruction status by gender. The main effect for PBL instruction status was used to test H11. The level of significance was set at .05.

RQ6. To what extent is the difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra affected by student gender, IEP status, SES, and ethnicity?

H12. The difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student gender.

The two-way interaction effect for PBL instruction status by gender from the ninth ANOVA was used to test H12. The level of significance was set at .05.

H13. The difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by IEP status.

A tenth two-factor ANOVA was conducted to test H13. The two categorical variables used to group the dependent variable, student growth on the MAP mathematics assessment were PBL instruction (receiving, not receiving) and IEP status (has an IEP, does not have an IEP). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for IEP status, and a two-way interaction effect for PBL instruction status. The two-way interaction effect for PBL instruction status by IEP status was used to test H13. The level of significance was set at .05.

H14. The difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student SES.

An eleventh two-factor ANOVA was conducted to test H14. The two categorical variables used to group the dependent variable, growth on the MAP mathematics assessment, were PBL instruction (receiving, not receiving) and SES (free/reduced, no designation). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for SES, and a two-way interaction effect for PBL instruction status by SES. The two-way interaction effect for PBL instruction status by SES was used to test H14. The level of significance was set at .05.

H15. The difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student ethnicity.

A twelfth two-factor ANOVA was conducted to test H15. The two categorical variables used to group the dependent variable, growth on the MAP mathematics assessment, were PBL instruction status (receiving, not receiving) and ethnicity (White, non-White). (The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for ethnicity, and a two-way interaction effect for PBL instruction status by ethnicity. The two-way interaction effect for PBL instruction status by ethnicity was used to test H15. The level of significance was set at .05.

Limitations

In 2008, Lunenburg and Irby stated that limitations are “factors that may have an effect on the interpretation of the findings or on the generalizability of the results” (p. 133). There are potential limitations to this study. One of the limitations was the limited time of implementation of PBL instruction in education. This instructional method has gained momentum through organizations such as the Buck Institute; however, at the time of this study, PBL was still in its initial stages of training and implementation across the nation. An additional limitation was the number of participants and teacher classrooms utilized in this study. While this study allowed the examination of the impact of PBL in an Applied Algebra classroom as it relates to student anxiety, confidence, and growth in mathematics, the number of participants, teachers, and schools utilized in the study may not be representative of the larger population. Additionally, it is important to note that in specific cases there are missing data points due to circumstances beyond the researcher's control. These circumstances included but are not limited to students moving into or out of the Applied Algebra classroom during the year due to unforeseen circumstances. The moving into and out of the Applied Algebra classrooms affected both the MAP testing data and the survey data. Furthermore, some students skipped questions on the survey when it was administered. Additionally, students who were not present during the administration of the survey, due to leaving the Applied Algebra classroom prior to the survey being administered, were not included in those corresponding data points.

Summary

This study was conducted to examine the impact of PBL in the Applied Algebra classroom as it relates to anxiety, confidence, and MAP growth in mathematics. This chapter included the research design, selection of participants, measurements used, data collection procedures, data analysis and hypothesis testing, and the limitations of the study. Chapter 4 contains the results of the data analysis.

Chapter 4

Results

The purpose of this study was to determine if PBL instruction had an impact on student anxiety and confidence in the Applied Algebra Classroom. This study also focused on the impact of PBL instruction on academic growth as measured by the MAP mathematics assessment using the difference in student MAP RIT scores from fall to spring. The first purpose of this study was to determine if there was a difference in student anxiety and confidence in mathematics between students receiving PBL based instruction in the Applied Algebra classroom and students not receiving PBL based instruction in the Applied Algebra Classroom. The second purpose of this study was to determine if there was a difference in student growth from fall to spring on the MAP mathematics assessment between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction. The third purpose of this study was to determine if there were differences between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction were affected by student gender, SES, IEP status, and ethnicity. Presented in this chapter are the descriptive statistics and the results of the hypothesis testing as it connects to the research questions examined in this study.

Descriptive Statistics

There were 56 total participants in this study. Of the 56 participants, 25 received PBL instruction, and 31 did not receive PBL instruction. Participant demographic variables that were used in this study were gender, SES, IEP status, and ethnicity. The frequencies of these participant characteristics are found in Table 1.

Table 1

Participant Characteristics

Participant Characteristics	*f* – (Received)	*f* – (Did not receive)
PBL Instruction	25	31
Gender		
Female	10	10
Male	15	21
IEP status		
Had an IEP	18	18
Did not have an IEP	7	13
SES		
Free	11	8
Reduced	2	2
Full Pay	12	18
Ethnicity		
Black	9	5
Hispanic	3	5
Multi-racial	2	2
White	11	15

Hypothesis Testing

The results of the testing which addressed the six research questions utilized in this study are discussed in this section. Each research question addressed in the study is followed by the corresponding hypotheses, the methodology used, and the results of each test.

RQ1. To what extent is there a difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra?

H1. There is a statistically significant difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra.

A two-factor analysis of variance (ANOVA) was conducted to test H1 and H2. The two categorical variables used to group the dependent variable, student anxiety in mathematics, were PBL instruction status (receiving, not receiving) and gender (male, female). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for gender, and a two-way interaction effect for PBL instruction status by gender. The main effect for PBL instruction status was used to test H1. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between the means, $F = 8.858$, $df = 1, 46$, $p = .206$. The mean anxiety for students receiving PBL instruction in Applied Algebra ($M = 22.14$, $SD = 8.36$, $n = 22$) was not different from the mean anxiety for students not receiving PBL instruction in Applied Algebra ($M = 26.25$, $SD = 6.83$, $n = 28$). H1 was not supported.

RQ2. To what extent is the difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra affected by student gender, IEP status, SES, and ethnicity?

H2. The difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student gender.

The two-way interaction effect for PBL instruction status by gender from the first ANOVA was used to test H2. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between at least two of the means, $F = 0.486$, $df = 1, 46$, $p = .489$. See Table 2 for the means and standard deviations for this analysis. No follow-up post hoc was warranted. H2 was not supported. The difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra was not affected by student gender.

Table 2

Descriptive Statistics for the Results of the Test for H2

PBL Instructions	Gender	*M*	*SD*	*N*
Receiving	Female	23.50	2.78	8
	Male	21.36	10.34	14
Not Receiving	Female	29.60	6.77	10
	Male	24.39	6.30	18

H3. The difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student IEP status.

A second two-factor ANOVA was conducted to test H3. The two categorical variables used to group the dependent variable, student anxiety, were PBL instruction status (receiving, not receiving) and IEP status (has an IEP, does not have an IEP). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for IEP status, and a two-way interaction effect for PBL instruction by IEP status. The two-way interaction effect for PBL instruction status by IEP status was used to test H3. The level of significance was set at .05.

The results of the analysis indicated a statistically significant difference between at least two of the means, $F = 4.668$, $df = 1, 46$, $p = .036$. See Table 3 for the means and standard deviations for this analysis. A follow-up post hoc was conducted to determine which pairs of means were different. The Fisher's Least Significant Difference (LSD) critical value was 5.377. The differences between the means had to be greater than this value to be considered significant ($\alpha = .05$). Two of the differences were greater than this value. The mean for students without an IEP receiving PBL instruction in Applied Algebra ($M = 27.50$) was higher than the mean for students with an IEP receiving PBL instruction in Applied Algebra ($M = 20.13$). The mean for students with an IEP not receiving PBL instruction in Applied Algebra ($M = 27.11$) was higher than the mean for students with an IEP receiving PBL instruction in Applied Algebra ($M = 20.13$). H3 was supported.

