Fall 2020

The Impact of Blended Learning Upon Mathematics Attitudes and Academic Achievement: An Action Research Study

Aronda Yvette Frazier

THE IMPACT OF BLENDED LEARNING UPON MATHEMATICS ATTITUDES AND ACADEMIC ACHIEVEMENT: AN ACTION RESEARCH STUDY

by

Aronda Yvette Frazier

Bachelor of Science
South Carolina State University, 1995

Master of Education
South Carolina State University, 1999

Educational Specialist
South Carolina State University, 2002

Submitted in Partial Fulfillment of the Requirements

For the Degree of Doctorate of Education in

Curriculum and Instruction

Education

University of South Carolina

2020

Accepted by:

Suha Tamim, Major Professor

Yasha Becton, Committee Member

Leigh D'Amico, Committee Member

Suzy Hardie, Committee Member

Cheryl L. Addy, Vice Provost and Dean of the Graduate School

DEDICATION

This dissertation is dedicated to my mother, Eva L. Frazier, who has always been my biggest supporter and cheerleader. Thank you for encouraging me to follow my dreams.

ACKNOWLEDGEMENTS

Writing this dissertation has certainly be a marathon and not a sprint. This monumental achievement would not have been possible without the support, guidance, and expertise of Dr. Suha Tamim. Without her continuous encouragement, I would have likely aborted this mission before its fruition. Dr. Tamim, thank you for everything that you have done. I would also like to thank my dissertation committee of Dr. Yasha Becton, Dr. Leigh D'Amico, and Dr. Suzy Hardie for sharing with me the benefit of their knowledge and experience.

ABSTRACT

Negative attitudes toward mathematics can adversely impact student achievement in the subject area. Successful development and implementation of blended learning in high school mathematics has the potential to positively impact student attitudes towards mathematics and towards their ability to do mathematics and their mathematics achievement. Developed out of my concern for the mathematical challenges that my students face, this convergent mix-methods action research study was conducted to determine if blended learning would positively affect my students' attitudes toward mathematics and their mathematics achievement. Guided by the research questions, 'What impact does learning have on students' attitudes towards geometry, specifically two units of study involving triangles?', 'What impact does blended learning have on students' mathematics achievement in a geometry course, specifically during two units of study involving triangles?', and 'How do high school students perceive the impact of blended learning in their geometry class?', this study incorporated a four-step action research cycle and involved the collection of both quantitative and qualitative data. Study findings include a 25-point average increase in mathematics academic achievement; with all students showing growth, and inconclusive changes in attitudes toward mathematics. Sixty-two percent of the students indicated that they were more engaged during blended learning and if given a choice, would take another blended learning course. I, in conjunction with my students, used the results of this study to develop an action plan that

can potentially impact the mathematical attitudes and achievement of students throughout this nation's entire mathematics educational community.

Keywords: Blended learning, constructivism, mathematics anxiety, mathematics attitudes, self-concept

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Although described as a thought, a lifestyle, and a universal language, that is "accepted as an indispensable field in today's fast-developing world for individuals, society, scientific research, and technological developments," (Yasar, 2016, p. 931) and despite well documented uses in numerous careers, mathematics is an academic discipline with a reputation for being unnecessarily challenging, tedious, and worthless. Mumcu and Aktas (2015), contend that of the numerous problems in mathematics education worldwide, negative attitudes toward mathematics is one of the primary reasons for said problems. Studies show that a disproportionate number of students have a negative attitude towards mathematics, in general, and specifically in their ability to be successful in mathematics courses (Ahmad, Shafie, & Janier, 2008; Elçi, 2017; Mumcu & Aktas, 2015; Yasar, 2016; Yushau, 2006). Attitudes, or predispositions to respond either positively or negatively to a specific phenomenon, situation, institution, or person, are determining factors in human behavior and are predictors of success (Ahmad et al., 2008; Elçi, 2017; Lin, Tseng, & Chiang, 2017; Mumcu & Aktas, 2015; Yasar, 2016; Yushau, 2006). When students perceive that mathematics is a difficult subject and exhibit concern about their ability to be successful in mathematics, their attitudes toward mathematics are adversely affected and said students tend to lose self-confidence as it relates to in mathematics, thus, negative attitudes towards mathematics typically translate to poor mathematics achievement (Ahmad et al., 2008; Elci, 2017; Hoffman, 2010; Mumcu & Aktas, 2015; Williams & Williams, 2015; Yasar, 2016; Yushau, 2006).

Previous studies have suggested that blended learning, an instructional learning approach with face-to-face classroom instruction and self-paced, online instruction, can potentially improve both learners' mathematics attitudes and achievement (Ahmad et al., 2008; Galia, 2016; Lin et al., 2017; Smith, J., & Suzuki, 2015; Yudt & Columba, 2017; Yushau, 2006). The results of a 2010 meta-analysis conducted by the Department of Education indicate that blended learning may be a more promising alternative than either exclusive on-line or exclusive face-to-face instruction (U.S. Department of Education, 2010). This action research was based on research questions that ask how high school students perceive the impact of blended learning and how blended learning will impact high school students' mathematics attitudes and achievement.

Problem of Practice

In my role as a veteran high school mathematics teacher with twenty-four years of experience, I have often been perplexed by many of my students' strong feelings of contempt, pessimism and apathy towards mathematics. The looks of doubt, cynicism and distrust that regularly emanate from their teenage faces concern me deeply. Yasar (2016) opined that "perhaps the most important factor which influences mathematics success levels of students is the students' attitude towards mathematics classes" (p. 932).

For the past three years, the high school at which I am employed has been a one-to-one school, and thus provided each student with access to laptop computer. Our initial deployment and implementation of the devices was neither as seamless nor as effective as I believe that they should have been. At the time, there was, and remains, an intense pressure from the district-level personnel for teachers to “put the technology in the hands of the students daily.” Throughout this process, I heard the term “blended learning” tossed around, seemingly almost carelessly, whenever the laptops, students, and a teacher were all present in a classroom at the same time. Blended learning is so much more than students completing an assignment or activity on their laptops once or twice a week. Blended learning is the purposeful, systemic planning, and delivery of instructional content comprised of traditional, more teacher-centered face-to-face instruction and self-paced, student-centered online instruction (Ahmad et al., 2008; Galia, 2016; Lin et al., 2017; Smith, J., & Suzuki, 2015; Yudt & Columba, 2017; Yushau, 2006).

Repeatedly during my teaching career, I have been told "I hate math,” “I can’t do math,” and “I’ll never understand math!" Amid pressures to implement technology usage, an urge to effectively utilize technology in my classroom, a desire to employ genuine blended learning practices, and a natural tendency to improve student achievement, I researched and explored the appropriate use of blended learning and its perceived effectiveness. These experiences led me to ponder the effects of blended learning on my students’ mathematical attitudes and subsequently their achievement. A previous semester spent intensely assessing student progress in one of my Algebra 2 classes, as a requirement for my state’s teacher evaluation system, and a summer spent facilitating summer school courses delivered via APEX learning, spurred my decision to focus my study on students enrolled in one of my Geometry classes and to utilize APEX Learning as the online component of my blended learning curriculum. APEX Learning

(2018) is an AdvancEd accredited, College Board approved digital curriculum adopted by my school district for use in 6-12 education. APEX Learning (2018), which offers comprehensive courses, adaptive tutorials, virtual school, and a management tool to assist teachers in planning, preparing, developing and implementing the program, is one of the leading providers of blended and virtual learning opportunities in the United States.

Purpose of Study

The purpose of this action research study was to determine if the teacher-researcher's students' mathematics attitudes and achievement would be impacted by the implementation of blended learning in one of her geometry classes at Gulf Coast High School (pseudonym), in accordance with the identified problem of practice (PoP) for this dissertation in practice (DiP). Bandura (1997), stated that people's beliefs about their capabilities are better predictors of their behavior than what they are actually capable of accomplishing, because these beliefs help determine what individuals do with the knowledge and skills they possess.

Rationale and Significance of the Study

The knowledge gained from this action research will be used as a basis to effect change within my classroom, my department, and my school. Affective behaviors have been shown to be vital to the process of learning mathematics (Ahmad et al., 2008; Balentyne & Varga, 2016; Balentyne & Varga, 2017; Hoffman, 2010; Mumcu & Aktas, 2015).

According to Mumcu and Aktas (2015):

> [N]egative attitudes toward mathematics may prevent the student's understanding and success in [a mathematics] lesson. Many students see mathematics as a difficult, complex, and abstract topic and many variables, such as motivation to learn mathematics, mathematics anxiety, and attitudes toward mathematics affect achievement in mathematics more than in other disciplines (pp. 208-209).

Additionally, students' predetermined attitudes toward mathematics tend to adversely influence their general dispositions toward learning (Ahmad et al., 2008; Balentyne & Varga, 2017).

In their 2017 quantitative study, Balentyne and Varga investigated the relationship between students' achievement and attitudes in an eighth-grade blended mathematics course. The researchers found a significant correlation between achievement growth and each of the four attitudinal factors, value, motivation, enjoyment, and self-confidence, which in turn were correlated to overall attitudes toward mathematics and to each other. Given their limited sample size, which was restricted to high performing students, Balentyne and Varga (2017), recommended future studies with more diverse samples, different curricula, and different instructors. This study focused on average ability level, predominantly high school juniors, and utilized curriculum addressing South Carolina Career and College Ready Geometry Curriculum Standards.

In present-day educational settings, it is widely accepted that, given the right circumstances, all students can learn. Once the appropriate educational prerequisites and learning atmosphere, are created, every young person can learn mathematics and can be successful (Mumcu & Aktas, 2015; Samuelsson & Granstrom, 2007). Mumcu and Aktas (2015) asserted that, "in order to increase the number of people who can understand and use mathematics, it is critical to deal with the students who believe that they cannot succeed in mathematics and do not like the subject" (p. 218).

Research Questions

As a teacher researcher, I have posed the following action research questions out of concern that some achievement difficulties are related to students' attitudes about mathematics in general and in their own capabilities to do mathematics:

1) What impact does blended learning have on students' attitudes towards geometry, specifically a unit of study involving triangles?
2) What impact does blended learning have on students' mathematics achievement in a geometry course, specifically during a unit of study involving triangles?
3) How do high school students perceive the impact of blended learning in their geometry class?

Theoretical Framework

The foundations of constructivism, which emerged, to some degree, in continuum of theoretical exploration of behaviorism and cognitivism, have been traced back to an 18^{th} century teaching philosophy, "the one way of 'knowing' a thing is to have made it, by philosopher Giambattista Vico" (Ultanir, 2012, p. 197). In essence, "knowing is to know how to make. One knows a thing only when one can tell what components it consists of" (Ultanir, 2012, p. 197). Constructivist theorists believe that real understanding is only constructed when leaners' previous experiences and prior knowledge interact with new ideas, events, and activities with which the learners come in contact. Throughout the process learners actively engage in meaning-making (Altuna & Lareki, 2015; Ertmer & Newby, 2013; Galia, 2016; Harasim, 2012; Hoover, 2008; Mayes & de Freitas, 2004; Mayes & de Freitas, 2007; Mergel, 1998; Ultanir, 2012).

Utilized effectively, blended learning integrates the best traditional teaching practices with the most appealing elements and conveniences of e-learning to create an instructional practice that increases student engagement, fosters reflective thinking, enhances contextual learning, and promotes and cultivates learner control, self-reliance, independence, responsibility, and self-discipline, all of which characterize constructivist learning, especially as defined by John Dewey, Jean Piaget, and Lev Vygotsky (Galia, 2016; Lin et al., 2017; Yasar, 2016; Yudt & Columba, 2017; Yushau, 2006). Dewey's unprecedented push for student freedom of movement and active participation in the learning process, individualized curricula, and self-directed learning are characteristic of blended learning (Dewey, 1938; Mergel, 1998; Picciano, 2017; UItanir, 2012). Piaget's emphasis on each learner evolving through his stages of development, assimilating and accommodating new ideas and learning at his or her own pace is fundamental to blended learning, particularly the e-learning component (Harasim, 2012; Mayes & de Freitas, 2004; Mayes & de Freitas, 2007; Picciano, 2017; UItanir, 2012; Yilmaz, 2011). In this action research, APEX Learning (2018) served as individualized curricular and self-directed learning in the sense that pretest data determined which APEX lessons each individual student was required to complete independently and at their own pace. Germane to blended learning is the design of web-based learning environments as Lev

Vygotsky's zones of development (ZPD) by employing features such as: learning activities that incorporate real or simulated activity systems; structured interactions among participants; guidance from a subject-matter expert, the teacher; and the locus of control passes to the increasingly competent learners (Mayes & de Freitas, 2004; Picciano, 2017; Yilmaz, 2011).

Neither social nor educational theory, constructivism is both a "scientific and meta theory which defines the possibility and limitations of daily life theories in the formation of humanity" (Ultanir, 2012, p.196). Central to the constructivist approach to learning is the learners' active search for and creation of meaning from their experiences and interactions with environmental factors (Altuna & Lareki, 2015; Ertmer & Newby, 2013; Galia, 2016; Harasim, 2012; Hoover, 2008; Mayes & de Freitas, 2004; Mayes & de Freitas, 2007; Mergel, 1998; Ultanir, 2012). Harasim (2012) asserted that "people learn by constructing their own understanding of knowledge of the world through experience and reflecting upon that experience" (p. 12). Characterized by subjective mental representations formed when new information is linked to prior knowledge, constructivist learning is comprised of activity/practice, concept/knowledge, and culture/context (Ertmer & Newby, 2013). In this action research study, during the individualized, computerized portion of the blended learning, exemplifies the constructivist learning described by Ertmer and Newby (2013).

Research Design

The action research study for the problem of practice (PoP) is a convergent mixed-methods design (Creswell, Plano Clark, Gutmann, & Hanson, 2003) whose purpose was to explore the role of blended learning in influencing student attitudes and achievement in mathematics, particularly in geometry. The “mixed” forms of data collected in this study included quantitative attitude survey and pretest-posttest achievement data and qualitative field notes, journals, and semi-structured interview data on blended learning. Because all data collection methods have limitations, the use of convergent mixed methods methodology can potentially neutralize or eliminate some of the disadvantages of quantitative and qualitative methodologies (Creswell et al., 2003). The discussion of the research design included a description of Gulf Coast High School (pseudonym), the study participants, the intervention, data collection and data analysis.

This action research, which was set in comprehensive high school located in a rural, central South Carolina school district, took place during the spring of 2019, a year prior to COVID-19. The study participants were students enrolled in one of my geometry classes. Over a six-week period the students were taught an instructional unit on triangle components, relationships, and congruence using the blended learning instructional strategy inside the teacher's classroom, which was the students’ usual instructional environment. On Mondays and Wednesdays, self-paced instruction was delivered via APEX Learning, online curriculum. Each student had access to a laptop computer within their normal classroom setting. On Tuesdays and Thursdays, the teacher delivered instruction on specified portions of the unit and incorporated the content needs of the students, as identified during her facilitation of the online curriculum. On Fridays the students took part in reflective activities, such as journaling, and engaged in cooperative learning opportunities.

Initial data was collected using the APEX Learning pretest on the triangle unit. The assessment was administered online and determined which online lessons each student will be required to complete. I administered the Modified Fennema-Sherman Mathematics Attitude Scale, which is one of nine subscales developed by Elizabeth Fennema and Julia A. Sherman and is comprised of 47 Likert scale items (Yáñez-Marquina & Villardón-Gallego, 2016). The Modified Fennema-Sherman Attitude Scales, which can be used either separately or jointly have an exploratory factor analysis “split-half reliability (for the subscales): 86-93 (N=1,600)” (Yáñez-Marquina & Villardón-Gallego, 2016, pp. 562, 563). Throughout the study, I used field notes to document student questions and behaviors. At the conclusion of the study, the students took the APEX Learning triangles unit test and retook the mathematics attitude scale.