Table 3

Descriptive Statistics for the Results of the Test for H3

PBL Instruction	IEP Status	*M*	*SD*	*N*
Receiving	IEP	20.13	5.56	16
	No IEP	27.50	12.37	6
Not Receiving	IEP	27.11	6.15	18
	No IEP	24.70	8.03	10

H4. The difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student SES.

A third two-factor ANOVA was conducted to test H4. The two categorical variables used to group the dependent variable, student anxiety, were PBL instruction status (receiving, not receiving) and SES (free/reduced, no designation). The two-factor ANOVA can be used to test three hypotheses including a main effect were PBL instruction status, a main effect for SES, and a two-way interaction effect for PBL instruction status by SES. The two-way interaction effect for PBL instruction status by SES was used to test H4. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between at least two of the means, $F = 0.029$, $df = 1, 46$, $p = .865$. See Table 4 for the means and standard deviations for this analysis. No follow-up post hoc was warranted. H4 was not supported. The difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra was not affected by student SES.

Table 4

Descriptive Statistics for the Results of the Test for H4

PBL Instruction	SES	*M*	*SD*	*N*
Receiving	Free/Reduced	22.18	9.09	11
	No Designation	22.09	8.01	11
Not Receiving	Free/Reduced	26.80	6.23	10
	No Designation	25.94	7.30	18

H5. The difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student ethnicity.

A fourth two-factor ANOVA was conducted to test H5. The two categorical variables used to group the dependent variable, student anxiety, were PBL instruction status (receiving, not receiving) and ethnicity (White, non-White). The two-factor ANOVA can be used to test three hypotheses including a main effect were PBL instruction, a main effect for ethnicity, and a two-way interaction effect for PBL instruction status by ethnicity. The two-way interaction effect for PBL instruction status by ethnicity was used to test H5. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between at least two of the means, $F = 2.025$, $df = 1, 46$, $p = .161$. See Table 5 for the means and standard deviations for this analysis. No follow-up post hoc was warranted. H5 was not supported. The difference in student anxiety in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra was not affected by student ethnicity.

Table 5

Descriptive Statistics for the Results of the Test for H5

PBL Instruction	Ethnicity	*M*	*SD*	*N*
Receiving	White	21.10	4.07	10
	Non-White	23.00	10.86	12
Not Receiving	White	28.20	6.90	15
	Non-White	24.00	6.27	13

RQ3. To what extent is there a difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra?

H6. There is a statistically significant difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra.

A fifth two-factor ANOVA was conducted to test H6 and H7. The two categorical variables used to group the dependent variable, student confidence, were PBL instruction status (receiving, not receiving) and gender (male, female). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for gender, and a two-way interaction effect for PBL instruction status by gender. The main effect for PBL enrollment status was used to test H6. The level of significance was set at .05.

The results of the analysis indicated a statistically significant difference between the means, F = 6.278, df = 1, 45, p = .016. The mean confidence for students receiving

PBL instruction in Applied Algebra (*M* = 13.95, *SD* = 2.70, *n* = 22) was higher than the mean confidence for students not receiving PBL instruction in Applied Algebra (*M* = 12.44, *SD* = 2.04, *n* = 27). H6 was supported.

RQ4. To what extent is the difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra affected by student gender, IEP status, SES, and ethnicity?

H7. The difference in student confidence in mathematics between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction is affected by student gender.

The two-way interaction effect for PBL instruction status by gender from the fifth ANOVA was used to test H7. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between at least two of the means, $F = 0.630$, $df = 1, 45$, $p = .432$. See Table 6 for the means and standard deviations for this analysis. No follow-up post hoc was warranted. H7 was not supported. The difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra was not affected by student gender.

Table 6

Descriptive Statistics for the Results of the Test for H7

PBL Instructions	Gender	*M*	*SD*	*N*
Receiving	Female	13.38	1.77	8
	Male	14.29	3.12	14
Not Receiving	Female	11.11	1.90	9
	Male	13.11	1.81	18

H8. The difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by IEP status.

A sixth two-factor ANOVA was conducted to test H8. The two categorical variables used to group the dependent variable, student confidence, were PBL instruction status (receiving, not receiving) and IEP status (has an IEP, does not have an IEP). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction, a main effect for IEP status, and a two-way interaction effect for PBL instruction status by IEP status. The two-way interaction effect for PBL instruction status by IEP status was used to test H8. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between at least two of the means, $F = 1.540$, $df = 1, 45$, $p = .221$. See Table 7 for the means and standard deviations for this analysis. No follow-up post hoc was warranted. H8 was not supported. The difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra was not affected by IEP status.

Table 7

Descriptive Statistics for the Results of the Test for H8

PBL Instruction	IEP Status	*M*	*SD*	*N*
Receiving	IEP	14.13	2.45	16
	No IEP	13.50	3.51	6
Not Receiving	IEP	12.00	1.17	17
	No IEP	13.20	2.94	10

H9. The difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student SES.

A seventh two-factor ANOVA was conducted to test H9. The two categorical variables used to group the dependent variable, student confidence, were PBL instruction status (receiving, not receiving) and SES (free/reduced, no designation). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for SES, and a two-way interaction effect for PBL instruction status by SES. The two-way interaction effect for PBL instruction status by SES was used to test H9. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between at least two of the means, $F = 1.671$, $df = 1, 45$, $p = .203$. See Table 8 for the means and standard deviations for this analysis. No follow-up post hoc was warranted. H9 was not supported. The difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra was not affected by student SES.

Table 8

Descriptive Statistics for the Results of the Test for H9

PBL Instruction	SES	*M*	*SD*	*N*
Receiving	Free/Reduced	13.64	3.04	11
	No Designation	14.27	2.41	11
Not Receiving	Free/Reduced	13.22	2.17	9
	No Designation	12.06	1.92	18

H10. The difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student ethnicity.

An eighth two-factor ANOVA was conducted to test H10. The two categorical variables used to group the dependent variable, student confidence, were PBL instruction status (receiving, not receiving) and ethnicity (White, non-White). The two-factor ANOVA can be used to test three hypotheses including a main effect were PBL instruction status, a main effect for SES, and a two-way interaction effect for PBL instruction status by ethnicity. The two-way interaction effect for PBL instruction status by ethnicity was used to test H10. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between at least two of the means, F = 0.296, df = 1, 45, p = .589. See Table 9 for the means and standard deviations for this analysis. No follow-up post hoc was warranted. H10 was not supported. The difference in student confidence in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra was not affected by student ethnicity.

Table 9

Descriptive Statistics for the Results of the Test for H10

PBL Instruction	Ethnicity	*M*	*SD*	*N*
Receiving	White	13.90	2.18	10
	Non-White	14.00	3.16	12
Not Receiving	White	12.07	1.33	15
	Non-White	12.92	2.68	12

RQ5. To what extent is there a difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra?

H11. There is a statistically significant difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra.

A ninth two-factor ANOVA was conducted to test H11 and H12. The two categorical variables used to group the dependent variable, growth on the MAP mathematics assessment, were PBL instruction status (receiving, not receiving) and gender (males, females). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for gender, and a two-way interaction effect for PBL instruction status by gender. The main effect for PBL instruction status was used to test H11. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between the means, $F = 1.324$, $df = 1, 45$, $p = .256$. The mean growth from fall to spring on the MAP mathematics assessment for students receiving PBL instruction in Applied Algebra (*M* = -1.52, *SD* = 6.98, *n* = 21) was not different from the mean growth from fall to spring on the MAP mathematics assessment for students not receiving PBL instruction in Applied Algebra (*M* = 0.04, *SD* = 7.68, *n* = 28). H11 was not supported.

RQ6. To what extent is the difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra affected by student gender, IEP status, SES, and ethnicity?

H12. The difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student gender.

The two-way interaction effect for PBL instruction status by gender from the ninth ANOVA was used to test H12. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between at least two of the means, $F = 2.456$, $df = 1, 45$, $p = .124$. See Table 10 for the means and standard deviations for this analysis. No follow-up post hoc was warranted. H12 was not supported. The difference in student growth from fall to spring on the MAP mathematics assessment in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra was not affected by student gender.

Table 10

Descriptive Statistics for the Results of the Test for H12

PBL Instructions	Gender	*M*	*SD*	*N*
Receiving	Female	-2.00	7.87	9
	Male	-1.17	6.58	12
Not Receiving	Female	3.80	6.83	10
	Male	-2.06	7.48	18

H13. The difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by IEP status.

A tenth two-factor ANOVA was conducted to test H13. The two categorical variables used to group the dependent variable, student growth on the MAP mathematics assessment were PBL instruction (receiving, not receiving) and IEP status (has an IEP, does not have an IEP). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for IEP status, and a two-way interaction effect for PBL instruction status. The two-way interaction effect for PBL instruction status by IEP status was used to test H13. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between at least two of the means, $F = 0.159$, $df = 1, 43$, $p = .692$. See Table 11 for the means and standard deviations for this analysis. No follow-up post hoc was warranted. H13 was not supported. The difference in student growth from fall to spring on the MAP mathematics assessment in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra was not affected by IEP status.

Table 11

Descriptive Statistics for the Results of the Test for H13

PBL Instruction	IEP Status	*M*	*SD*	*N*
Receiving	IEP	-1.75	7.55	16
	No IEP	-0.80	5.40	5
Not Receiving	IEP	-0.06	6.97	18
	No IEP	2.75	6.61	8

H14. The difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student SES.

An eleventh two-factor ANOVA was conducted to test H14. The two categorical variables used to group the dependent variable, growth on the MAP mathematics assessment, were PBL instruction (receiving, not receiving) and SES (free/reduced, no designation). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for SES, and a two-way interaction effect for PBL instruction status by SES. The two-way interaction effect for PBL instruction status by SES was used to test H14. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between at least two of the means, $F = 2.965$, $df = 1, 43$, $p = .092$. See Table 12 for the means and standard deviations for this analysis. No follow-up post hoc was warranted. H14 was not supported. The difference in growth from fall to spring on the MAP mathematics assessment in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra was not affected by student SES.

Table 12

Descriptive Statistics for the Results of the Test for H14

PBL Instruction	SES	*M*	*SD*	*N*
Receiving	Free/Reduced	-5.70	6.15	10
	No Designation	2.27	5.50	11
Not Receiving	Free/Reduced	0.00	7.95	8
	No Designation	1.17	6.53	18

H15. The difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra is affected by student ethnicity.

A twelfth two-factor ANOVA was conducted to test H15. The two categorical variables used to group the dependent variable, growth on the MAP mathematics assessment, were PBL instruction status (receiving, not receiving) and ethnicity (White, non-White). The two-factor ANOVA can be used to test three hypotheses including a main effect for PBL instruction status, a main effect for ethnicity, and a two-way interaction effect for PBL instruction status by ethnicity. The two-way interaction effect for PBL instruction status by ethnicity was used to test H15. The level of significance was set at .05.

The results of the analysis indicated there was not a statistically significant difference between at least two of the means, $F = 0.151$, $df = 1, 43$, $p = .700$. See Table 13 for the means and standard deviations for this analysis. No follow-up post hoc was warranted. H15 was not supported. The difference in growth from fall to spring on the MAP mathematics assessment in mathematics between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra was not affected by student ethnicity.

Table 13

Descriptive Statistics for the Results of the Test for H15

PBL Instruction	Ethnicity	*M*	*SD*	*N*
Receiving	White	-3.00	6.84	9
	Non-White	-0.42	7.18	12
Not Receiving	White	0.36	6.77	14
	Non-White	1.33	7.22	12

Summary

Chapter 4 began with a presentation of the descriptive statistics related to this study. The second section provided the results of the hypothesis testing related to the six research questions. Chapter 5 includes the study summary, findings related to the literature, and the conclusions.

Chapter 5

Interpretation and Recommendations

The research in this study was focused on the difference between student anxiety, student confidence, and student achievement between students who received PBL instruction and students who did not receive PBL instruction in the Applied Algebra classroom. The chapter begins with the study summary, which includes an overview of the problem, purpose statement and research questions, a review of the methodology, and the major findings of the study. Following the study summary, the findings related to the literature and the conclusions are presented.

Study Summary

This section provides a summary of the research conducted for this study. The summary contains an overview of the problem regarding the decline of both student confidence and student achievement and an increase in student anxiety relating to mathematics. Following this section, the purpose of the study and the research questions are stated. The summary section concludes with the overview of the methodology and major findings of the study.

Overview of the problem. Mathematics competency remains a critical skill for student success post-high school. Employers continually seek workers who have the ability to solve complex problems and think at a critical level. However, the increase in student anxiety, the inability to demonstrate mathematics confidence, and the concern surrounding students' inability to demonstrate academic growth in mathematics is an increasing challenge in schools today. Moreover, as student mathematics assessment scores continue to decline as they enter high school, the causes behind this downward trend must be examined (Kotok, 2017). Possible explanations behind the absence of mathematics success rest in students' inabilities to accurately understand numeric processes. Additionally, the lack of student engagement, largely due to students not seeing the relevance to the content area might contribute to this downward spiral. One potential solution to this lack of achievement is to increase student confidence and decrease student anxiety in mathematics through the implementation of PBL instruction.

Purpose statement and research questions. The purpose of this study was to determine if PBL instruction has an impact on student anxiety and confidence in the Applied Algebra Classroom. This study also focused on the impact of PBL instruction on academic growth, as measured by the MAP mathematics assessment using the difference in the MAP scores from fall to spring. The first purpose of this study was to determine if there was a difference in student anxiety and confidence in mathematics between students receiving PBL based instruction in the Applied Algebra classroom and students not receiving PBL based instruction in the Applied Algebra classroom. The second purpose of this study was to determine if there was a difference in student growth from fall to spring on the MAP mathematics assessment between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction. The third purpose of this study was to determine if there were differences between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction were affected by student gender, SES, IEP status, and ethnicity. To address the purposes of this study, six research questions were posed, and 15 related hypotheses were tested.