The perceptions of blended learning survey, a ten-item Likert Scale, was used to determine each student’s opinion of blended learning. I conducted semi-structured, one-on-one interviews with a purposefully selected sampling of students (McNiff & Whitehead, 2010; Plainkas et al, 2013). In an effort to glean different perspectives, not influenced by student achievement, I selected two above average, two average, and two below average performing students, as indicated by mathematics achievement within this course. Initial questions focused on the interviewees’ thoughts, feelings, and perceptions about mathematics and about their individual ability to perform mathematically in general and in Geometry class. Individually tailored follow-up questions were used to explore responses in more detail and to stimulate further discussion.

The quantitative data I gathered from administering the Modified Fennema-Sherman Mathematics Attitude Scale, the perceptions of blended learning survey, and pretest and unit test (posttest), which was administered and scored by the APEX Learning program, were simplified and organized using descriptive statistics then entered into an

Excel spreadsheet. The quantitative data I gathered from the one-on-one interviews were organized and scrutinized for patterns in the field notes, journals, and interview transcripts. I, then, utilized coding, to "represent and capture a datum's primary content and essence" (Saldaña, 2009, p, 3).

Positionality

Positionality refers to an individual's world view and one's chosen stance on a specific research task (Foote & Bartell, 2011). Because research represents a shared space, molded by the teacher and students, the identities and biases of said individuals, have the potential to greatly impact the research process (Bourke, 2014; Greene, 2014).

This action researcher is a veteran mathematics teacher at Gulf Coast High School, where I have taught for the past twelve years. I have taught for a total of twenty-four years at three different high schools. I am a graduate of Gulf Coast High School and earned Bachelor of Science and Master of Education in Mathematics Education and an Educational Specialist degree in Secondary Administration. I am a secondary mathematics teacher and secondary principal certified and am gifted and talented, advanced placement (Calculus AB) and International Baccalaureate endorsed. Additionally, I am ADEPT (Assisting, Developing, and Evaluating Professional Teaching) and SAFE-T (Summative ADEPT Formal Evaluation of Classroom-Based Teachers) endorsed, and serve as a mentor for first year teachers and as an evaluator for second year teachers seeking continuing contract status in the state of South Carolina. I currently teach Algebra 2 and geometry.

Mathematics and academics, in general, have always come easily for me. I consisted earned A's and B's throughout my academic career. I graduated number seven in my high school class of 333 and Summa Cum Laude in my undergraduate program. I pursued a career in mathematics because of my love for the content area and my ability to grasps the concepts with ease. Early on in my teaching career, my academic achievement and love for the subject matter, made it difficult for me to understand why my pupils neither excelled in or adored mathematics. My teaching experiences and interactions with students helped me to more objectively view my students, their mathematics achievement, and their attitudes toward mathematics.

Within this action research study, my role was that of geometry teacher and active participant in the convergent mixed methods research design implementing blended learning to determine impacts on student mathematical attitudes and achievement and student perceptions of the impact of blended learning. As an insider-researcher, one who conducts research from within a group, organization, or culture of which the researcher is a member (Greene, 2014), at the study's onset, I administered the attitude surveys and monitored the online administration of the pretest. Throughout the study, I served as instructor as who facilitated the APEX Learning and conducted lessons on alternate days, and as researcher as I used field notes to document student questions and behaviors. At the study's conclusion, I re-administered the attitude survey, monitored the online administration of the unit test (posttest), and conducted one-on-one surveys of the predetermined students.

Limitations

The limitations of this action research were primarily related to characteristics of the sample. First, the students in this study were all enrolled in one of the teacher's Geometry classes and comprise a small, convenience sample and, as such, may not be representative of all high school Geometry students. However, this study is highly replicable. Second, due to the racial and ethnic composition of Gulf Coast High School the sample was comprised of all African-American students. Because geometry is a third-year mathematics course, 81% of the students were sixteen-year-old juniors. Despite these shortcomings, the present action research study has high practical significance and might be of value to both the local area in which it was conducted as well as the international community elsewhere in the world, community in the country.

Summary and Organization of the Dissertation

The purpose of this action research was to determine if the implementation of blended learning as a method of instruction has an impact on the mathematics attitudes and achievement of students within a South Carolina Geometry class. Chapter one describes the problem of practice and introduces blended learning as a potential solution to negative attitudes toward mathematics and poor mathematics achievement. Chapter two, of this study, contains relevant literature that will guide the action research and help to determine the effectiveness of blended learning as a feasible solution to the research questions posed. Chapter three delineates the stages of action research, the methodology employed by the teacher-researcher and the ethical considerations of the research. Chapter 4 presents the findings of this study and chapter 5 details the recommendations and implications stemming from this action research.

Glossary of Terms

This glossary contains operational definitions of technical terms essential to this action research study.

Attitude. An individual's strong convictions toward people, things and/or situations (Mumcu & Aktas, 2015).

Blended Learning. An instructional strategy that involves a thoughtful combination of traditional, face-to-face instruction and online instruction (Balentyne & Varga, 2017).

E-learning. Online access to learning resources at anytime from anywhere (Torrisi-Steele, 2010).

Mathematics Anxiety. An individual's feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary and academic situations (Hoffman, 2010).

Self-Concept. An individual's beliefs of self-worth associated with his/her perceived competence (Pajares & Miller, 1994).

Self-paced Instruction. Instruction during which, based upon readiness, students learn different objectives at different times (Balentyne & Varga, 2017).

CHAPTER 2

LITERATURE REVIEW

Mertler (2017) described research as one of numerous means by which human beings search for answers to questions. Throughout the course of my career as a high school mathematics teacher, I have sought instructional strategies to improve my students' mathematics achievement. Over time, my focus shifted to teaching methodology that positively impact students' attitudes toward mathematics, which studies have shown are directly related mathematics achievement (Alt, 2014; Bandura, 1997; Kingir, Tas, Gok, & Vural, 2013). That exploration eventually gave birth to this action research, whose problem of practice was to determine if a specific instructional strategy (blended learning) would positively impact high school students' attitudes towards mathematics and thus their mathematics achievement. This chapter presents the review of literature that give credence to this action research.

Literature review is a description, summary and evaluation of sources related to an action research topic (Machi & McEvoy, 2016; Mertler, 2017). This chapter is a synthesis of current knowledge pertaining to the following research questions:

1) What impact does blended learning have on students' attitudes towards Geometry, specifically a unit of study involving triangles?

2) What impact does blended learning have on students' mathematics achievement in a Geometry course, specifically during the unit of study involving triangles?
3) How do high school students perceive the impact of blended learning in their Geometry class?

This literature review is comprised of an examination of the theoretical basics, historical foundations, characteristics, pros, cons, and examples of blended learning.

Literature Review Methodology

To gather relevant literature for this action research study, I used electronic databases such as Education Resources Information Center (ERIC), EBSCOhost, JSTOR, government websites, doctoral dissertations, newspaper articles, books, and academic journals. The online search of the literature began with the University of South Carolina's Online Library and expanded to Google Scholar. Keywords entered into the search engines included blended learning, mathematics achievement, student perceptions, and mathematics attitudes. The following literature review describes the theoretical and historical perspectives of blended learning, blending learning classroom environments, the advantages and disadvantages of blended learning, blended learning for social justice, and recent studies of blended learning in high school mathematics classes.

Historical Perspectives

Claiming that not all instruction is appropriate for online delivery, Tarnopolsky (2012) claimed that blended learning grew out of the practical experience in e-learning. Claiming theoretical and practical infeasibility, Garrison and Vaugh (2008) asserted that the notion of dualistic thinking, which lends itself to choosing between conventional face-to-face and online instruction, was obsolete. Conversely, there existed numerous contexts in which learning would best take place if the combination of traditional classroom and web-based training is provided (Garrison & Vaugh, 2008; Tarnopolsky, 2012). The evolution of information technology spurred the transformation of teaching from face-to-face instruction, to e-learning, to what some call the best of both worlds, blended learning (Garrison & Vaugh, 2008; Graham & Dziuban, 2007; Karma, Darma, & Santiana, 2019; Skrypnyk, et al., 2015; Tarnopolsky, 2012; Torrisi-Steele, 2011). Garrison and Vaugh (2008) contended that the propensity of blended learning can be attributed to the "advances and proliferation of communications technology in most segments of society" (p.2).

In traditional face-to-face instruction, teachers and their pupils are in the same location (Boelens, De Weaver, & Voet, 2017; Graham & Dziuban, 2007). Conversely, technology-mediated instruction, such as e-learning and blended learning, use information and communication technologies (ICT), which permits teacher-pupil interactions without requiring that they be in the same location (Graham & Dziuban, 2007). Karma et al., (2019) defined e-learning as a student-focused learning media that utilizes electronic equipment, such as computers and smartphones, to deliver instruction. They went on to state that e-learning is basically an online version of face-to-face instruction, in that it only focused on presenting instructional content via the Internet (Karma et al., 2019). It is from a desire to make e-learning more effective, that e-learning was combined with face-to-face learning to create blended learning, which lends itself to a redefinition of instruction in which technology is used to carry out learning activities

(Boelens et al., 2017; Hakala & Myllymaki, 2016: Graham & Dziuban, 2007; Karma et al., 2019).

Blended Learning Defined

While this literature review produced a myriad of definitions of blended learning, there were commonalities among the descriptions. Blended learning is the "deliberate 'blending' face-to-face and online instructional activities, with the goal of stimulating and supporting learning" (Boelens et al., 2017, p. 2). Graham (2006) defined blended learning as a combination of two historically separate models, face-to-face instruction and computer-mediated instruction. Although Hanson and Chem (2006) claimed that a widely accepted definition of blended learning was allusive, they concluded that the meaning of blended learning lies somewhere on the continuum between traditional in class meetings and totally online courses. And Davis and Fill (2007) described blended learning as a combination of traditional face-to-face teaching strategies and authentic online learning activities.

Blended refers to a smooth, inseparable intermingling of different entities in such a way as to harmoniously operate (Dictionary.com, n.d.). Learning is the acquisition of knowledge, skills, and understanding through experiences, study, and or being taught (Physics Catalyst, 2019). Blended learning, an information and communication technologies ICT, is the combining of traditional face-to-face instruction and online learning (Graham & Dziuban, 2007; Hakala & Myllymaki, 2016; Karma et al., 2019; Skrypnyk, et al., 2015). Graham and Dziuban (2007) asserted that it is imperative that blended learning capitalize on the strengths of both online and face-to-face instruction, in order to create a more active learning environment. Specifically, the oral communication of face-to-face instruction and the written communication of online instruction are "optimally integrated such that the strengths of each [instructional strategy] are blended into a unique learning experience congruent with the context and intended educational purpose" (Garrison & Vaugh, 2008, p. 3).

Blended learning relaxes the location- and time-bound constraints of physical classrooms and provides instructional opportunities that support student learning from any place, at almost any time. With blended learning, students have some degree of control over of certain aspects of their learning, such as the pace at which they complete assignments and interact with course content and the time of day (or night) and their physical location when completing assignments and interacting with course content (Graham, 2006; Graham & Dziuban, 2007; Prescott et al, 2017). At its core, blended learning is comprised of "both supervised 'bricks and mortar' attendance, and an online component, all of which are designed to deliver an integrated learning experience" (Doyle, Moore, Murphy, & Sewell, 2017, p. 2).

Blended learning, as referenced in this action research study is the combination of instruction from two historically separate models of teaching and learning, traditional face-to-face instruction and synchronous and asynchronous online instruction, with emphasis on the use of computer-based technologies (Graham, 2006). While the blended learning model utilized during this action research study was comprised of fairly typical face-to-face instruction, the online instruction was pretty atypical. The online component of this study's intervention consisted of the students working primarily inside the classroom, with occasional opportunities to work at home. Hence in this action research study, the students had some degree of control over of certain aspects of their learning, such as the pace at which they completed assignments and their interaction with course content, but had scant control over the time or day (or night) and their physical location when completing assignments and interacting with course content (Graham, 2006; Graham & Dziuban, 2007; Prescott et al, 2017).

Theoretical Perspectives

Advances in educational technologies, school districts' acquisition of one-to-one student devices, and a quest for new approaches to delivering educational content and meeting the academic needs of diverse students, have precipitated the popularity of blended learning (Borba et al., 2016; de Barros, Simmt & Maltempi, 2017; O'Connor, Mortimer & Bond, 2011). Blended learning, an instructional strategy that combines traditional face-to-face instruction and asynchronous online or e-learning, "helps to diversify the instructional delivery in mathematics curriculum, as well as, exploring the benefits of web-based technologies in mathematics education" (Lin et al., 2017, p. 747). Utilized effectively, blended learning integrates the best traditional teaching practices with the most appealing elements and conveniences of e-learning to create an instructional practice that increases student engagement, fosters reflective thinking, enhances contextual learning, and promotes and cultivates learner control, self-reliance, independence, responsibility, and self-discipline, all of which characterize constructivist learning (Galia, 2016; Kingir et al., 2013; Lin et al., 2017; Yasar, 2016; Yudt & Columba, 2017; Yushau, 2006).

Constructivism, which, according to Torrisi-Steele (2010) is widely as the philosophical foundation of blended learning, is a learning theory that emphasizes students' construction of their own understanding of the world in which they live by reflecting on their individual or social experiences. Constructivists view knowledge as the interaction between learners' existing knowledge and beliefs and their new experiences. The main tenets of constructivism include the learners' active role in their knowledge construction process, the sociocultural contributions to learning, self-regulated learning, and the focus on authentic learning tasks (Kingir et al., 2013; Tarnopolsky, 2012; Torrisi-Steele, 2010). Individuals activate their current knowledge to interpret new information, and to attempt to integrate new information into their existing knowledge structures. Using a set of cognitive and metacognitive strategies, and having goals and motivation to attain those goals, are essential factors for effective learning (Kingir et al., 2013; Torrisi-Steele, 2010). Constructivism, which has both cognitive and social aspects, is supported by the works of John Dewey, Jean Piaget, and Lev Vygotsky, each of whom had unique perspectives that supported the development and sustainment of blended learning (Dewey, 1938; Mayes & de Freitas, 2004; Picciano, 2017; Tarnopolsky, 2012; UItanir, 2012; Yilmaz, 2011).

Deweyan Approach. The early 20th century work of educator John Dewey was instrumental in the evolution of traditional education into progressive education and served as a catalyst for the subsequent works of Jean Piaget and Lev Vygotsky (UItanir, 2012). Dewey challenged the school of thought that learners were sponges, who passively absorbed knowledge, and countered that learning only occurs as a result of hands-on experiences. According to Dewey, all learning takes place via unique, individual experiences that lead to positive growth and ultimately results in better citizens (Dewey, 1938; Picciano, 2017; Tarnopolsky, 2012; UItanir, 2012).

Dewey (1938) stated that:

> If an experience arouses curiosity, strengthens initiative and sets ups desires and purposes that sufficiently intense to carry a person over dead places in the future, continuity works in a very different way. Every experience is a moving force. Its value can be judged only on the ground of what it moves towards and into (p. 38).

Dewey's push for student freedom of movement and active participation in the learning process, individualized curricula, and self-directed learning are characteristic of blended learning (Dewey, 1938; Mergel, 1998; Picciano, 2017; Tarnopolsky, 2012; UItanir, 2012). Additionally, Dewey (1938) believed that teachers should serve as guides tasked with supporting the learners as they gauge and achieve new knowledge through their own means, monitoring student growth, and setting up beneficial student activities, all of which exemplify the role of teachers, particularly during the e-learning component of blended learning.

Piagetian Approach. Jean Piaget's approach to constructivism focuses on the individual and how the individual constructs knowledge (Harasim, 2012; Mayes & de Freitas, 2004; Mayes & de Freitas, 2007; Picciano, 2017; UItanir, 2012; Yilmaz, 2011). "Piaget's theory of cognitive constructivism proposes that humans cannot be given information, which they immediately understand and use; instead humans must construct their own knowledge" (UItanir, 2012). Like Dewey's, Piaget's constructivist theory of knowledge was based on the premise that learners do not learn by copying or absorbing ideas from the external world, but by constructing individual meaning through must construct active and personal experimentation and observation. Consequently, Piaget opposed the direct teaching of disciplinary content (Harasim, 2012; Mayes & de Freitas, 2004; Mayes & de Freitas, 2007; Picciano, 2017; UItanir, 2012).

Piaget's assumption that conceptual development occurs through intellectual activity rather than by the absorption of information, significantly influenced school-level educational research (Mayes. & de Freitas, 2004; Tarnopolsky, 2012). Piaget's contributions to the constructivist theory center around adaptation, which is comprised of assimilation and accommodation, and the stages of development of a child's mind. Piaget's stages of development, sensorimotor, pre-operational, concrete operational and formal operational, describe the logical progression of a child's ability to learn at different ages (Tarnopolsky, 2012; UItanir, 2012). During assimilation learners bring new knowledge to their schema and, likewise, during accommodation the learners change their schema in preparation for the new information or knowledge. Piaget's theory on assimilation and accommodation is consistent with the constructivist view of learners' individual construction of new knowledge. Piaget's emphasis on each learner evolving through his stages of development, assimilating and accommodating new ideas and learning at his or her own pace is fundamental to blended learning, particularly the e-learning component. During the e-learning component of this blended learning study, my students each worked at his or her own pace on individually prescribed for them based upon his or her pretest score (Harasim, 2012; Mayes & de Freitas, 2004; Mayes & de Freitas, 2007; Picciano, 2017; Tarnopolsky, 2012; Torrisi-Steele, 2010; UItanir, 2012; Yilmaz, 2011).

Vygotskian Approach. Lev Vygotsky's approach to constructivism focuses is socio-cultural in nature and addresses the role of the individuals around a learner and their effect on how the learner sees the world (Harasim, 2012; Mayes & de Freitas, 2004; Picciano, 2017; Yilmaz, 2011). He posited that learning is problem solving and that the basis of the learning process is the social construction of solutions to problems. Vygotsky's emphasis on social interaction for the development of higher cognitive functions was instrumental in shaping constructivist pedagogy (Mayes & de Freitas, 2004; Picciano, 2017; Yilmaz, 2011).

In 1934 Vygotsky developed the concept of the zone of development (ZPD) which he defined the as the "distance between a learner's current conceptual development, as measured by add independent problem solving, and that learner's potential capability," (Mayes & de Freitas, 2004, p.18) as measured by what can be accomplished with the support of or in collaboration with more astute peers. Vygotsky described the learning process as the establishment of ZPD among the learner, the learners, and the problem to be solved (Picciano, 2017). Constructivist ideals are most apparent in ZPD's influence on the design of learning environments. Germane to blended learning is the design of web-based learning environments as ZPDs by employing features such as: learning activities that incorporate real or simulated activity systems; structured interactions among participants; guidance from a subject-matter expert, the teacher; and the locus of control passes to the increasingly competent learners (Mayes & de Freitas, 2004; Picciano, 2017; Tarnopolsky, 2012; Yilmaz, 2011).

Even though Dewey, Piaget and Vygotsky were all constructivist theorists, they differed, somewhat in how they envisioned learners and learning. The Deweyan learner was self-directed student who worked within a learning community that supports student inquiry. The Piagetian learner was the focus of the learning experience and was active in the construction of his or her own knowledge, while the teacher served as facilitator. Finally, the Vygotskian learner was an active learner, who required frequent interactions with peers and the teacher (Harasim, 2012; Mayes & de Freitas, 2004; Mayes & de Freitas, 2007; Picciano, 2017; Tarnopolsky, 2012; Torrisi-Steele, 2010; UItanir, 2012; Yilmaz, 2011). Although Dewey, Piaget, and Vygotsky each had unique visions of pupils, the learning environment, and the significant learning factors, their theoretical perspectives supported blended learning, and findings to answer the second research question, which sought to determine the impact of blended learning on students' mathematics achievement.

Blended Learning Environments

Learning environments, the social contexts in which learning takes place, typically includes students, the teacher, the classroom and instructional materials (Kingir et al., 2013). This section will examine blended learning environments and their relationship with constructivist learning environments.

Although blended learning is a combination of face-to-face instruction and technology-mediated-learning, blended learning environments differ from both face-to-face and online learning environments. Blended learning environments, however, have characteristics of both (Graham 2006; Graham & Dziuban, 2007). Graham and Dziuban (2007) described blended learning environments as a paradigm, rather than a linear combination of distance and traditional learning environments.

A constructivist learning environment is a place where learners work collaboratively and support each other as they utilize various tools and resources in their guided quest of learning goals and problem-solving activities (de Kock, Sleegers, and Voeten, 2004; Kingir et al., 2013; Picciano, 2017; Tenenbaum, Naidu, Jegede, & Austin, 2001). Within the constructivist classroom environment, both teachers and students are authorities of knowledge, and content is delivered via individual, small group or whole-class instruction, allowing students to exchange ideas and to learn from various points of view. The role of teachers in constructivist learning environment, coincides closely with the role of teacher in blended learning, is to provide authentic and meaning for activities that foster and support learning by enabling students to ascertain goals and to access appropriate information resources and tools (Kingir et al., 2013; Picciano, 2017; UItanir, 2012). Teachers in both constructivist and blended learning models provide guidance and stimulate students to reflect on their own learning processes (Graham 2006; Graham & Dziuban, 2007 Tenenbaum, et al, 2001). In their investigation of students' attitudes and achievement in a blended mathematics course, Balentyne and Varga (2017) discovered a significant positive correlation between achievement growth attitudes towards mathematics. They went on to recommend that mathematics teachers consider integrating self-pacing and blended learning into their classes (Balentyne & Varga, 2017).

Rationale for Blended Learning Implementation

Although frequently documented advantages of blended learning include cost effectiveness, greater accessibility, convenience, increased success rates, decreased dropout rates, and improved faculty and student skills, paramount are enhanced learning experiences (Garrison & Vaugh, 2008; Graham & Dziuban, 2007; Prescott et al., 2017 Tarnopolsky, 2012). Graham and Dziuban (2007) stated that efficiency and convenience should be secondary to the primary goal of blended learning, which is redesigning the teaching and learning relationship. Additionally, they opined that educators tend to adopt blended learning to “explore gains and tradeoffs in comparison with strictly traditional settings” or entirely online learning environments (Graham & Dziuban, 2007, p. 70). Blended learning advocates believe that there are inherent benefits to face-to-face instruction and to online instruction, and, thus, focus on finding an effective balance between the two (Higgins & Gomez, 2014).

Blended learning lends itself to quality teaching and learning practices. Central to the interest in blended learning is a quest for more engaging learning experiences (Garrison & Vaugh, 2008; Graham & Dziuban, 2007; Prescott et al., 2017 Tarnopolsky, 2012). Citing the need for in-depth engagement to facilitate the construction of student meanings, Garrison and Vaugh (2008) stated that blended learning should be utilized, in lieu of passive teaching strategies like lecturing. Interactive learning experiences, which are characteristic of e-learning programming, appear to be more aligned to higher-order learning outcomes (Garrison & Vaughan, 2008; Tarnopolsky, 2012).

Blended learning is a student-centered instructional technique that is characterized by interactivity between students and their teacher, among the students, and between the students and the course content (Graham, 2006; Graham & Dziuban, 2007; Hakala & Myllymaki, 2016; Higgins & Gomez, 2014). Blended learning allows teachers to provide personalized and differentiated instruction to me the needs of individual students (Prescott et al., 2017).

Like all instructional strategies, blended learning is not without challenges. In fact, some of the advantages of blended learning, are also challenges to its successful implementation. Boelens et al., (2017) identified four challenges to blended learning: incorporating flexibility, engaging interactions; facilitating students' learning styles, and cultivating an affective learning environment. Blended learning is more flexible than traditional learning in that it grants students some modicum of control over the time, place, path, and/or pace of learning. However, planning for said flexibility can be a novice and daunting task for instructors, as the must relinquish some of the control germane to more teacher-centered instruction. Careful planning and attention to social interaction, particularly during face-to-face instruction, is critical to combating feelings of isolation and encouraging a sense of collegiality among blended learning classmates (Boelens et al., 2017; Garrison & Vaugh, 2008; Graham & Dziuban, 2007; Prescott et al., 2017 Tarnopolsky, 2012). Finally, Boelens et al., (2017) recommended cultivating student organizational, time management, and self-regulatory skills, and fostering student motivation, self-efficacy, and positive attitudes to meet the individualized instruction and affective needs of blended learning pupils.

Graham and Dziuban (2007) contended that the "simple elegance" of blended learning is also a potential weakness, if the instructor focuses extensively on the method of instruction rather than the "holistic nature of the learning experience" (p. 270). For instance, rather than describing a blended learning course in terms of the percentage of time devoted to online versus the percentage for face-to-face, detail the nature of the instructional activities taking place in distinct components of the class (Cross, 2007; Graham & Dziuban, 2007). Cross (2007) added that a more useful to discuss how the course makes use of the benefits of face-to-face and online platforms. Garrison and Vaugh (2008) argued that although concept of blended learning appeared simple, its practical implications are quite complex. Blended learning requires a fundamental redesign of the structure of and approach to teaching and learning; specifically, the restructuring of class contact hours to allow for extended access to web-based opportunities (Boelens et al., 2017; Cross, 2007; Garrison & Vaugh, 2008; Graham & Dziuban, 2007; Prescott et al., 2017 Tarnopolsky, 2012). Effective blended learning is not happenstance, but requires deliberate preparation and implementation of an instructional design so that the educational program is blended in design, not just in delivery (Shantakumari, 2015). In their investigation of students' attitudes and achievement in a blended mathematics course, Balentyne and Varga (2017) discovered a significant positive correlation between achievement growth attitudes towards mathematics. They went on to recommend that mathematics teachers consider integrating self-pacing and blended learning into their classes (Balentyne & Varga, 2017).

Blended Learning for Social Justice

According to Jong and Jackson (2016), teaching for social justice is a critical pedagogy used to empower students to become social change agents in the community and world in which they live. Specifically, teaching mathematics for social justice provides all students with opportunities to learn rigorous mathematics content in meaningful, culturally relevant ways, in an effort to elevate the socio-economic statuses of "marginalized individuals and groups, and that work towards reducing deficit-oriented beliefs about who is or is not 'good' at mathematics" (Leonard & Evans, 2012, p. 100). The educational gap between underserved student populations, such as minorities and females, and their communities and those with greater financial and technological resources is widening (Dziuban, Graham, Moskai, Norberg, & Sicilia, 2018). Equal access to education is a critical need, especially in underserved communities. That leads to the question, “Can blended learning help increase access, thereby alleviating some of the issues faced by our lower income students while resulting in improved academic achievement?” Balentyne and Varga (2017) stated that because self-paced blended learning allowed students the flexibility of taking different course, blended learning “may help to expand course opportunities, especially in rural or financially limited school districts” (p. 700).

In their investigation of the role of disciplinary climate in the classroom and student math self-efficacy on math achievement, Cheema and Kitsantas (2014) found self-efficacy to be one of the most important predictors of academic achievement. Perhaps, even more importantly self-efficacy’s effect on academic achievement is not the same for all racial groups. Although minuscule distinction was observed in the effect of self-efficacy on math achievement between Hispanic and white students, a compelling disparity was found between black and white students. The increasing availability of blended learning provides educational opportunities that may counteract the impact of such racial disparities (Balentyne & Varga, 2017; Dziuban et al., 2018).

Blended Learning Studies

The studies described illustrate the use of blended learning in a variety of settings and circumstances. There are examples set in elementary, middle, and high schools, as well as a college. Courses involved in these examples are mathematics, science, English/Language Arts and English as a Second Language (ESL). Each case offers a unique perspective in terms of commercially purchased curricula with software, textbooks, instructional materials, and specific procedures for implementation and use, versus embedded blended instruction, which is teacher-produced content captured as an online cognitive tool.

Blended learning and student attitudes. Studies have shown that blended learning positively impacts student attitudes. Yapici and Akbayin (2012) sought to determine the effect of blended learning on high school biology students' achievement in the course and their attitudes towards the Internet. Forty-seven students comprised an experimental group, which were taught using blended learning. Another sixty students made up a control group and were taught using traditional teaching methods. The students were assigned to specific classrooms and the classrooms were randomly selected and assigned to either the control or experimental group. Data collection instrumentation, for both groups, included a biology achievement test was used as the pre- and post-assessment and the Internet Use Attitude Scale (IUAS) (Grgurović, 2011). The study, which lasted eleven weeks, yielded the following results. The blended learning model "contributed more to the students' biology achievement than the traditional teaching methods" (Grgurović, 2011, p. 235). Additionally, there was a statistically significant improvement in the experimental group's attitudes towards the Internet (Grgurović, 2011; p. 235).

Blended learning and student achievement. Studies conducted by Karam et al., (2017), Smith and Suzuki (2015), and Setyaningrum (2018), presented blended learning at the middle and high school levels. In 2017 Karam et al., studied the implementation of the blended mathematics curriculum Cognitive Tutor Algebra 1 (CTA1) in 74 middle schools and 73 high schools within 51 school districts across seven states. The study examined the relationship between the implementation of blended learning and student outcomes.   With each state, schools with similar background characteristics were pair and randomly assigned to the treatment or control group. Schools in the control group used their regular Algebra 1 curriculum sans software and those in the treatment group implemented CTA1. The study data, which was collected from online teacher surveys and subsequent interviews, showed that none of the CTA1 components were fully implemented as recommended by the CTA1 developer. Student groupings and software usage were the prescribed practices adhered to most frequently, while curriculum structure and materials, curriculum content, and assessment were adhered to least frequently. Feeling that there was insufficient time to complete the entire curriculum, the teacher tended to allot less than recommended time on software usage and on non-routine word problems, and to spend more time on classroom instruction and reviewing previously taught skills with which the teachers perceived students needed additional assistance. Successes of this study include the comparison between classes using the CTA1 curriculum and those not, and the number of schools and states taking part in the study. The major challenge to this study was that the curriculum was not followed with fidelity (Karam et al., 2017).

Seeking to compare the academic outcomes of Algebra 2 students engaged in teacher-delivered multimedia blended instruction with those receiving traditional teacher-delivered live-lecture instruction, Smith and Suzuki (2015) conducted a four-week, quasi-experimental study of fifty-six students enrolled at a comprehensive public high school. In this study, two Algebra 2 classes taught by a single veteran mathematics teacher were randomly assigned as the treatment and control groups. Each day the mathematics teacher taught identical lessons, one live-lecture (control group) and one using embedded blended learning (treatment group), both in her normal classroom setting. Each multi-media lesson, which were accessed by the treatment group using iPads, included teacher demonstrations with video and accompanying audio (Smith & Suzuki, 2015).

Data was collected using pretest/posttest and a student survey were used to measure student knowledge and satisfaction with the instruction, respectively. Students in the treatment group showed significantly greater gains from pretest to posttest and evaluated their learning experiences much more positively than did the control group. Touting increased teacher flexibility and availability to provide individualized support, accessibility to lessons outside of classroom, lack of distractions and individual control of lesson pacing, eighty percent of the thirty-two students in the treatment group preferred the embedded blending learning over traditional live lectures (Smith & Suzuki, 2015).