Review of the methodology. A quantitative research design was utilized in this study. The participants in the study were 59 students from two schools in a Midwest suburban district who were enrolled in an Applied Algebra class. One of the classrooms utilized a PBL instructional model, and the other classroom utilized a traditional instructional model. The independent variables of interest in this study were PBL instructional status (receiving, not receiving), and student demographics including gender (male, female), IEP status (had an IEP, did not have an IEP) SES (free/reduced, no designation), and ethnicity (White, non-White). The dependent variables were mathematics anxiety, mathematics confidence, and MAP mathematics growth from fall to spring. To measure student anxiety in mathematics, the AMAS was used. The AMAS contains nine items, and response options are presented using a five-point Likert-type scale. To measure student confidence, four items from the SAS were used. The responses for the four confidence items were presented on the survey using a five-point Likert-type scale. To measure student mathematics achievement, the difference in student RIT scores from fall to spring on the NWEA MAP mathematics assessment was utilized. Twelve two-factor ANOVAs were conducted to test the 15 hypotheses.

Major findings. The results of the data analysis for the current study revealed that there was not a statistically significant difference in overall student anxiety between students receiving PBL instruction and students not receiving PBL instruction. The results also showed that there was no significant difference in mathematics anxiety between students who received PBL instruction and students who did not receive PBL instruction based on SES, gender, or ethnicity. However, the results of the study did indicate that there was a significant difference in student anxiety in mathematics between students receiving PBL instruction and students not receiving PBL instruction based on student IEP status. Students with an IEP who received PBL instruction reported less anxiety in mathematics.

Moreover, the results of the analysis indicated that there was a statistically significant difference in student confidence in mathematics between students receiving PBL instruction and students not receiving PBL instruction. Students who received PBL instruction were more confident in mathematics than students who did not receive PBL instruction. However, in the current study, confidence in mathematics was not affected by SES, gender, IEP, or ethnicity. Finally, there was no significant difference in student growth from fall to spring on the MAP mathematics assessment between students receiving PBL instruction in Applied Algebra and students not receiving PBL instruction in Applied Algebra. Additionally, the difference in achievement based on PBL instruction was not affected by student gender, SES, IEP status, or ethnicity.

Findings Related to the Literature

The findings from this study related to the literature on the impact of PBL instruction on student anxiety in mathematics, student confidence in mathematics, and achievement in mathematics are included in this section. The current research was also focused on the differences in the impact of PBL instruction based on gender, SES, IEP status, and ethnicity. However, the amount of research available to compare the results of this study was limited.

The first variable examined in the study was the perceptions of mathematics anxiety between students who received PBL instruction and students who did not receive PBL instruction. Wingfield and Meece (1988) discussed the theory that anxiety and worry cause “self-deprecating thoughts about one’s performance” (p. 76). Wingfield and Meece (1988) shared that these thoughts and feelings experienced by students during learning might prevent them from retaining the concepts and skills taught in the classroom. The theory of Wingfield and Meece (1988) was supported by Ashcroft and Krause (2007) and the results of their research on anxiety in the mathematics classroom, which indicated that anxiety “compromises the functioning of working memory when people do arithmetic or math” (p. 243). The function of the working memory is vital in the attainment of basic numeracy skills. Students who experience high anxiety spend a great amount of working memory attempting to decrease their anxiety rather than learning a new concept or skill (Ashcroft & Krause, 2007, p. 246). The current study revealed that overall student anxiety was not impacted by PBL instruction. Also, anxiety was not impacted by PBL instruction based on gender, SES, or ethnicity. However, the current study revealed that student anxiety was lower for students with an IEP who received PBL instruction. The fact that PBL instruction revealed lowered anxiety for students with an IEP, who already have a compromised ability to function at a high cognitive level in the area of mathematics, is critical. The lowered anxiety levels might allow these students the opportunity to use more of their working memory in the attainment of mathematics skills rather than working to decrease their anxiety.

Second, the current study examined confidence in the area of mathematics between students receiving PBL instruction and not receiving PBL instruction. The current study revealed that overall confidence was higher for students receiving PBL instruction. However, the data analysis revealed that confidence based on gender, SES, IEP status and ethnicity were not impacted by PBL instruction. Hackett and Betz (1989) purported that “mathematics self-efficacy contributed more significantly than sex, or years of high school mathematics” (p. 262). They discussed “that mathematics self-efficacy is a situational or problem-specific assessment of an individual’s confidence in her or his ability to successfully perform or accomplish a particular task or problem” (Hackett & Betz, 1989, p. 262). The current research supported Bandura (1994) as he reported that the stronger student self-perceived abilities are, the higher the goals and expectations are for the student. Furthermore, Khezri et al. (2010) focused on self-efficacy as the main construct linked to students’ ability to accomplish specific tasks such as mathematics. The literature also supported the idea that confidence is linked to students seeing the relevance of the task. Filcik et al. (2012) reported that relevant instruction using a PBL framework caused students to be more engaged than their non-PBL counterparts. The current research supports the literature in the area of confidence. Overall, students in the current study who received PBL instruction were more confident in mathematics than students who did not receive PBL instruction. The increase of confidence and self-efficacy through the implementation of PBL instruction was supported by the current research.

Finally, the current study examined student achievement between students receiving PBL instruction and students not receiving PBL instruction. The current study’s research was in contrast to the literature. The data analysis of the current research revealed that there was not a statistically significant difference between student growth on the MAP mathematics assessment from fall to spring for the students who received PBL instruction and students who did not receive PBL instruction. The current research supported the findings of Kirchner et al. (2006) in their discussion that PBL instruction does not necessarily provide all the important information so that the working memory and cognitive structures of the brain can process information properly. The processing of information is necessary to perform well on assessments. The current study also supported the research from Kirschner et al. in their claim that "complete information taught will result in a more accurate representation and is more easily acquired" (p. 78). The current research is also supportive of Bennett's (2016) findings as it related to low SES student achievement being "negative and significant" (para. 4). Finally, the findings of the current research support the discussion provided by Guido (2016). One of his discussion points centers around the theory that tests are typically fact-based using multiple-choice items and the retrieval of factual information is necessary. PBL instruction focuses more on the collaboration and justification of reasoning which might leave some important factual information to student discovery. These findings in the literature supported by the current research are notable and worthy. However, the current research was in contrast with the findings of other researchers. Ajai et al. (2013) examined both the traditional method of instruction and the PBL method and found that the learning in a PBL classroom was "more likely to possess a more meaningful in-depth knowledge of the content area" (p. 133). The current research did not support this more meaningful in-depth knowledge of mathematics and should be noted.

Conclusions

The section that follows provides conclusions drawn from the current research on the impact of PBL instruction on student anxiety, confidence, and achievement. Implications for actions and recommendations for further research are included. This section closes with concluding remarks from the researcher.