Setyaningrum (2018) conducted a quasi-experimental study that compared the effectiveness of blended learning and traditional instruction on students' conceptual understanding of mathematics, which refers to exemplifying the concept, classifying examples and non-examples of the concept, creating multiple representations of the concepts, and applying the concept. The study participants were 127 eighth grade students, in four classrooms, which were randomly assigned to the experimental and control groups. The experimental group was taught using blended learning via Moodle. The control group was taught traditionally, using the textbook as the primary resource. Over a six-week period, the students took part in a solid geometry unit of study. Data collection instrumentation included twenty-question multiple-choice pre- and posttests and student interviews (Setyaningrum, 2018).

A higher mean posttest score implied that the students taught through blended learning demonstrated a better conceptual understanding than those who were taught traditionally. Interview finding showed that almost 75% of the students indicated that they preferred the use of blended learning in mathematics. When asked if blended learning helped them to learn mathematical concepts, consensus among the experimental group was that the instructional videos were helpful in learning mathematics and were more interesting than textbooks (Setyaningrum, 2018). Based upon the study results, Setyaningrum (2018) concluded that “blended learning using Moodle should be widely used to enhance students’ active learning and to construct knowledge” (p. 250).

Karam et al’s., (2017) study revealed a common occurrence in the education arena. Feeling that there was insufficient time to complete the entire curriculum, the teacher deviated from the prescribed software usage and topics of instruction, and thus, did not follow the curriculum with fidelity. Although blended learning allows for considerable flexibility, overuse of said flexibility can be to the detriment of academic progress. The similarities between the findings of Karam et al., (2017) and Smith and Suzuki (2015) suggests the online component of blended learning can be commercially produced, as in the Karam et al., (2017) study or teacher-created, as in Smith and Suzuki’s (2015) study. Additionally, Setyaningrum’s (2018) findings support the usage of blended learning at the middle and high school levels.

Blended learning has proven to be increase student achievements in disciplines other than mathematics. At the conclusion of their study of the impact of blended learning on the academic achievement of high school biology students, Kazu and Demirkol (2014) concluded that the experimental group, which was taught using blended learning, was significantly more successful than the control group, which was taught by traditional means. During the 2014 - 2015 school year, Prescott et al., (2018) conducted a study to determine the effectiveness of a blended learning program instituted for reading intervention in a Title I elementary school. The researchers concluded that blended learning is a viable instructional strategy for improving reading performance of pupils enrolled in a Title I elementary school. Furthermore, Prescott, et al., (2018) stated that their findings were particularly noteworthy because they showed "how a blended learning approach can provide supportive benefits for students from low-SES [socio-economic status] backgrounds or students who were ELs, who historically fall behind their peers in reading development" (p.504).

Student perceptions. The Constructivist Learning Environment Scale (CLES) was designed to measure the extent to which a classroom environment is consistent with the tenets of the constructivist learning environment and is used to determine students' perceptions of a constructivist learning environment. Kingir et al. (2013), reasoned that since the constructivist learning environment is a multidimensional construct, CLES provides multidimensional assessment on five dimensions, personal relevance, uncertainty, shared control, critical voice, and student negotiation (Boz et al., 2016; Kingir et al., 2013). Personal relevance measures the degree to which learning is made relevant to students' everyday experiences. The uncertainty dimension assesses the extent to which students view scientific knowledge as evolving. Shared control evaluates to what degree the students share with the teacher control of their learning. Critical voice measures to what extent students feel that it is legitimate to express a critical view of their instruction. Finally, the student negotiation dimension measures whether students have the opportunity to share, explain, and justify their own ideas (Boz et al., 2016; Kingir et al., 2013).

Fast et al. (2010) determined that students who perceived their classroom environments to be caring, challenging, and mastery oriented had noticeably greater levels of math self-efficacy, and greater levels of math self-efficacy positively predicted math performance. Kingir et al. (2013) explored the relationships among constructivist learning environment perception variables (personal relevance, uncertainty, shared control, critical voice, student negotiation), motivational beliefs (self-efficacy, intrinsic interest, goal orientation), self-regulation, and science achievement. At least one dimension of the constructivist learning environment was associated with students' intrinsic interest, goal orientation, self-efficacy, self- regulation, and science achievement. Self-efficacy emerged as the strongest predictor of both mastery and performance avoidance goals rather than the approach goals. Intrinsic value was found to be significantly linked to science achievement through its effect on self-regulation. The relationships between self-efficacy and self-regulation and between goal orientation and science achievement were not significant. The researchers found that all dimensions of constructivist learning environment were directly and positively associated with intrinsic value, thus suggesting that students possess the constructivist learning environment variables tend to enjoy the classroom activities and show interest in the learning task (Kingir et al., 2013). As it pertains to the relationship between constructivist learning environment perceptions and self-efficacy, the study results indicated "non-significant associations among all dimensions of constructivist learning environment and self-efficacy, except for student negotiation and personal relevance" (Kingir et al., 2013, p. 220).

Hubackova and Semradova (2016) concluded blended learning is acceptable and even favored by students. They went on to claim that teacher-pupil interactions, the implementation of constructivist principles, and the electronic format of blended learning is an effective instructional strategy for a variety of disciplines, particularly foreign languages. In a quest to determine student perceptions to blended learning, Shantakumari, (2015), found that the study participants perceived blended learning to be "less stressful and more effective than traditional in-class delivery" (p. 326). Additionally, blended learning was deemed an easy to follow, when compared to traditional instruction, and enhanced learning. The online component promoted increased student interactions with the content (Shantakumari, 2015).

These studies were selected because they bring attention to the importance of appropriate implementation of the blended learning instructional design, as improper implementation can adversely impact program effectiveness. The studies serve as evidence to the effectiveness of blended learning as an instructional strategy at various grade levels and across numerous disciplines. Additionally, these examples exemplified many of the tenets of constructivism, such as students as active participants in the learning, teachers as facilitators, real-world applications, individualized student courses of study, and non-traditional assessment (Altuna & Lareki, 2015; Ertmer & Newby, 2013; Harasim, 2012; Hoover, 2008; Mayes & de Freitas, 2004; Mayes & de Freitas, 2007; Mergel, 1998).

Summary

Blended learning, which Torrisi-Steele (2011) defined as an instructional strategy developed by integrating the "best of face-to-face approaches with the best of technology mediated approaches," (p. 538) evolved to practical experiences of e-learning and is grounded in the constructivist learning theory. Blended learning is the intervention applied in the action research study which sought ultimately improve students' attitudes towards mathematics and their mathematics achievement. Chapter three delineates the stages of action research, the methodology I employed and the ethical considerations of the research. More specifically, the intervention and the data collection instruments will be described in detail.

CHAPTER 3

METHODOLOGY

Grounded in the notion of taking purposeful action with educational intent and characterized by testing the validity of claims made therein, action research, is the basis for improved social and professional practices (McNiff & Whitehead, 2010). Mertler (2017) defined action research as any systematic inquiry conducted by educators or other stakeholders for the "purpose of gathering information about how their particular schools operate, how they teach and how their students learn" (p. 4). Conversely, traditional research, which is typically conducted by researchers who are removed from the environment, focuses on explaining educational issues, questions or processes. Action research, which lends itself to reflection, encourages and empowers teachers to become continuous, lifelong learners and practitioners of their craft (McNiff & Whitehead, 2010; Mertler, 2017).

John Dewey (1938) stated:

> [A] primary responsibility of educators is that they not only be aware of the general principle of shaping of actual experience by environing conditions, but that they also recognize the concrete, what surroundings, physical, and social, that exist so as to extract from them all they have to contribute to building up experiences that are worthwhile (p. 40).

According to Foster, Rzhetsky and Evans (2015), Dewey saw both knowledge construction and, by extension, democracy as being rooted in action in the sense that understanding is actively constructed through (inter)action within one's environment.

Reflection, as defined by Mertler (2017), is the act of exploring what you are doing, why you are doing it, and what are its outcomes. As a teacher, I routinely reflect upon the lessons I have taught, focusing on how I taught the concepts and if my students successfully comprehended what I taught. Do I need to reteach some or all the concepts? What about my method of delivery, was it effective? Based upon the conclusions I draw during my reflective process, in hopes of improving my students' achievement, I adapt, alter, and adjust my plans for the next class session. I have come to learn that my reflective process is just the beginning of a process that can effect real change and improvement. According to Murray (2015), reflection is not merely thinking about one's instruction. Reflection is purposeful, begins with a problem which is defined and sometimes redefined, seeks possible solutions, experiments with said solutions, and finally assess the results (Murray, 2015). John Dewey, as quoted by Tannebaum, Hall and Deaton (2013), described reflective thought as a "specialized form of thinking [that] stems from doubt and perplexity felt in a directly experienced situation and leads to a purposeful inquiry and problem resolution" (p. 243). I have always been perplexed by many of my students' strong dislike of, earnest disdain for, and heartfelt claims of inability to perform mathematics. It is this perplexity that led me to wonder about ways to improve my students' mathematics achievement and attitudes toward mathematics.

Dewey (1938) stated that:

> If an experience arouses curiosity, strengthens initiative and sets ups desires and purposes that sufficiently intense to carry a person over dead places in the future, continuity works in a very different way. Every experience is a moving force. Its value can be judged only on the ground of what it moves towards and into (Dewey, 1938, p. 38).

Consequently, in this action research I sought determine how blended learning impacts Geometry achievement and attitudes in high school students and how said students perceive the impact of blended learning.

Statement of the Problem of Practice

Mertler (2017) described research as one of numerous many means by which human beings search for answers to questions. Throughout the course of my career as a high school mathematics teacher, I have sought ways to improve my students' mathematics achievement. In doing so, I have explored a variety of instructional strategies and methodology, seeking a solution to poor student mathematics achievement and students' negative attitudes toward mathematics. That exploration eventually gave birth to the present action research, whose problem of practice sought to determine how students perceive the impact of blended learning and the impact of blended learning on student Geometry achievement and students' attitudes toward Geometry. This chapter presents the methodology that I employed to answer my research questions.

Research Questions

As a researcher, I have posed the following action research questions out of concern that my students' attitudes towards mathematics and their mathematics achievement:

1) What impact does blended learning have on students' attitudes towards geometry, specifically a unit of study involving triangles?
2) What impact does blended learning have on students' mathematics achievement in a geometry course, specifically during a unit of study involving triangles?
3) How do high school students perceive the impact of blended learning in their geometry class?

Purpose of the Study

The purpose of the present action research study is to determine how blended learning will impact my students' attitudes toward mathematics and their mathematics achievement in my Geometry class at Gulf Coast High School (pseudonym), in accordance with the identified problem of practice (PoP) for this dissertation in practice (DiP).

Research Design

The action research study for the problem of practice (PoP) is a convergent mixed-methods design (Creswell et al., 2003) whose purpose is to explore the impact of blended learning on influencing student achievement and attitudes in mathematics, particularly in Geometry mixed" forms of data collected in this study will include quantitative attitude survey and pretest-posttest achievement data and qualitative blended learning semi-structured interview data.

Mertler (2017) described action research as a recursive, cyclical process comprised of four stages (planning, acting, developing and reflecting), each of which I addressed in the design of this action research. During the first stage in the action research cycle, the planning stage, I brainstormed, reflecting upon teaching and learning, particularly my instructional practices, student achievement and learning environments, gathered information and conducted a review of literature. During this initial stage I developed and refined my research questions. The second stage in the action research cycle, the acting stage, is comprised of implementing the plan, collecting data and analyzing data. At this stage in this action research, I collected quantitative data and used statistical analysis to determine the impact of student attitudes toward mathematics and its subsequent impact upon mathematical achievement. I also collected qualitative data, which was analyzed and then triangulated with the quantitative data to develop the findings for this action research. During stage three, the developing stage, I developed an action plan. According to Miller, as cited by Mertler (2017), during this stage of the action research process, the teacher is basically trying to answer the following question: Based on my study findings, what are my next steps? Finally, at the fourth stage, reflecting, I reflected upon the action research process. Mertler (2017) described reflection as a crucial step in the action research process, during which the teacher-researcher reviews what has taken place, ascertains its effectiveness and makes determinations about possible modifications for future implementations of the project.

Research Site

This action research was conducted within a rural school district in southeastern United States. The district, which serves 6,630 students, has three high schools, one of which is this study's research site. Gulf Coast High School (pseudonym) is committed to creating an educational environment that will ensure students' success in school and in life (PowerSchool, 2018). The school, located in the Midlands of South Carolina, offers a comprehensive curriculum designed to meet the needs of students seeking post-secondary degrees from two- and four- year institutions, entrance into the work force, and/or a military career. Some of Gulf Coast's program offerings include four Advanced Placement courses, a duel credit available through a local technical college that serves fifty students, career and technology course, and a freshman academy for first-time ninth graders. Gulf Coast, a Title I school, has an enrollment of 1,193 ninth through twelfth grade students, 95% of whom are African American, 3% Caucasian and 2% have Asian, Hispanic and Native American ethnic backgrounds (PowerSchool, 2018). One hundred percent of the student body qualifies for the school's free or reduced breakfast and lunch programs (PowerSchool, 2018). Ninety-percent of Gulf Coast's faculty is African American; the remaining 10% of the faculty is Caucasian.

Sample

The students who took part in this action research were students at Gulf Coast High School (pseudonym), who were enrolled in one of my semester-long geometry courses, which met daily for 90 minutes. The students in this study were twenty-one African American pupils, whose first language is English, ranging in age from 15 to 17. There were four sophomores and seventeen juniors. Fifty-seven percent of the students were female, one of whom had special needs and had an Individual Education Plan (IEP) specified use of calculators, preferential seating, and assistance from her resource teacher, as needed, and the remaining 43% were male. Of the male students, one 17-year-old was a SPED student whose IEP's accommodations included specified extended time to complete assignments, preferential seating, and the use of a calculator. Additionally, two other male students were taking geometry for the second time (PowerSchool, 2018). It has been my experience that repeating courses negatively impact students' attitudes toward mathematics.

Intervention

This action research took place midway my semester- long geometry class, because I felt that it was important to first develop relationships; procedures, and routines within my classroom setting. At the point of data collection, I knew my students as both scholars and as individuals, and they knew me as both a teacher and as a person. Additionally, my students were familiar with my teaching and management styles. As an introduction to this research study, I introduced my students to the concept of action research, explained the purpose and relevance of this particular action research study, and provided an overview of how the study would be conducted. At that point, I administered the Fennema-Sherman Attitude Scale (see Appendix A) to gather baseline data. Then to ensure that they understood the essential vocabulary associated with this study, I defined, explained and provided examples: traditional face-to-face instruction, online learning, and blended learning. My students were accustomed to my emphasis on the use of proper terminology and my request that they "speak mathematically," and thus were to receptive to learning the new terms and eagerly took part in the discussion.

The primary intervention utilized in this action research was APEX Learning (2018), a district-wide initiative that all teachers were expected to utilize in some way. While many teachers at my school elected to utilize APEX Learning as a supplement and for students performing poorly in class, I decided to employ APEX Learning more prominently in my courses. I had previous experience using APEX Learning as the sole curriculum for summer school courses, and thus, perhaps, more insight into the program than my co-workers. I valued the breadth and depth of the APEX's mathematical content and decided it was be an appropriate choice for the online portion of the instructional delivery for this blended learning action research.

APEX Learning (2018) is a Seattle, Washington based digital curriculum platform founded by Microsoft co-founder Paul Allen in 1997. Initially developed to provide online courses focused on test preparation, specifically, Advanced Placement tests, APEX now offers remedial, core, test preparatory and Advanced Placement (AP) courses and addresses the needs of students ranging from struggling learners to accelerated scholars. APEX Learning (2018) includes readiness and intervention programs, readiness assessments, alternative education, college and career readiness, virtual learning, credit recovery, tutorials, and blended learning. Additionally, APEX (2018) is AdvancEd accredited and approved for National Collegiate Athletic Association (NCAA) eligibility.