Implications for action. Based on the findings of this study and the research conducted, it is incumbent upon school districts to explore the idea of alternative instructional methods including PBL particularly for students with an IEP. This study has implications for district and building administrators and teachers. First, for district administrators, this study offers insight into the discussion surrounding student anxiety and confidence in the area of mathematics. With an increase in student confidence and a decrease in student anxiety, students are in a stronger position to learn and understand the concepts presented in a mathematics classroom. District administrators should be aware of the training and support that building administrators and classroom teachers require to collectively promote high engagement and relevance in the area of mathematics. However, district administrators must be cognizant of the data from the current study surrounding the lack of student growth on the MAP mathematics assessment in the PBL classroom. An examination of PBL instructional methods in the Applied Algebra classroom might be warranted. District leaders might also want to consider PBL instruction as a viable instructional method to decrease anxiety in students with an IEP. This decreased anxiety might promote greater learning opportunities for students in mathematics.

Furthermore, this study has implications for building administrators due to the findings related to increased mathematics confidence and decreased mathematics anxiety for some students. As building administrators work closely with teachers, they must continue to generate the conversation surrounding the importance of both student engagement and the impact of student confidence and self-efficacy. Building administrators could encourage teachers not to be beholden to the traditional methods of instruction in the mathematics classroom, but rather grant teachers the permission and provide support for them to take risks to meet the needs of all students. Building leaders and teachers should also consider the impact of PBL in regard to decreasing mathematics anxiety for students with an IEP. This decrease in anxiety might help students with an IEP be more successful in the mathematics classroom.

Finally, this study has implications for teachers. University teacher preparation programs could add the PBL instructional framework training to their coursework. The training of future educators could create a foundation for the importance of relevance and engagement in the mathematics classroom. Additionally, through professional development provided by the district and with the support of building administrators, teachers would have the opportunity to impact student learning in a relevant and meaningful way in the area of mathematics. Teachers can examine the learning outcomes and objectives for units of study and begin to instruct in a way that promotes relevance and engagement in a more meaningful way. Additionally, with the growing number of students with an IEP in the general education classroom, PBL might provide an opportunity for teachers to meet the needs of all students by providing multiple entry points for student engagement and achievement. Through this pedagogical approach to instruction, teachers could have the opportunity to create greater confidence and to decrease anxiety in the mathematics classroom.

Recommendations for future research. The purpose of this study was to examine the impact of PBL instruction on student anxiety, confidence, and achievement in the Applied Algebra classroom. Because PBL was in its beginning implementation stages at the time of this study, a full body of research was not readily available on its impact. Thus, the first recommendation that stems from this study was to conduct the study over a multi-year period to monitor the full impact of this instructional approach in mathematics. A second recommendation would be that the study be conducted utilizing a larger sample size to generate more impactful data reporting.

Regarding data collection, a recommendation would be that a different survey, perhaps more extensive, be utilized to measure both student anxiety and confidence. Furthermore, the survey could be administered at both the beginning and the end of the Applied Algebra course to generate pre-course and post-course anxiety and confidence levels in mathematics to determine whether there was a change. Furthermore, since District S has started using the Panorama SEL survey platform, they could consider the correlation between student survey results of overall school anxiety and mathematics anxiety. Additionally, future research exploring the correlation between anxiety and student achievement and confidence could be performed.

Next, concerning student achievement, a recommendation would be made to not only use the NWEA MAP assessment but also to utilize the state mathematics assessment. Moreover, there would also be a recommendation to utilize the ACT assessment scores as a data point in mathematics achievement. Within the realm of data collection, there would also be a recommendation to utilize a progress monitoring tool such as common formative assessments (CFA). The use of CFAs as a data point would provide teachers with the data to make instructional decisions about student learning, interventions, and possibly deepen the scaffolding needs for all students.

In the area of research methods, it would be recommended that a mixed methods research study be conducted. The quantitative data of this study provides support for the numerical data analysis, however; interviews with teachers and students would provide additional qualitative data important to the results regarding anxiety and confidence. The interviews would support or not support the idea that this instructional method has a wrap-around impact on students.

It would also be a recommendation that the study be conducted across a variety of disciplines in a building. Research conducted, and data gathered from a variety of disciplines within a building would provide additional data points to examine PBL implementation. Furthermore, conducting this research at the middle school level would provide the opportunity to research more of an integrated approach to PBL, which, in many ways, is the foundational component of this instructional approach.

Concluding remarks. The results of the present study provided information on the impact of PBL instruction in the Applied Algebra classroom. The study focused on the areas of student anxiety in mathematics, student confidence in mathematics, and student achievement in mathematics. The data collected and analyzed revealed that PBL instruction increased mathematics confidence for all students in the Applied Algebra classroom and revealed that mathematics anxiety was lower for students with an IEP in a classroom where PBL instruction was utilized. It is by gaining confidence and lowering anxiety that authentic, perhaps more productive learning, could occur for all students. However, the data from the current study revealed that PBL was not impactful on student achievement on the MAP mathematics assessment. Given this data, it would be recommended that PBL instructional methods in the Applied Algebra classroom be revisited and possibly revised. The authentic and strategic implementation of PBL is a variable that should be continually examined.

Instructional pedagogy remains at the forefront of educational discourse. Educators must perpetually evaluate and reflect on their own instructional practices while at the same time continuing to keep the goal of student learning at the center of the work in their classrooms. It is in the examination of these varied methodologies that educators could ultimately be equipped to support all students in their educational journey and provide them with the opportunity for reduced anxiety, increased confidence, and overall achievement beyond the Applied Algebra classroom.

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Appendices

Appendix A: SAS Survey

Table 1
Tests of Concurrence on Survey Items

SAS Items	F-S Items	Test Statistic	Sig.
1. I think mathematics is important in life.	3. Knowing mathematics will help me earn a living.	t(136) = -.506	.614
	5. Math will not be important to me in my life's work. [Transposed]	t(137) = -4.56	.000
	10. I'll need mathematics for my future work.	t(137) = -3.79	.000
	21. Taking math is a waste of time. [Transposed]	t(137) = -4.48	.000
	29. I see mathematics as something I won't use very often when I get out of high school. [Transposed]	t(137) = -5.12	.000
	42. Math is not important for my life. [Transposed]	t(137) = -4.37	.000
	44. I study math because I know how useful it is.	t(137) = -6.80	.000
2. In middle school, my math teachers listened carefully to what I had to say.	2. My teachers have been interested in my progress in math.	t(136) = 2.90	.004
	7. Getting a teacher to take me seriously in math is a problem. [Transposed]	t(136) = 4.18	.000
	16. It's hard to get math teachers to respect me. [Transposed]	t(137) = 3.34	.001
	22. I have a hard time getting teachers to talk seriously with me about math. [Transposed]	t(137) = 5.29	.000
	30. I feel that math teachers ignore me when I try to talk about something serious. [Transposed]	t(137) = 4.83	.000
15. I feel confident in my abilities to solve mathematics problems.	1. I am sure that I can learn math.	t(137) = 13.5	.000
	12. I am sure of myself when I do math.	t(137) = -.968	.335
	19. I'm not the type to do well in math. [Transposed]	t(135) = 1.15	.251
	37. I know I can do well in math.	t(136) = 6.94	.000
	41. I am sure I could do advanced work in math.	t(137) = .895	.372
16. In the past, I have not enjoyed math class.	23. Math has been my worst subject.	t(136) = -6.91	.000
17. I receive good grades on math tests and quizzes.	33. I can get good grades in math.	t(137) = 7.13	.000
18. When I see a math problem, I am nervous.	4. I don't think I could do advanced math.	t(137) = 1.24	.217
	8. Math is hard for me.	t(137) = 2.73	.007
	32. Most subjects I can handle OK, but I just can't do a good job with math.	t(137) = .439	.662
	43. I'm no good in math.	t(136) = -1.68	.096

Appendix B: AMAS Survey

TABLE 1
Factor Loadings of Retained AMAS Items

Item	*Factor Loading*	
	Learning Math Anxiety	*Math Evaluation Anxiety*
1. Having to use the tables in the back of a math book.	*.52*	.35
2. Thinking about an upcoming math test 1 day before.	.27	*.86*
3. Watching a teacher work an algebraic equation on the blackboard.	*.77*	.35
4. Taking an examination in a math course.	.22	*.89*
5. Being given a homework assignment of many difficult problems that is due the next class meeting.	.31	*.66*
6. Listening to a lecture in math class.	*.86*	.25
7. Listening to another student explain a math formula.	*.82*	.17
8. Being given a "pop" quiz in math class.	.29	*.84*
9. Starting a new chapter in a math book.	*.75*	.26

NOTE: AMAS = Abbreviated Math Anxiety Scale. Factor loadings in italics specify the designated factor.

Appendix C: SAS Survey Use Approval Email

Gail Holder

From: Tapper, John R <jtapper@smcvt.edu>
Sent: Monday, January 22, 2018 6:47 PM
To: Gail Holder
Cc: Susan Rogers
Subject: Re: SAS Permission Request

As far as I'm concerned, you have permission to use survey questions. If you have other questions, please contact Stephen Hegedus, the dean of the College of Education at Southern Connecticut University.

John

John Tapper Ph.D

On Jan 22, 2018, at 7:29 PM, Gail Holder [redacted] wrote:

> Dr. Tapper,
>
> Thank you for taking a few minutes to talk with me regarding the request to use questions from the SAS for my dissertation work.
>
> Here are a few details for your information:
>
> Name: Gail E. Holder
> School: Baker University
> Dissertation Advisor: Dr. Susan Rogers, Ph.D.
> Dissertation Title:
> **The Impact of Project Based Learning Instruction on Anxiety, Confidence, and Academic Growth in the Applied Algebra Classroom**
>
> Would it be possible for you to send me a quick response of permission to move forward with using questions from this survey?
>
> Again, thank you for your time and have a wonderful evening!
>
> CONFIDENTIALITY NOTICE: This message is [redacted] The message and any attachments may be confidential or privileged and are intended only for the individual or entity identified above as the addressee. If you are not the addressee, or if this message has been addressed to you in error, you are not authorized to read, copy or distribute this message or any attachments. We ask that you please delete this message and any attachments and notify the sender by return email or by phone [redacted]

Appendix D: AMAS Survey Use Approval Email

Gail Holder

From:	Melissa Hunt <dr.hunt@melissakhuntphd.com>
Sent:	Wednesday, February 07, 2018 5:30 PM
To:	Gail Holder
Subject:	Re: Survey Permission

Gail,

You have my permission to use the AMAS. Best of luck with your study.

Melissa Hunt

Sent from my iPhone

On Feb 7, 2018, at 6:11 PM, Gail Holder <gehold[redacted]rote:

> Dr. Hunt:
>
> Thank you for taking the time to return my call today regarding my potential use of the AMAS survey.
>
> I would like to confirm that I have permission to use the AMAS survey for my research on student anxiety and mathematics.
>
> **Details:**
> Name: Gail E. Holder
> University: Baker University
> Dissertation Advisor: Dr. Susan Rogers, PhD
>
> Thank you for your consideration.
>
> Thank you,
> *Gail Holder*
> Assistant Director of Teaching and Learning
> Secondary ELA Coordinator
> [redacted]
> geholder[redacted]
> @inspired4Lgeh
>
> CONFIDENTIALITY NOTICE: This message is from the [redacted]. The message and any attachments may be confidential or privileged and are intended only for the individual or entity identified above as the addressee. If you are not the addressee, or if this message has been addressed to you in error, you are not authorized to read, copy or distribute this message or any attachments. We ask that you please[redacted]sage and any attachments and notify the sender by return email or by phone [redacted]

Appendix E: District Internal Research Application Request

Research Application Request - Internal

Applications to conduct research are accepted at three different points during the school year (refer to submission dates). Applications received after the submission date will be denied but may be resubmitted during the next window. For course work that does not fall within one of the submission windows exceptions will be made on an as needed basis. **Allow a minimum of two (2) weeks for completion of the review process.**

SUBMISSION DATES:

- **Fall** Research Submission 1: If you are wishing to conduct research during the Fall Semester – applications must be submitted by the end of the day **September 15**. Any applications submitted after September 15 will be denied.
- **Spring** Research Submission 2: If you are wishing to conduct research during the Spring Semester – applications must be submitted by the end of the day **January 30**. Any applications submitted after January 30 will be denied.
- **Summer** Research Submission 3: If you are wishing to conduct research during the Summer Semester – applications must be submitted by the end of the day **June 8**. Any applications submitted after June 5 will be denied.

INSTRUCTIONS:

Your final application should include submission of the following requirements:

- ☐ The completed application (required for all types of research) – must be typed.
- ☐ If conducting research as a means to secure an advanced degree (doctorate or mas ters), include:
  - a copy of the university/college Human Experimentation Committee project review and approval letter (if applicable), AND
  - a letter you're your academic advisor/committee (or other appropriate university/college official) indicating that the search project has been reviewed and approved.
- ☐ If conducting research and/or a survey for the purpose of research that is associated with a college class assignment, please include documentation from that class regarding purpose and verification of assignment. Include a letter from the instructor and from your principal indicating they give you permission to conduct the research/survey for the college class assignment.
- ☐ Acknowledgement that you will abide by th[redacted]ublic Schools Student Privacy IDAE policy.
- ☐ You will not use or reference the [redacted]blic Schools (district or individual school) by name in your study.
- ☐ All requirements can be scanned and sent as attachments through email to Rich [redacted].

Research Application Request - Internal

1. **Applicant(s) Name: Gail Holder**
2. **Position: Assistant Director of Teaching and Learning**
3. **School/Location: IRC**
4. **Telephone:913-780-7006**
5. **Email Address: [redacted]**

6. **Project Title: An Examination of the Impact of Project-Based Learning on anxiety, confidence and growth in the Applied Algebra Classroom.**

7. **The proposed research is for:**
   a. **Seeking an advanced degree: Yes X No**

b. **Conducting research as part of a college class assignment: Yes X No**
   College Semester: Fall Spring X Summer
   Other: please explain

University/College Affiliation Name:
University/College Name: Department: Baker University
Street Address:
City, State and Zip Code: Phone Number:
Fax Number:

8. **Anticipated Dates:**
   Beginning Date:
   Ending Date:
   Date Final Report Available/Provided to [redacted] Public Schools: November 2018

9. **Participant Description:**
   - Educational Level of Students involved in the study (preschool, elementary, middle level, high school): High School
   - Number of schools involved in the study: 2
   - Names of schools you would like to involve in your study: 2
   - Number of teachers involved in the study: 2
   - Number of students involved in the study: **60**

10.
Has the project been submitted to a Human Experimentation Committee? Respond Yes or No.
10a. If no, please explain why your project has not been submitted to a committee on human experimentation.