Following the action research overview and essential vocabulary discussion, I introduced and modeled use of the APEX Learning program to the students. The students accessed APEX Learning via Schoology, the district's learning management system, using their district-issued usernames and passwords. The students, in turn, completed the "Student Getting Started Guide" and accompanying quiz to familiarize themselves with the program (APEX Learning, 2018). Over a two-day period, the students used APEX Learning to review solving linear equations, so they have an opportunity to become comfortable using the program, while simultaneously reviewing an essential mathematical concept, prior to this action research's intervention. The students then took the unit pretest, which determined the unit activities each student was required to complete.

The instructional topic selected for this intervention is triangles, with a focus on the components of triangles, the relationships between triangles, and triangle congruence, because the topic is addressed in several of the South Carolina Career and College Ready curriculum standards for Geometry (South Carolina Department of Education, 2015). Over a five-week period the students were taught a unit on triangles using the blended learning instructional strategy. On Mondays and Wednesday, self-paced instruction was delivered via APEX Learning, online curriculum. The online instruction took place in the classroom under my direct supervision. APEX Learning (2018) consists of standards-based instruction that includes simulations, drop-and-drag activities, and graphing tools. Each lesson included a study guide and accompanying videos for direct instruction, places emphasis on key vocabulary, and provides reading support (APEX Learning, 2018).

On Tuesdays and Thursday, I delivered instruction on specified portions of the unit and incorporated the content needs of the students, as identified during my facilitation of the online curriculum. I incorporated various teacher-centered instructional strategies, such as explicit direct instruction, demonstration and modeling; and student-centered instructional strategies, such as the use of graphic organizers, vocabulary building activities, and the creation of foldables and entries in interactive notebooks. Topics for lessons on Tuesdays and Thursdays were determined by student questions during online instructions, lessons that student scored poorly on, and my professional judgment.

On Fridays the students took part in reflective activities, such as journaling, and engage in cooperative learning opportunities. Journal entries served as debriefing and closure activities, as well as a means of self-assessment. Cooperative learning opportunities consisted of small group assignments, think-pair-shares, peer tutoring, and ultimately a partner project.

Quantitative Data Collection Instruments

Quantitative data collection instruments used in this action research include the Modified Fennema-Sherman Attitude Scale (see Appendix A), a perceptions of blended learning survey (see Appendix B), and APEX Learning's pretest and unit test for the unit on triangles.

Modified Fennema-Sherman Mathematics Attitude Scale. A shortened version of the 108-item Fennema-Sherman Mathematica Attitude Scale (FSMAS), the Modified Fennema-Sherman Mathematics Attitude Scale (see Appendix A), one of nine subscales developed by Elizabeth Fennema and Julia A. Sherman. FSMAS was developed as a part of a grant from the National Science Foundation primarily to gain insight concerning females' learning mathematics (Doepken, Lawsky, & Padwa, nd; Fennema & Sherman, 1976; Lim & Chapman, 2013; Sachs & Leung, 2007; Yáñez-Marquina & Villardón-Gallego, 2016). Citing the length of the original instrument, an approximate 45-minute completion time, and subsequent respondent fatigue, Sachs and Leung (2007) asserted a need a shortened version of the FSMAS. It is for similar reasons that the I elected to use the Modified Fennema-Sherman Attitude Scale (see Appendix A), which is comprised of 47 Likert scale items. The Modified Fennema-Sherman Attitude Scale (see Appendix A) consists of four subscales that measure confidence, usefulness, mathematics as a male domain, and teacher perception. Each subscale consists of 12 items, half of which measure a positive attitude and the other half a negative attitude (Doepken, Lawsky, & Padwa, nd; Lim & Chapman, 2013; Sachs & Leung, 2007, Yáñez-Marquina & Villardón-Gallego, 2016). Although the students rated their level of agreement (strongly agree to strongly disagree) to statements about their attitudes toward mathematics on all 47 items, only the items on the confidence and usefulness scales were utilized for this action research, as they related to the first research question about student perceptions of the impact of blended learning. Ranging from distinct lack of confidence to definite confidence the, "Confidence in Learning Mathematics Scale (C) is intended to measure confidence in one's ability to learn and to perform well on mathematical tasks" (Fennema & Sherman, 1976, p. 326). The Mathematics Usefulness Scale (U) is designed to measure respondents' beliefs about the usefulness of mathematics in their present life and its usefulness in their future education and career choices (Fennema & Sherman, 1976).

Perceptions of blended learning survey. The perceptions of blended learning survey (see Appendix B), a twelve-item survey I developed, was used to determine each student's opinion of blended learning. Students were asked how strongly they agreed or disagreed with eleven Likert Scale statements about blended learning. The twelfth question asked respondents to rank traditional face-to-face instruction, online instruction, and blended learning according to their individual preferences. Prior to administration of the survey, it was pilot-tested by five students enrolled at the research site. The student feedback indicated that the questions were clear and that the students understood what was being asked, hence no changes were made.

APEX Learning pretest and unit test (posttest). Initial data was collected using the APEX Learning online pretest for the instructional unit about triangles. Per software design, the pre-assessment, which was comprised of 47 multiple-choice questions, had three versions that were randomly assigned to the students. The pretest was designed to assess the students' knowledge of the concepts covered in the instructional unit. Upon completion of the pretest, each student was given a personal study plan that outlined which unit activities each student was required to complete (APEX Learning, 2018). The "personal study plans" indicated which, if any, lessons each student had tested out of and which lessons had to completed.to satisfy APEX Learning requirements. Upon completion of the unit's online curriculum, each student took the APEX Learning online unit test, which served as the posttest for this study. Comprised of 25 multiple-choice questions, per software design, the unit test (posttest) assessed the student-participants' knowledge of triangles after taking part in the blended learning instruction.

Qualitative Data Collection Instruments

Qualitative data collection instruments used in this action research were field notes and semi-structured interview protocol (see Appendix C).

Field notes. Once considered researchers' private, personal musings, ideas, and queries regarding their research observations and other data collection, field notes are now considered a crucial component of qualitative research (Philippi & Lauderdale, 2018). Field notes are used to document descriptive information, such as settings, actions, and conversations observed, and reflective information, like the researcher's questions, concerns, and thoughts during and in response to data collection. A reflective approach to the research process presents researchers with on opportunity to discuss their presuppositions, choices, and experiences during the research process (Ortlipp, 2008). As my students worked on APEX Learning, I monitored their progress and behavior, answered their questions and simultaneously conducted the field study. I noted student questions, interactions, and reactions to APEX Learning activities, and I reflected upon my interpretations of what was taking place.

Semi-structured interview questions. Interviews, which range from structured to unstructured, when effectively employed, often result in honest conversations and lead to enhanced insights for all participants. When conducting structured interviews, the interviewer must pose the questions exactly as they appear on the interview schedule, in the same order and style of delivery to all interviewees. In contrast, unstructured interviews have no set schedule of questions and the interviewer has the freedom to follow where the interviewee leads with in the general framework of the study (McNiff & Whitehead, 2010). This action research's semi-structured interviews conducted with a purposeful sampling of students using academic grades in this course as selection criterion; I selected two above average, two average, and two below average performing students to interview. Initial questions (see Appendix C) focused on the interviewees' thoughts, feelings and perceptions about blended learning, about learning mathematics and about their individual ability to perform mathematically in general and in geometry class. Individually tailored follow-up questions were used to explore responses in more detail and to stimulate further discussion. The interviews took place in our regular classroom and lasted, on average, twelve minutes.

Palinkas et al, (2013) defined purposeful sampling as a technique used in qualitative research to identify and select individuals or groups of individuals who are especially knowledgeable about or experienced with a particular subject of interest. In this proposed action research, I employed purposeful sampling to account for the major academic variations among my students (Palinkas et al, 2013). Upon analysis of the student-participants academic performance in this course, I selected two above average, two average, and two below average performing students to interview. Academic performance is the only construct of concern in this action research thus gender, race and other factors will not be considered.

Table 3.1 Data Collection Instruments

Research Questions	Data Collection Instruments	Data Type
What impact does blended learning have on students' attitudes towards Geometry, specifically a unit of study involving triangles?	Modified Fennema-Sherman Attitude Scale	Quantitative
	Field notes	Qualitative
	Semi-structured interviews	Qualitative
What impact does blended learning have on students' mathematics achievement in a Geometry course, specifically during the unit of study involving triangles?	APEX Learning Pretest/Posttest	Quantitative

	Field notes	Qualitative
How do high school students perceive the impact of blended learning in their Geometry class?	Perceptions of blended learning survey	Quantitative
	Field notes Semi-structured Interviews	Qualitative Qualitative

Data Collection Methods

At the onset of this study, I administered the APEX Learning online pretest at the start of the triangle unit and Modified Fennema-Sherman Mathematics Attitude Scale (see Appendix A). The APEX Learning program assessed the pretest results and determined which online lessons each individual student was required to complete. At the conclusion of the unit, the student took the APEX Learning unit test, and at the conclusion of the study, retook the Modified Fennema-Sherman Mathematics Attitude Scale (see Appendix A) and took the perceptions of blended learning survey (see Appendix B). As a final means of data collection, the teacher conducted semi-structured interviews with two above-average, two average, and two below-average performing students.

Data collection for this action research study took place during the spring semester of 2019, which was a year before COVID-19, and included both qualitative and quantitative in nature. I gathered quantitative data by administering the Modified Fennema-Sherman Mathematics Attitude Scale (see Appendix A), the perceptions of blended learning survey (see Appendix B), and APEX Learning pretest and unit test (posttest) to all students. My use of APEX Learning is in compliance with school and district curricular and technology use expectations. Qualitative data included teacher observations, journaling and semi-structured interviews (see Appendix C). The observations were conducted in a manner that afforded me the flexibility to complete other instructional activities and routine tasks simultaneously or to engage in brief but concentrated periods of observation and note-taking.

Data Analysis

Data analysis is my attempt to fully and accurately summarize, describe and represent the data that I collected (Mills, 2014). The primary goal of data analysis, as noted by Mertler (2017), Mills (2014) and Thomas (2006), is to compile the vast amounts of data collected into smaller, more feasible pieces of information. Mertler (2017) advised teacher-researchers to select data analysis techniques that are appropriately aligned with their research question(s).

Quantitative data analysis. Analysis of quantitative data is a deductive process that utilizes descriptive and/or inferential statistics to condense and summate the data (Mertler, 2017; Mills, 2014). With the quantitative data I gathered from administering the Modified Fennema-Sherman Mathematics Attitude Scale (see Appendix A), the perceptions of blended learning survey (see Appendix B), and APEX Learning pretests and unit tests, I used descriptive statistics as a means to simplify and organize the data. First, I reviewed the surveys for completeness and then entered the data an Excel spreadsheet.

Qualitative data analysis. According to Thomas (2006), inductive analysis refers to "approaches that primarily use detailed readings of raw data to derive concepts, themes, or a model through interpretations made from the raw data" (p. 238) by a teacher-researcher. Inductive analysis of qualitative data is a three-step process (organization, description and interpretation) to classify and group the data into themes for the construction of a framework for presenting the key findings of the study (Mertler, 2017). During the organizational step, I began by looking for and recording any patterns in field notes, journals, interview transcripts and the like, utilizing a system of categorization, such as coding. Coding is the process of analyzing and grouping data that provide similar types of information (Dana & Yendol-Hoppey, 2014; Mertler, 2017). A code is typically a "word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data," such as interview transcripts, participant observation field notes and journals (Saldaña, 2009, p. 3). The coding process takes place in two cycles. During the First Cycle coding process, I coded data ranging from a "single word to a full sentence to an entire page of text to a stream of moving images" (Saldaña, 2009, p. 3). During the Second Cycle coding processes, the portions coded were the same size as First Cycle's or even longer passages of text can be the exact same units, longer passages of text; at that time, I reconfigured the codes developed thus far, as needed (Saldaña, 2009). Additionally, as I compared, contrasted and categorized the data, I employed a memoing technique to explain and expand upon my coded categories. Dana and Yendol-Hoppey (2014) defined memoing as a procedure for elaborating on the coded categories. From the analysis of the qualitative data and the coding process, four themes emerged.

During the description or second step of induction analysis, the teacher-researcher made connections between the data collected and their research questions (Mertler, 2017; Thomas, 2006). At this point in the action research process, I asked myself: How does the information in each coded category help me to understand mathematics self-efficacy and to answer my research questions? I reflected upon the coded categories and describe them in terms of their link to or ability to answer my research question, thus establishing clear connections the data and my research topic.

The third step in the induction analysis process, interpretation, is characterized by close examination and astute scrutiny of the coded categories and their contents, with the intent to develop a framework of the underlying structure of observations that are evident in the raw data (Mertler, 2017; Thomas, 2006). After reflecting upon and poring over my findings, I devised themes and developed general conclusions and/or theories. Throughout the inductive analysis process, I was certain not to, as cautioned by Schwalbach (as cited by Mertler, 2017), diminish, misconstrue, downplay or misinterpret any of my data. I took care to employ techniques such as peer debriefings, stakeholder checks and consistency checks to demonstrate Lincoln and Guba's (as cited by Thomas, 2006) four general types of trustworthiness in qualitative research: credibility, transferability, dependability, and confirmability.

Plan for Reflecting with Participants on Data

The reflecting stage of action research is characterized by sharing and communicating study results and reflecting on the action research process. Mertler (2017) defined reflection as the act of a teacher-researcher critically scrutinizing what he/she is doing, why he/she is doing it and what the effects have been. I journaled as my method of reflection prior to and throughout my entire action research. At my study's conclusion I reflected upon everything that had taken place and critiqued the who, what, when and how of my action research study. My examination of those logistical features of my study were imperative to ascertaining changes I might make to potential study replications.

In terms of communicating study results, I had a debriefing with all students, during which they had an opportunity to voice any questions, concerns, suggestions and revelations from their action research experience. I will also share my study finding with the members of my department, with my school's faculty and staff, as well as with mathematics teachers in my district and across the state. I intend to present my findings at conferences, such as the South Carolina Council of Teachers of Mathematics (SCCTM).

Ethical Considerations

"Being authentic (or real) in relationship with another is at the heart of collaborative action research and is at heart a matter of ethics" (McElroy, 1990, p.209). Abed (2015) asserted that social science research, especially educational research, must be conducted based upon undebatable, ethical principles. Ethics refers to a focus on that which is deemed right and good. To adopt an ethical stance is to be concerned/solicitous in order to make that which is good

Mertler (2017) stated that a primary responsibility of teacher-researchers is to ensure that the action research adheres to ethical standards. He (Mertler, 2017) went on to describe the ethical treatment of students, colleagues, and their respective data, as a key component of action research design. Ethics are not merely something to consider at the commencement of a research study but should rather be "borne in mind throughout the entire research process as concerns about the ethics ought to be the leading consideration of any research study" (Abed, 2015, p. 1).

Mertler (2017) identified four ethical issues (principles of accurate disclosure, importance, beneficence and honesty) to consider when planning action research. As teacher-researcher, I addressed the principle of accurate disclosure via informed consent forms which will describe the nature of this action research as well as the level involvement of the student-participants. Signatures were secured from students who are eighteen years of age and from the parents of minor students. Because the students were enrolled in my Geometry class, it was imperative that I emphasized to my students and their parents that participation is in the action was completely voluntary and that opting out of the study would not adversely impact teacher-student relationships and interactions, the caliber of course instruction, or student grades. Additionally, I communicated my intentions to reduce risks to students by maintaining their privacy, protecting their anonymity, guaranteeing confidentiality, and taking measures to avoid harm and deception.