10b. Paste a copy of the letter from the Human Experimentation Committee regarding your study (Word format)

Below or attach a scanned copy along with your request.

11. Major research questions and purpose of the study:

RQ1. To what extent is there a difference in student anxiety in mathematics between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction?

RQ2. To what extent is the difference in student anxiety in mathematics between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction affected by student gender, IEP status, SES, and ethnicity?

RQ3. To what extent is there a difference in student confidence in mathematics between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction?

RQ4. To what extent is the difference in student confidence in mathematics between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction affected by student gender, IEP status, SES, and ethnicity?

RQ5. To what extent is there a difference in student growth from fall to spring on the MAP mathematics assessment between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction?

RQ6. To what extent is the difference in student growth from fall to spring on the MAP mathematics assessment between students enrolled in Applied

Algebra receiving PBL based instruction and those not receiving PBL instruction affected by student gender, IEP status, SES, and ethnicity?

The purpose of this study was to determine if Project-Based Learning instruction has an impact on student anxiety and confidence in the Applied Algebra Classroom. Additionally, this study focused on the impact of PBL instruction on academic growth measured by the MAP mathematics assessment using fall to spring MAP scores. The first purpose of this study was to determine if there was a difference in student anxiety and confidence in mathematics between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction. The second purpose of this study was to determine if there was a difference in student growth from fall to spring on the MAP mathematics assessment between students enrolled in Applied Algebra receiving PBL based instruction and students enrolled in Applied Algebra not receiving PBL based instruction. The third purpose of this study was to determine if the differences were affected by student gender, SES, IEP status, and ethnicity.

12. Research Design/Data Analysis:

Quantitative

13. Please provide a letter from your faculty advisor/committee or other appropria te official indicating that the research project has been reviewed and the researcher has met all requirements necessary to conduct the proposed research. Paste an electronic copy of the letter into this section or attach a scanned copy along with your request.

14. Please provide a copy of your class syllabus if you are conducting research as part of a class project. Paste an electronic copy of the document into this section or provide a scanned copy when submitting your application.

I/We acknowledge that we have read and will abide by the [redacted] Student Privacy IDAE policy.

Signature of Applicant **Date**

January 8, 2018
[redacted]
Director of Assessment and Research
[redacted]

Dear Mr. [redacted]

This letter is written as confirmation that, as Gail Holder's major advisor at Baker University, I have reviewed and approved her study, *The Impact of Project-Based Learning Instruction on Student Academic Growth in the Applied Algebra Classroom*. Additionally, I can confirm that her study has been reviewed and approved by Baker University School of Education Research Analyst, Peg Waterman. If you have any questions, please contact me.

Sincerely,

Susan K. Rogers, Ph.D.
Associate Professor
Baker University Graduate School of Education
913-344-1226 (Office)
785-230-2801 (Cell)

Appendix F: Research Approval Letter from District S

[redacted]

March 1, 2018

Dear Gail:

I am pleased to inform you that your request to do research in the [redacted] District has been **approved**. We do have a copy of the letter of support from your advisor, Dr. Rogers, as well as your application.

In any of your work, please do not make any reference to the [redacted] District or any specific school– please reference [redacted] as a "large suburban district in the mid-west" or a school as a "suburban school in the state of Kansas"– or some other reference name of your choice, but do not use the [redacted] name or any school names. Additionally, please do not use any student or staff identifying information.

When your research if completed, the District would love to see your results. Looks like a very interesting project, and one we have not had done in the district.

Good luck with your research, Gail!

Sincerely,

[redacted]

[redacted]

Appendix G: Baker University IRB Proposal for Research Permission Form

BAKER UNIVERSITY

IRB Request

Date March 18, 2018 IRB Protocol Number ____________ (IRB use only)

I. Research Investigator(s) (students must list faculty sponsor)

Department(s) Graduate School of Education

	Name	Signature	
1.	Gail Holder	[signature]	Principal Investigator
2.	Dr. Susan Rogers	Susan Rogers	☑ Check if faculty sponsor
3.	Margaret Waterman	Margaret Waterman	☐ Check if faculty sponsor
4.			☐ Check if faculty sponsor

Principal investigator contact information

Phone 913-669-1854

Email geholder@olatheschools.or

Address 15980 South Clairborne
Olathe, KS. 66062

Note: When submitting your finalized, signed form to the IRB, please ensure that you cc all investigators and faculty sponsors using their official Baker University (or respective organization's) email addresses.

Faculty sponsor contact information

Phone 785-230-2801

Email susan.rogers@bakeru.edu

Expected Category of Review: ☐ Exempt ☑ Expedited ☐ Full ☐ Renewal

II. Protocol Title

The Impact of Project Based Instruction on Anxiety, Confidence, and Academic Growth in the Applied Algebra Classroom.

III. Summary:

The following questions must be answered. Be specific about exactly what participants will experience and about the protections that have been included to safeguard participants from harm.

A. In a sentence or two, please describe the background and purpose of the research.

The purpose of this study is to examine the impact of Project Based Learning on student mathematics anxiety, mathematics confidence, and mathematics growth. The participants in this study will be students enrolled in an Applied Algebra classroom in two high schools. There will be approximetly 30 students surveyed from each school. The students in the two classes are from varied SES, gender, ethnic, and IEP status backgrounds. The two schools utilized in the study have similar demographics and are in the same district. The data will be utilized to compare the PBL effect group to the non-effect group.

B. Briefly describe each condition, manipulation, or archival data set to be included within the study.

There will be no condition ot manipulation utilized in this study. The only archival data used will be fall MAP score data in order to compare it to the Spring MAP data scores.

IV. Protocol Details

A. What measures or observations will be taken in the study? If any questionnaire or other instruments are used, provide a brief description and attach a copy.

To measure mathematics anxiety, the AMAS Survey will be used. This survey has 9 items and student responses are measured on a Leikert scale. To measure mathematics confidence, 5 questions from the Student Attitude Survey, the SAS, were used. These 14 questions were combined into one survey for ease of administion and participation. The survey was put into a Google Form and will be administered electronically to participants.

B. Will the subjects encounter the risk of psychological, social, physical, or legal risk? If so, please describe the nature of the risk and any measures designed to mitigate that risk.

No, subjects will not have any risks during the study.

C. Will any stress to subjects be involved? If so, please describe.

No, subjects will not encounter any stress during the study.

D. Will the subjects be deceived or misled in any way? If so, include an outline or script of the debriefing.

No, subjects will not be decieved or misled in any way during the study.

E. Will there be a request for information which subjects might consider to be personal or sensitive? If so, please include a description.

The study will require identification of Free and Reduced status, IEP status, and race. This information will only be associated with an ID number, which will be created by the researcher. There will not be any information requested of the student in these areas. All of this information will be provided by the assessment department.

F. Will the subjects be presented with materials which might be considered to be offensive, threatening, or degrading? If so, please describe.

No, there will be no offensive, threatening, or degrading materials used in the study.

G. Approximately how much time will be demanded of each subject?

Subjects will be asked to spend 5 minutes on the anxiety/confidence survey. No other time is asked of teachers or participants.