The principles of importance and beneficence are closely aligned with each other. The principle of importance indicates that research findings should somehow contribute to human knowledge or be useful elsewhere in the field of education (Mertler, 2017). According to Mertler (2017), the principle of beneficence states that the purpose of research should be to acquire knowledge about human beings and the educational process. Research should be beneficial to someone or some group of people. Research “should never be conducted as a means of doing harm to individuals or groups or to denigrate, find fault, or suppress academic progress (Mertler, 2017, p. 115). This action research study was designed to ascertain the impact of blended learning on mathematics achievement and attitudes. If the findings of this study are consistent with those of previous studies on this topic and confirm the teacher-researcher’s hypothesis of positive correlation, then the findings will be used as a basis for determining and developing strategies to improve student mathematic achievement and related affective characteristics.

In accordance with the principle of honesty, honesty must be exhibited in all aspects of action research, “from the specification of the purpose of the research study to the collection and analysis of data and the ultimate conclusions drawn upon its completion” (Mertler, 2017, p. 115). I was honest with students and parents about the purpose of this action research and was honest about what data I would collect and how I would collect it. In addition to considering the ethical principles and guidelines required, the proposed action research projected conform to all district and school policies.

Rigor and Trustworthiness

Rigor and trustworthiness address credibility, the confidence placed in the truth of the inferences drawn from one’s research. Trustworthiness essentially poses the question “Can the findings be trusted?” (Creswell & Miller, 2000; Korstiens & Moser, 2018). According to Creswell and Miller (2000) qualitative researchers typically establish the validity of their studies by employing procedures such as member checking, triangulation, thick description, peer review, and external audits.

During this action research, I used triangulation, specifically, methodological triangulation, to validate the qualitative data collected from field notes and semi-structured interview questions. Triangulation, which has origins in military naval navigation, is a "validity procedure where researchers search for convergence among multiple and different sources of information to form themes or categories in a study" (p. 126). Methodological triangulation involves corroborating data collected through multiple methods, such as the field notes and semi-structured interview questions, utilized in this study (Creswell & Miller, 2000; Korstiens & Moser, 2018).

Summary

"One factor that affects the achievement of students in educational environments is the self-efficacy perceptions toward the lessons" (Mumcu & Aktas, 2015, p. 210). Consequently, the purpose of this action research study was to determine if blended learning positively impacted my Geometry students' mathematics achievement and attitudes. classes. The research questions that guided the study were: What impact does blended learning have on students' attitudes towards geometry, specifically a unit of study involving triangles? What impact does blended learning have on students' mathematics achievement in a geometry course, specifically during a unit of study involving triangles? How do high school students perceive the impact of blended learning in their geometry class? I answered my research questions by a convergent mixed methods action research design characterized quantitative surveys and qualitative methods. I incorporated Mertler's (2017) four-step action research cycle and included the Modified Fennema-Sherman Mathematics Attitude Scale (see Appendix A), the perceptions of blended learning survey (see Appendix B), APEX Learning pretests and unit tests (posttests), field notes and semi-structured interviews (see Appendix C), as my instrumentation of choice. The findings from the employment of said instrumentation will be discussed in chapter 4 of this DiP.

CHAPTER 4

FINDINGS

According to McNiff and Whitehead (2010), action research is about improving practice (action) and creating knowledge about practice (research). Within the opuses of this action research, I sought to improve my practice, teaching mathematics, by creating knowledge about teaching mathematics using blended learning, which is a combination of traditional face-to face instruction and online instructional delivery that has some element of student control over time, place, path, and/or pace. Hence, the purpose of this action research study was to determine if blended learning positively impacted my Geometry students' mathematics achievement and attitudes. Set at Gulf Coast High School (pseudonym) located in South Carolina, this action research was guided by the following research questions:

1) What impact does blended learning have on students' attitudes towards geometry, specifically a unit of study involving triangles?
2) What impact does blended learning have on students' mathematics achievement in a geometry course, specifically during a unit of study involving triangles?
3) How do high school students perceive the impact of blended learning in their geometry class?

I answered my research questions by a convergent mixed methods action research design characterized quantitative and qualitative methods.

I incorporated Mertler's (2017) four-step action research cycle and included the Modified Fennema-Sherman Mathematics Attitude Scale (see Appendix A), the

perceptions of blended learning survey (see Appendix B), APEX Learning pretests and unit tests (posttests), field notes, and semi-structured interviews (see Appendix C), as the instrumentation of choice. The Modified Fennema-Sherman Attitude Scale (see Appendix A), which was administered at the beginning and end of the action research study, used to determine the students' confidence in their ability to learn mathematics and the students' opinions on the usefulness of mathematics. On the perceptions of blended learning survey (see Appendix B), the students were asked how strongly they agreed or disagreed with eleven Likert Scale statements about blended learning, and then to rank traditional face-to-face instruction, online instruction, and blended learning according to their individual preferences. APEX Learning was utilized access the students' academic growth from the pretest to the posttest.

This action research's semi-structured interview participants were selected using purposeful sampling, which involved identifying and selecting individuals or groups of individuals who are especially knowledgeable about, or who have experience with the phenomenon of interest (Palinkas, et al., 2013, Sandelowski, 2000; Suri, 2011). I divided my class by academic averages in this course, above-average, average, and below-average, and then selected two students from each subgroup. Initial questions (see Appendix C) focused on the interviewees' thoughts, feelings and perceptions about mathematics and about their individual ability to perform mathematically in general and in Geometry class. Individually tailored follow-up questions were used to explore responses in more detail and to stimulate further discussion. Chapter 4 is dedicated to the analysis and interpretation of the data collected during this action research.

Quantitative Data

At the onset of this action research, an alphabetical student roster was generated, and then, for anonymity, each student was assigned a number. Monikers, Student 1, Student 2…Student 21, were used to identify students for reporting purposes.

Results of Modified Fennema-Sherman Attitude Scale. The Modified Fennema-Sherman Attitude Scale (see Appendix A) consists of 47 Likert Scale items that measure confidence, usefulness, mathematics as a male domain, and teacher perception. Each subscale consists of 12 items, half of which measure a positive attitude and the other half a negative attitude (Doepken, Lawsky, & Padwa, nd; Lim & Chapman, 2013; Sachs & Leung, 2007, Yáñez-Marquina & Villardón-Gallego, 2016). Although the student-participants answered all 47 items, only selected items were utilized to calculate the student rating because personal confidence about mathematics (question numbers 1, 4, 8, 12, 19, 23, 25, 32, 33, 37, 41 and 43) and usefulness of mathematics (question numbers 3, 5, 10, 13, 17, 21, 27, 29, 34, 39, 42 and 44). Student responses, which ranged from strongly agree to strongly disagree, received a numerical value from one to five, depending upon the choice selected, A, B, C, D, or E, and whether the item was identified as representing a positive attitude or a negative attitude. A score of 60 represents a perfect score.

Table 4.1 displays the confidence in learning data by student and includes the pre-confidence ratings, the post-confidence ratings, and the change in the two ratings; the data is presented in ascending order of change from pre-confidence to post-confidence. The table arranged by ascending change in confidence rather than by students, to ease analysis of data and to focus attention on the pertinent information presented in the tables.

Table 4.1 Confidence in Learning Mathematics

Name	Pre-Confidence	Post-Confidence	Change
Student 17	36	45	-1
Student 7	38	38	NC
Student 10	46	46	NC
Student 19	39	39	NC
Student 3	42	43	+1
Student 15	31	32	+1
Student 5	45	47	+2
Student 9	41	44	+3
Student 11	52	55	+3
Student 13	34	37	+3
Student 18	35	38	+3
Student 20	31	34	+3
Student 6	36	40	+4
Student 1	37	42	+5
Student 8	31	38	+5
Student 13	34	37	+5
Student 16	32	38	+6
Student 2	38	46	+8
Student 14	41	49	+8

Student 4	31	41	+10
Student 21	41	54	+13

Of the 21 students taking part in this action research study, 17 students showed growth on the Modified Fennema-Sherman Confidence Scale. Three students showed no change and one student showed negative change. The growth in confidence ranged from one point up to thirteen points. There, however, are no clear patterns to indicate whether the amount of growth was influenced by initial ratings.

Table 4.2 displays the usefulness of mathematics data per student and includes the pre-usefulness ratings, the post-usefulness ratings, and the change in the two ratings; the data is arranged in ascending order of change from pre-usefulness to post-usefulness. On both tables positive change is indicated by a plus sign, negative change by a minus sign, and no change is denoted by "NC". The table was arranged by ascending change in usefulness, rather than by students, to ease analysis of data and to focus attention on the pertinent information presented in the tables

Table 4.2 Usefulness of Mathematics

Name	Pre-Usefulness	Post-Usefulness	Change
Student 16	54	48	-6
Student 18	48	43	-5
Student 10	60	56	-4
Student 2	36	36	NC
Student 11	53	53	NC
Student 20	20	20	NC
Student 1	41	42	+1
Student 21	40	41	+1

Student 15	33	35	+2
Student 14	55	58	+3
Student 3	48	53	+5
Student 4	29	34	+5
Student 9	46	52	+6
Student 13	40	46	+6
Student 7	33	40	+7
Student 17	33	40	+7
Student 19	36	43	+7
Student 5	35	43	+8
Student 8	35	45	+10
Student 12	28	41	+13
Student 6	34	48	+14

Of the 21 students taking part in this action research study, 16 students showed growth on the Modified Fennema-Sherman Usefulness Scale. Three students showed no change and one student showed negative change. The growth in usefulness ranged from one point up to fourteen points. Again, there are no clear patterns to indicate whether the amount of growth was influenced by initial ratings.

Results of pretest and posttest. For this action research, APEX Learning was utilized for the online portion of the study and its pretest and unit tests (posttest) were used to measure mathematics achievement. One of three versions of the 47-item, multiple-choice pretest was randomly assigned to each student. Designed to assess the students' prior knowledge of the concepts addressed in the instructional units, the pretests determined, each student's personal study plan, which outlined which unit activities each student was required to complete (APEX Learning, 2018). The "personal study plans," which identified any lessons each student had tested out of and which lessons had to completed.to satisfy APEX Learning requirements, were the basis for the individualization of the curriculum. At the conclusion of the online curriculum, each student took the APEX Learning online unit test, which served as the posttest for this study. Comprised of 25 multiple-choice questions, the unit test (posttests) assessed the students' knowledge of triangles after taking part in the blended learning instruction. Unlike the pretest, all students took the same posttest.

Table 4.3 displays each student's APEX Learning pretest and posttest scores out of 100% and the change in the two scores: the data is arranged in ascending order of change from pretest to posttest. The table is arranged by change in score, rather than by students, to ease analysis of data and to focus attention on the pertinent information presented in the table. Positive change is indicated by a plus sign, negative change by a minus sign, and no change is denoted by "NC". The state of South Carolina employs a ten-point grading scale, thus a grade of 60% is considered passing.

Table 4.3 APEX Learning Pretest and Posttest

Name	Pretest	Posttest	Change
Student 18	62	64	+2
Student 3	51	56	+4
Student 13	60	64	+4
Student 10	62	68	+6
Student 14	62	68	+6
Student 6	13	28	+15
Student 17	9	24	+15
Student 1	42	60	+18

Student 8	42	60	+18
Student 20	42	60	+18
Student 9	51	72	+19
Student 2	20	44	+22
Student 15	58	80	+22
Student 5	40	64	+24
Student 11	42	68	+26
Student 21	29	68	+39
Student 12	20	64	+44
Student 4	29	80	+51
Student 16	29	80	+51
Student 19	24	76	+52
Student 7	8	72	+64

On the pretest, four students scored at or exceeded a minimum passing score of 60%; all of those students showed growth on the posttest. On the post-test, seventeen students, 81% of the class, scored at or exceeded the minimum passing score of 60%. Although all students did not earn a passing score of at least 60%, 100% of the students showed growth from pre- to post-test indicating that all students learned content taught during this study. The highest posttest score of 80%, which was earned by three students, is not indicative of mastery of the content. As with previous topics that the students did not fully master, I incorporated concepts from this unit of study into subsequent units of study, thus reinforcing the student knowledge of triangles. The average pretest score was 41% and the average posttest score was 63%. Change in pre-test and post-test scores ranged from two points to sixty-four points. The students who had the highest pre-test scores showed the least amount of growth.

Compilation of qualitative data. Table 4.4 displays a compilation each student's changes in confidence and usefulness of mathematics, and pre-/post-tests. The table is arranged by student identifiers to ease analysis and comparison of changes in confidence, usefulness, and pretest/posttest scores per student. Positive change is indicated by a plus sign, negative change by a minus sign, and no change is denoted by "NC".

Table 4.4 Change in Confidence, Usefulness and Pre/Posttest Per Student

Name	Change in Confidence	Change in Usefulness	Change in Pre/Post Test
Student 1	+5	+1	+18
Student 2	+8	NC	+22
Student 3	+1	+5	+4
Student 4	+10	+5	+51
Student 5	+2	+8	+24
Student 6	+4	+14	+15
Student 7	NC	+7	+64
Student 8	+5	+10	+18
Student 9	+3	+6	+19
Student 10	NC	-4	+6
Student 11	+3	NC	+26
Student 12	+5	+13	+44
Student 13	+3	+6	+4
Student 14	+8	+3	+6
Student 15	+1	+2	+22
Student 16	+6	-6	+51
Student 17	-1	+7	+15
Student 18	+3	-5	+2

Student 19	NC	+7	+52
Student 20	+3	NC	+18
Student 21	+13	+1	+39

Twelve students, 57% of the class, showed positive growth in all three categories, confidence in learning mathematics, usefulness of mathematics, and mathematics achievement. Five students, 24% of the class, had positive change in two of the categories and no change in the third. For instance, Student 11, an average academic performer in the course, initially showed strong confidence in learning mathematics, scoring 52 out of a possible 60 points on the pre-confidence, gained three points on the confidence scale improved by 26 points from pretest to posttest, showed no change on the usefulness scale. Three students, 14% of the class, had positive change in two categories and a negative change in the third category. Finally, Student 10 had a six-point increase from pretest to posttest, a four-point negative change in usefulness and no change in confidence.

Results of perceptions of blended learning survey. The perceptions of blended learning survey (see Appendix B), a twelve-item instrument that I developed, was used to determine each student's opinion of blended learning at the conclusion of the intervention. Students were asked how strongly they agreed or disagreed with eleven Likert Scale statements, and then rank traditional face-to-face instruction, online instruction, and blended learning according to their individual preferences. Figures 4.1 thru 4.11 display the students' responses to each of the Likert Scale items. Each graph depicts the percentage of respondents that selected strongly agree, agree, neutral, disagree or strongly agree in reference to blended learning statements. For analysis, the graphs were grouped based upon similarities in the topics in the questions.

Figure 4.1 Blended Learning Question #1

Question #1: Compared to traditional, face-to-face instruction, blended learning helps me better understand mathematics.

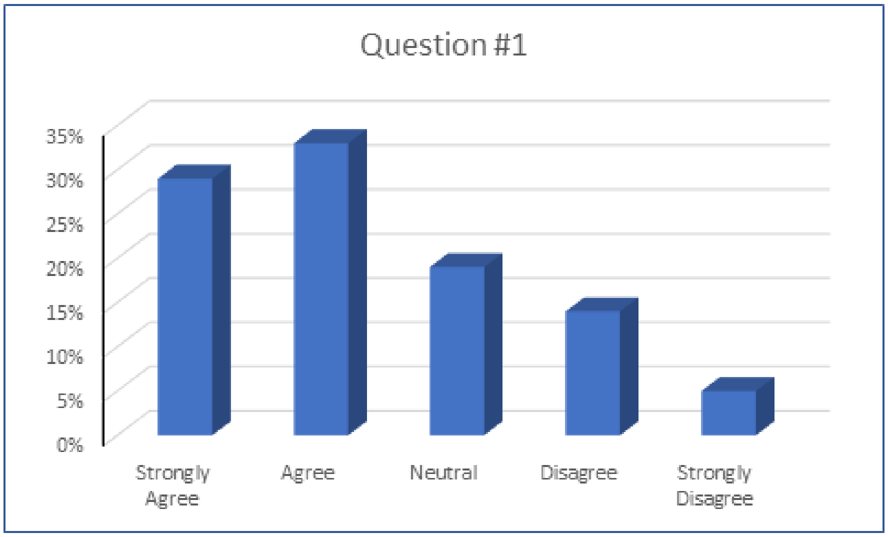


Figure 4.2 Blended Learning Question #2

Question #2: Blended learning enables me to become more involved in the learning process.

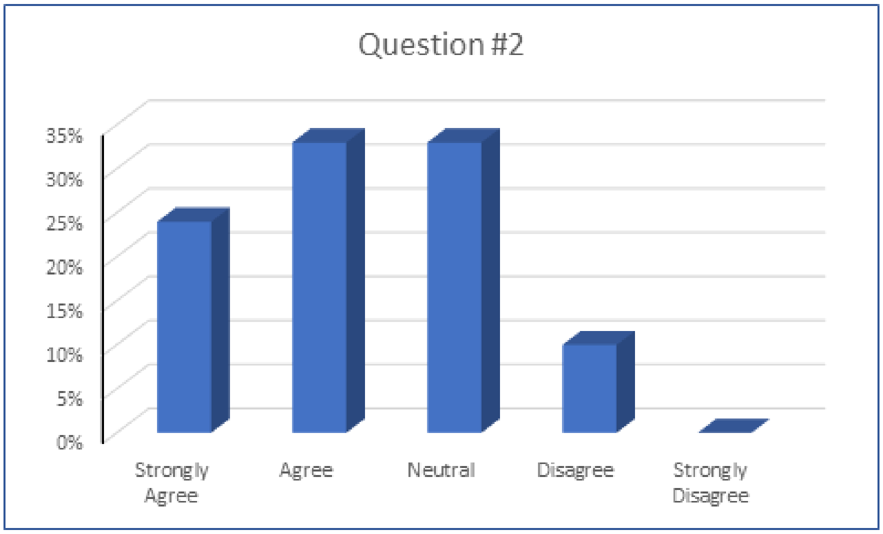
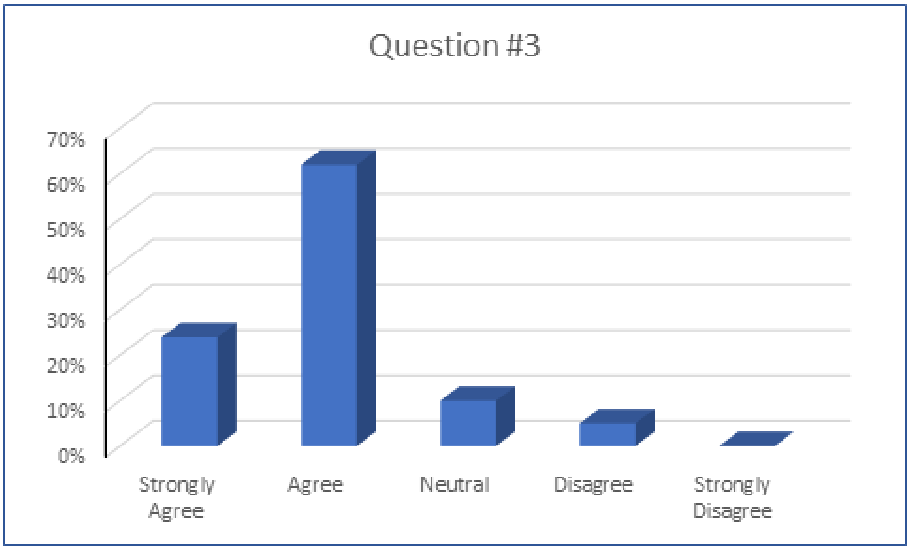


Figure 4.3 Blended Learning Question #3

Question #3: With blended learning I can control how fast or slow I move through lessons.



Responses to Questions 1, 2, and 3, indicated positive views of blended learnings. My students favored the control blended learning affords them in terms of their understanding of the content, their involvement in the learning process and their pace in completing instructional requirements.

Responses to Questions 4 and 5 indicate that, although they spent significant time working independently, the students did not feel isolated. The majority of the students were satisfied with their interactions with both their teacher and their peers. During Tuesday and Thursdays, during face-to-face instruction, the students were able to confer with their counterparts, and in some instances work together.

Figure 4.4 Blended Learning Question #4

Question #4: I am satisfied with my interactions with my teacher during blended learning.

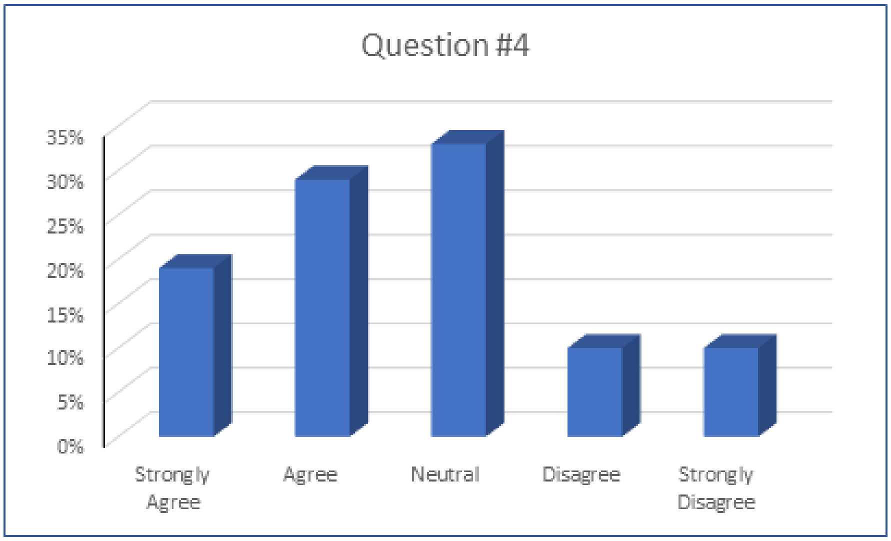


Figure 4.5 Blended Learning Question #5

Question #5: I am satisfied with my interactions with my classmates during blended learning.

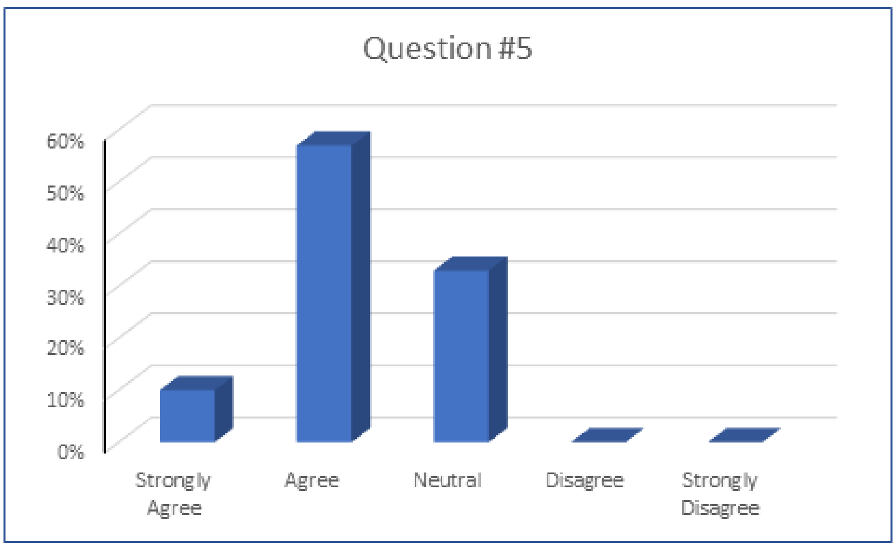


Figure 4.6 Blended Learning Question #6

Question #6: Compared to traditional, face-to-face instruction, blended learning is a more effective instructional strategy.

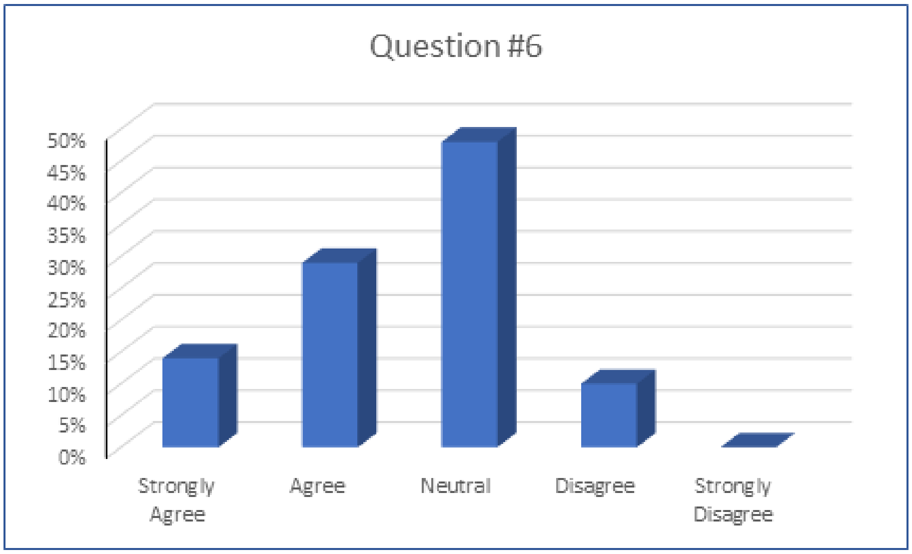
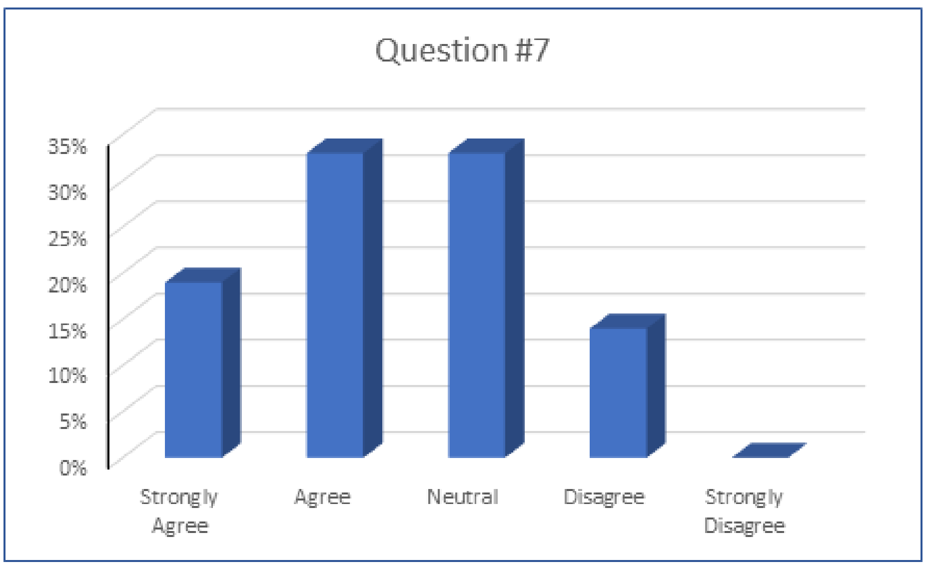


Figure 4.7 Blended Learning Question #7

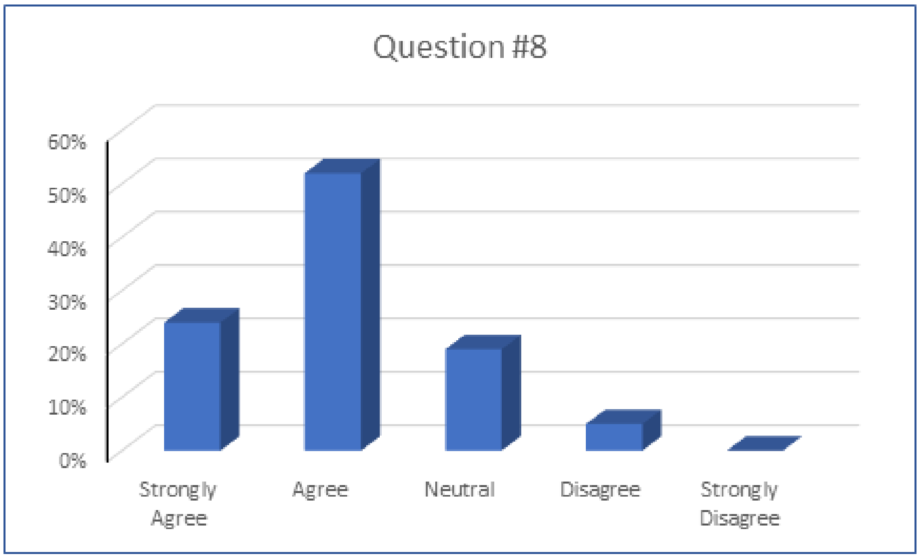
Question #7: I would recommend that other students take blended learning course.



Although in Questions 6 and 7 there were a significant number of neutral responses, 43% and 48%, respectively, the students demonstrated overall positive thoughts about blended learning. Forty-three percent of the students indicated that blended learning is more effective than traditional, face-to-face instruction and 52% indicated that they would recommend that other students take a blended learning course.

Figure 4.8 Blended Learning Question #8

Question #8: Blended learning is an effective way to learn mathematics.



Seventy percent of the students agreed or strongly agreed that blended learning is an effective way to learn mathematics. That overwhelmingly high percentage, indicates that despite their misgivings and some negative aspects of blended learning, the students valued blended learning as an effective method for learning mathematics.

In response to question 9, 55% of the students agreed or strongly agreed that compared to traditional and face-to-face instruction, they are typically more engaged during blended learning. These results were a bit astounding, given that the students spent approximately half of their instructional time working independently. My observations showed that perhaps, the student control over their instructional pace and materials may have factored positively into the student engagement.

Figure 4.9 Blended Learning Question #9

Question #9: Compared to traditional, face-to-face instruction, generally, I am more engaged during blended learning.