H. Who will be the subjects in this study? How will they be solicited or contacted? Provide an outline or script of the information which will be provided to subjects prior to their volunteering to participate. Include a copy of any written solicitation as well as an outline of any oral solicitation.

Subjects in this study are 29 students from building A and 30 subjects from building B. There has been no advanced information sent to subjects, nor will there be. Subjects will be asked to take a survey and answer the questions honestly. The subjects will be asked to complete the survey during the Applied Algebra class time. The information provided to the teachers prior to the survey administration and students at the time of the survey administration is attached.

I. What steps will be taken to insure that each subject's participation is voluntary? What if any inducements will be offered to the subjects for their participation?

Students will be told that their participation is voluntary and they can be exempt from participating in the survey if n ecessary. No inducements will be offered to the subjects for their participation in the study.

J. How will you insure that the subjects give their consent prior to participating? Will a written consent form be used? If so, include the form. If not, explain why not.

Due to the nature of the survey and there not being any identification of students or any threatening or sensitive inf omration asked, a written consent to take the survey is not necessary.

K. Will any aspect of the data be made a part of any permanent record that can be identified with the subject? If so, please explain the necessity.

No, there will not be any data from the study that will become part of the student's permanent record.

L. Will the fact that a subject did or did not participate in a specific experiment or study be made part of any permanent record available to a supervisor, teacher, or employer? If so, explain.

No, the information surrounding participation will not be available to anyone. The fact that participants participated or did not participate will not be a part of any permanent record.

M. What steps will be taken to insure the confidentiality of the data? Where will it be stored? How long will it be stored? What will be done with the data after the study is completed?

Once collected, the data will be stored in a secure location at the researcher's home. Once the study is complete, the data will be stored and then after 5 years destroyed.

N. If there are any risks involved in the study, are there any offsetting benefits that might accrue to either the subjects or society?

There are no risks involved with the study, thus there are no offsetting benefits to subjects or society.

O. Will any data from files or archival data be used? If so, please describe.

The archival data that will be used will be fall MAP mathematics scores and Spring MAP mathematics scores. The scores from these assessments will be used to compare the two groups of students. The two groups of students are those who have experienced the PBL instruction and those who have not experienced PBL instruction.

Appendix H: Baker University IRB Approval to Conduct Research Letter

March 28th, 2018

Dear Gail Holder and Susan Rogers,
The Baker University IRB has reviewed your project application and approved this project under Expedited Status Review. As described, the project complies with all the requirements and policies established by the University for protection of human subjects in research. Unless renewed, approval lapses one year after approval date.

Please be aware of the following:

1. Any significant change in the research protocol as described should be reviewed by this Committee prior to altering the project.
2. Notify the IRB about any new investigators not named in original application.
3. When signed consent documents are required, the primary investigator must retain the signed consent documents of the research activity.
4. If this is a funded project, keep a copy of this approval letter with your proposal/grant file.
5. If the results of the research are used to prepare papers for publication or oral presentation at professional conferences, manuscripts or abstracts are requested for IRB as part of the project record.

Please inform this Committee or myself when this project is terminated or completed. As noted above, you must also provide IRB with an annual status report and receive approval for maintaining your status. If you have any questions, please contact me at npoell@bakeru.edu or 785.594.4582.
Sincerely,

Nathan Poell, MA
Chair, Baker University IRB

Baker University IRB Committee
Scott Crenshaw
Jamin Perry, PhD
Susan Rogers, PhD
Joe Watson, PhD

Appendix I: Student Confidence and Anxiety Survey

Applied Algebra Survey-Building A

Directions:

Please respond to each question with your level of agreement. All responses are confidential. Thank you.

* Required

1. **My survey number is: (This number will be provided to you.) ***
Mark only one oval.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10
- ◯ 11
- ◯ 12
- ◯ 13
- ◯ 14
- ◯ 15
- ◯ 16
- ◯ 17
- ◯ 18
- ◯ 19
- ◯ 20
- ◯ 21
- ◯ 22
- ◯ 23
- ◯ 24
- ◯ 25
- ◯ 26
- ◯ 27
- ◯ 28
- ◯ 29
- ◯ 30

2. **1. I feel confident in my abilities to solve mathematics problems.**
Mark only one oval.

- ◯ 1-Strongly Disagree
- ◯ 2-Disagree
- ◯ 3-Neutral
- ◯ 4-Agree
- ◯ 5-Strongly Agree

3. **2. In the past, I have not enjoyed math class.**
Mark only one oval.

- ◯ 1-Strongly Disagree
- ◯ 2-Disagree
- ◯ 3-Neutral
- ◯ 4-Agree
- ◯ 5-Strongly Agree

4. **3. I receive good grades on math tests and quizzes.**
Mark only one oval.

- ◯ 1-Strongly Disagree
- ◯ 2-Disagree
- ◯ 3-Neutral
- ◯ 4-Agree
- ◯ 5-Strongly Agree

5. **4. When I see a math problem, I am nervous.**
Mark only one oval.

- ◯ 1-Strongly Disagree
- ◯ 2-Disagree
- ◯ 3-Neutral
- ◯ 4-Agree
- ◯ 5-Strongly Agree

6. **5. Having to use the tables in the back of the book make me anxious.**
Mark only one oval.

- ◯ 1-Strongly Disagree
- ◯ 2-Disagree
- ◯ 3-Neutral
- ◯ 4-Agree
- ◯ 5-Strongly Agree

7. **6. Thinking about an upcoming math test one day before makes me anxious.**
Mark only one oval.

- ◯ 1-Strongly Disagree
- ◯ 2-Disagree
- ◯ 3-Neutral
- ◯ 4-Agree
- ◯ 5-Strongly Agree

8. **7. Watching the teacher work on an algebraic equation on the board makes me anxious.**
Mark only one oval.

- 1-Strongly Disagree
- 2-Disagree
- 3-Neutral
- 4-Agree
- 5-Strongly Agree

9. **8. Taking an exam in math makes me anxious.**
Mark only one oval.

- 1-Strongly Disagree
- 2-Disagree
- 3-Neutral
- 4-Agree
- 5-Strongly Agree

10. **9. Being given a homework assignment of many difficult problems that is due the next class meeting makes me anxious.**
Mark only one oval.

- 1-Strongly Disagree
- 2-Disagree
- 3-Neutral
- 4-Agree
- 5-Strongly Agree

11. **10. Listening to a lecture in a math class makes me anxious.**
Mark only one oval.

- 1-Strongly Disagree
- 2-Disagree
- 3-Neutral
- 4-Agree
- 5-Strongly Agree

12. **11. Listening to another student explain a math formula makes me anxious**
Mark only one oval.

- 1-Strongly Disagree
- 2-Disagree
- 3-Neutral
- 4-Agree
- 5-Strongly Agree

13. **12. Being given a "pop" quiz in math class makes me anxious.**

Mark only one oval.

- 1-Strongly Disagree
- 2-Disagree
- 3-Neutral
- 4-Agree
- 5-Strongly Agree

14. **13. Starting a new chapter in a math book makes me anxious**

Mark only one oval.

- 1-Strongly Disagree
- 2-Disagree
- 3-Neutral
- 4-Agree
- 5-Strongly Agree