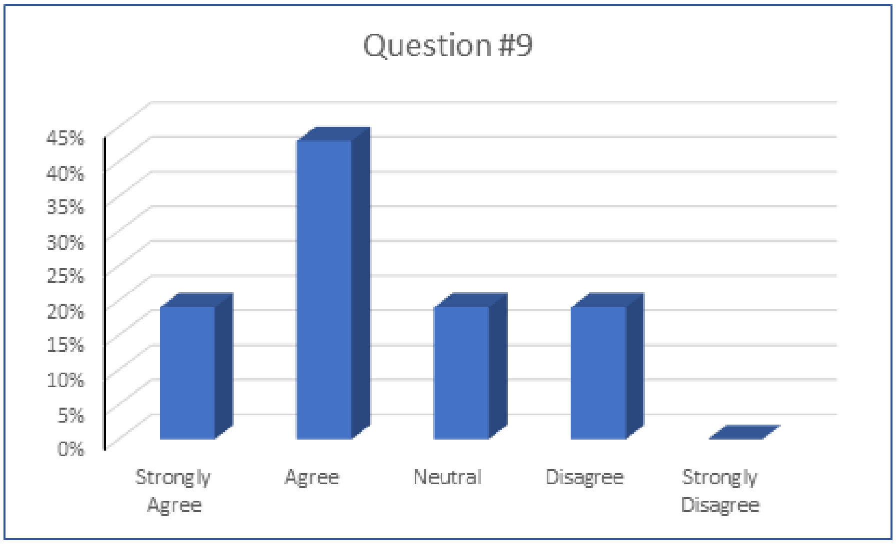
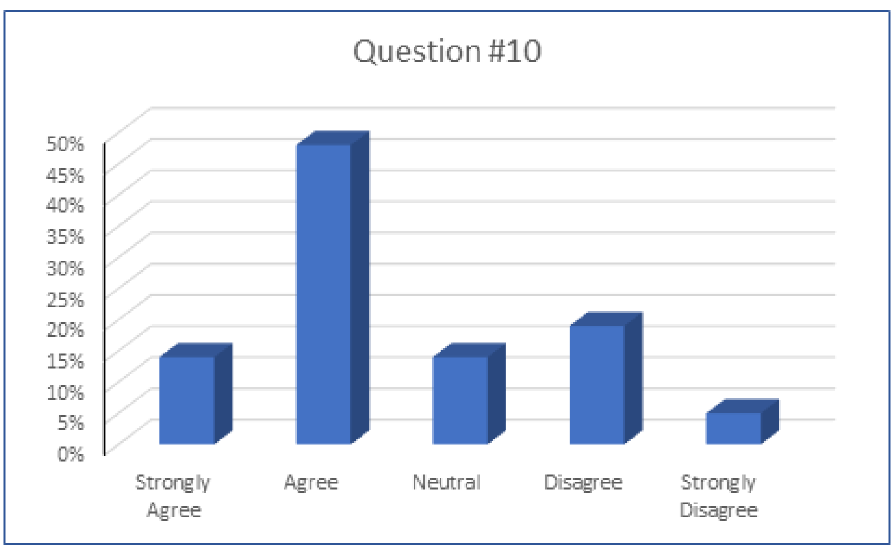


Figure 4.10 Blended Learning Question #10

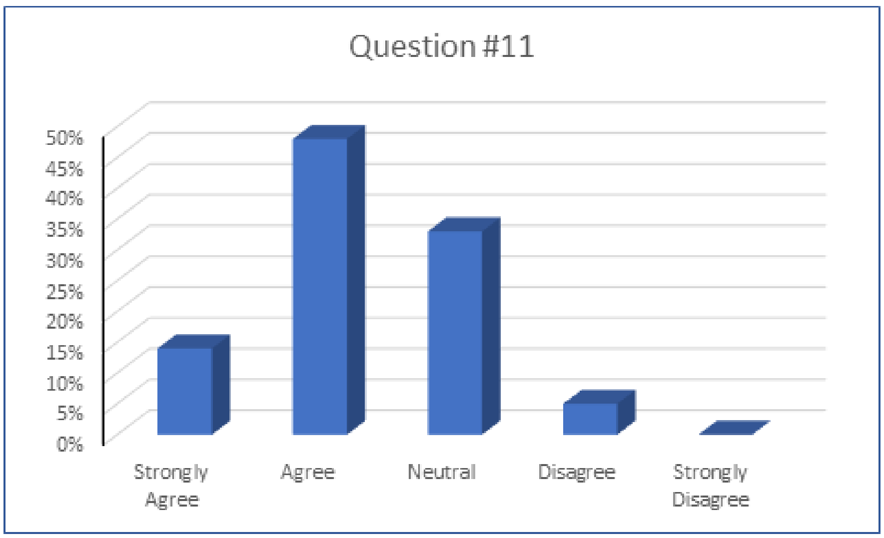
Question #10: Given a choice, I would take another blended learning course.



Given a choice, 57% indicated that they would take another blended learning course. The students in this action research study had never taken a blended learning course. As the novelty of blended learning wore off, the students began to look at the instructional strategy somewhat objectively. While they were not completely sold on blended learning, more than half of the students were willing to take another blended learning course and another 12% were neutral.

Figure 4.11 Blended Learning Question #11

Question #11: In general, I am satisfied with blended learning instructional strategy.



Nearly 60% of the students stated that they were satisfied with the blended learning instructional strategy. Another 36% of the students selected neutral. Only 7% of the students disagreed or strongly disagreed with the statement that they were satisfied with blended learning as an instructional strategy.

Responses to Questions 8 through 11, overwhelmingly favored blended learning. When asked to rank traditional face-to-face instruction, online instruction, and blended learning according to their individual preferences, 57% of student-participants ranked traditional face-to-face instruction first, blended learning second, and online instruction third. Nineteen percent of survey respondents ranked blended learning first.

Qualitative Data

During this action research, semi-structured interviews and field notes were used to collect qualitative data. This action research's semi-structured interviews (see Appendix C) were conducted with a purposeful sampling of students and were comprised of initial questions focused on the interviewees' thoughts, feelings and perceptions about blended learning, about learning mathematics and about their individual ability to learn mathematics. Individually tailored follow-up questions prompted more detailed responses. As the students worked independently using APEX Learning during the online learning component of this action research study, I used journaling to record my observations, musings, and interpretations. The flexible nature of observation technique employed afforded me the opportunity to simultaneously monitor pupil progress and behavior, answer student questions, and conduct the field study. I noted student questions, interactions, and reactions to APEX Learning activities. Analysis the semi-structured interviews and field notes revealed four major themes, teacher support, self-paced learning, video-based instruction, and benefits of blended learning.

Student profiles. Semi-structed interviews comprised approximately half of the qualitative data collected during this action research. The interviewees were selected using a purposeful sampling technique using academic performance as the variable. Upon analysis of the students' academic performance in this course, I selected two above average, two average, and two below average performing students, based upon their academic grades in this course, to interview.

At the onset of this action research, an alphabetical student roster was generated, and then, for anonymity, each student was assigned a number. Monikers, Student 1, Student 2…Student 21, were used to identify students for reporting purposes. Students 1, 8, 10, 12, 16, and 18, all of whom were high school juniors, were selected to take part in the semi-structured interviews, based upon their performance in this course. For data analysis and results discussions, I assigned these students pseudonyms.

Jade, Student 1, was a female, average-performing geometry student. The year prior, I taught her Algebra 2. Jade had an Individual Education Plan (IEP) that designated her as learning disabled and that identified her accommodations as use of calculators, preferential seating, and assistance from her resource teacher, as needed. It was my experience in the two years that I had known her, that Jade was a hard-working, conscientious, and academically astute pupil, who performed as well as the majority of her peers. Additionally, I found that, although Jade is capable to satisfactorily meeting geometry course objectives, she lacks confidence and desires continuous support and conformation from me.

Chris, Student 8, was a quiet, reserved male student who maintained a D average (60% - 69%) in this course. Chris, who did not demonstrate a desire to excel in this course, tended to do the bare minimum course requirements and was satisfied with just passing the course (earning an average of 60%). Throughout the course, I had to prompt and urge Chris to remain on task, to ask/answer questions, and to do his best work.

Jason, Student 10, was a charismatic, average Geometry performing member of our football team. I taught Jason Algebra 2 the previous semester and knew him quite well. Mathematics was not his favorite subject and he was not very confident in his ability to excel in the course. Jason generally underestimated his academic capabilities but was a hard worker, who earned Honor Roll (B average overall) status quarterly.

Adam, Student 12, performed above average in this and all of his classes. Adam, who was enrolled in some honors courses, expected to score perfect on all assignments and was upset if he did not. Very opinionated, Adam was not shy about sharing his views, nor did he require prompting. Adam did not enjoy school, per se, but valued learning and saw education as a means to an end, the path to a successful career and life. Adam consistently earned Principal's List (A average in all courses) honors.

Morgan, Student 16, was a gifted and talented female student who consisted earned an A (90% - 100%) in geometry. A Principal List's (A average in all courses) honoree each quarter, Morgan was self-motivated, driven, articulate, and always willing to assist her classmates. Morgan enjoyed school and possessed a genuine zest for knowledge.

Hailey, 18, was a female pupil who performed below average in this and many of her courses. Hailey generally disliked school and was prone to skipping class and school, if not closely monitored. Hailey generally did not work up to her potential and typically only did enough work to get by.

Analysis and subsequent coding of the interview transcripts revealed the following student-centered themes: an appreciation for teacher support, thriving on self-paced learning, a love/hate relationship with video-based instruction, and perceived benefits of blended learning.

An appreciation for teacher support. As an insider during this action research, I took on several roles. Prior to the start of the study, as researcher, I ensured that my students and their parents understood the action research process and the procedures we would follow. At the onset of the study, I introduced my students to the APEX Learning program, guided them through the "Student Getting Started Guide," and supported them during the two-day period they used APEX Learning to review of linear equations. On Mondays and Wednesdays, when my students engaged in APEX Learning, the online component of our blended learning, I acted as a facilitator of instruction, ensuring they remained on task, answering their questions, and providing technical support, as needed. On Tuesdays and Thursdays, when face-to-face traditional learning took place, I took on the role of a more traditional teacher; I planned and delivered instruction based primarily upon student needs, as identified during my facilitation of the online curriculum. Student questions asked me during online instruction, topics of the lesson quizzes that my students most frequently retook or scored poorly on, and my observations, drove my lesson decision making process. Additionally, I selected topics, that in my professional opinion, needed to be expanded upon. It was the second week of our study before my students realized the relationship between their questions during online instruction and the topics of my face-to-face instruction.

One of the components of blended learning that the students seemed to favor most is the individualized teacher support. Adam stated that, with blended learning there is "still a connection between the students and the teacher. The teacher can identify our problems comprehending and help us." All interviewees stated that teacher's explanations, answers to their questions, and support, were the aspects of the face-to-face instruction that contributed most to their understanding of the course content. Morgan said, "when I didn't understand the online content, the teacher explained it step-by-step." When asked what she like most about blended learning courses, Morgan went on to express her preference for the "teacher support and guidance during the online instruction."

Thriving on self-paced learning. Instructional pacing is the rate at which instructional activities take place during a lesson. Instructional pace is predicated on manipulatable variables such as wait time, the duration between instructional stimulus and student response, and inter-trial interval (ITI), duration between teacher feedback and the next antecedent instructional stimulus (Chou & Liu, 2005; Tincani & De Mers, 2016).

From the standpoint of a teacher, keeping the class moving at the right speed, hence meeting the needs of all students, is a daunting task. In my experience during whole group activities, discussions, and instruction, students who work at a faster pace are often frustrated because they have to "wait for" for their peers to catch up. Similarly, students who work at a slower pace tend to feel as though they are "holding up" the class and are preventing others from progressing. It is from this standpoint, that my students likely hailed the self-pace aspect of blended learning as a positive attribute. Half of the interviewees indicated that the self-paced aspect of blended learning was a favorable characteristic. Hailey stated that she did not feel "rushed with [the] online work."

In my observations, as documented in my field notes, I noticed that my students also saw self-paced aspect of the online component of blended learning as flexibility in how they spent their time. The students frequently went back to previous portion of lessons or other lessons altogether. During his interview Chris mentioned the ability to "go back at any time" to review notes and examples. Adam declared that the ability to replay the instructional videos was a major way that the online component of blended learning contributed to his understanding of course content. Finally, when asked what advice would he would give to a student new to blended courses, Adam responded, "remember you can go back." The self-paced nature of blended learning contributes to the students' sense of ownership and control in their learning, which in turn lends itself to the constructivist tenet of the learner's active role in knowledge construction.

A love/hate relationship with video-based instruction. Prior to our experience with blended learning, I frequently used short videos (four to seven minutes) as a part of whole group direct instruction. I projected the videos on the Starboard and played the videos, periodically pausing them to discuss key points and to ask and answer questions. Although my students had previous experience with instructional videos, they had mixed feelings about the video-based instruction on APEX Learning. Even though Adam opined that "the videos [online instruction] is not as thorough as the teacher," when asked what advice he would give a student new to blended learning, Adam said, "take notes from the videos and pay attention to the online instruction."

When Chris and Jason stated, respectively that "[the] computer work is a little confusing" and that "I didn't understand some of the online videos and examples," I posed a follow-up question, asking if they felt that they could receive assistance in those situations. Both students indicated that I provided aid and answered questions, as needed. As I observed my students during online instruction, I witnessed students attempting to skip the instructional videos and in other instances, questioned their attention to the videos based on their quiz grades and, in some cases, the questions they asked. Throughout the blended learning process, I emphasized the importance of the instructional videos.

In spite of claims that the videos were not thorough enough, were confusing, and were hard to understand, all interviewees admitted that the online videos, examples, and study/note-taking guides, paired with the ability to go back and review material, as needed, contributed most to the interviewees' understanding of the course content. For instance, although Jade indicated that she preferred face-to-face instruction because she disliked working with computers, she also stated that being able to replay the instructional videos contributed to her understanding of the course content.

Perceived benefits of blended learning. Four out of the six interviewees preferred blended learning because receiving "double instruction" (Hailey) and the "best of both worlds" (Morgan). Chris said, "with the online instruction, you can work at you own pace and the teacher is available to help you." Although Jade indicated that she preferred face-to-face instruction, she also stated that she got an overall "better understanding from blended learning" and touted the abilities to "replay videos, [to] go back to notes, and [to] take quizzes multiple times" contributing factors to her understanding of the course content.

From the semi-structured interviews and my observations as documented in my field notes, I gleaned that the students like the independence associated with blended learning, but also appreciated my ability to provide support during online and face-to-face instruction. I observed that the students were more attentive during the blended learning intervention I attribute that to the variety of instructional materials and strategies utilized. Chris stated that the online component taught concepts in "more ways" and had "more examples and problems." No two consecutive days involved the same teaching strategy. Even though blended learning may not have been some of the students' first choice, they found positive attributes about it. For instance, although Jade indicated a preference for face-to-face instruction and complained about the amount of work associated with the online lessons, she stated that the self-paced nature of the online component of blended learning was advantageous.

Data Triangulation

Triangulation refers to the researcher's use of multiple and varying sources to form themes and categories and to draw conclusions (Creswell & Miller, 2000; Green, 2014). In this study, I took a mixed methods approach to my research and utilized a combination qualitative and quantitative data to answer each research question.

The first research question, "What impact does blended learning have on students' attitudes towards Geometry, specifically a unit of study involving triangles?' was answered using data collected using the Modified Fennema-Sherman Attitude Scale, field notes, and semi-structured interview questions. The Modified Fennema-Sherman Attitude Scale was used to assess student views on their confidence in their ability to learn mathematics and their views of the usefulness of mathematics at both the onset and conclusion of this study. Although 81% of the students showed growth on the confidence scale and 76% showed growth on the usefulness scales, the growth was not significant nor were there clear patterns to indicate that the changes were influenced by initial ratings.

I used APEX Learning pre- and posttest scores and field notes to answer this study's second research question: "What impact does blended learning have on students' mathematics achievement in a Geometry course, specifically during the unit of study involving triangles?" A comparison of pre- and posttest data by student showed growth ranging from 2 points to 52 points, with an overall average change of approximately 25 points. All students demonstrated growth and posttest scores for 81% of the class exceed 60%, which is a passing grade in the state of South Carolina. This was corroborated by field notes and semi-structured interviews.

This action research study's third and final research question, "How do high school students perceive the impact of do blended learning in their Geometry class?" was answered using the perceptions of blended learning survey, field notes, semi-structured interviews. Overall, my students had positive views of blended learning and students favored the control blended learning afforded them in terms of their understanding of the content, their involvement in the learning process and their pace in completing instructional requirements. Although they spent significant time working independently, the students did not feel isolated, indicated satisfaction with their opportunities to interact with their peers and relished the individualized teacher support. In conclusion, sixty-two percent of the students indicated that they were more engaged during blended learning and if given a choice, would take another blended learning course.

Summary

In this action research study, I sought to determine if the implementation of blended learning as a method of instruction, would impact the mathematics attitudes and achievement of students within a South Carolina Geometry class. I utilized a mixed methods research design to conduct the six-week study. Study findings include a 25-point average increase in mathematics academic achievement and inconclusive changes in attitudes toward mathematics. Nearly two-thirds of the students indicated that they were more engaged during blended learning and if given the opportunity, would take another blended learning course. Chapter 5 details the recommendations and implications stemming from this action research.

CHAPTER 5

IMPLICATIONS AND RECOMMENDATIONS

McNiff and Whitehead (2010) contend that action research is about "improving practice through improving learning and articulating the reasons and potential significance of the research" (p. 2). The purpose of chapter five is to describe the details of, findings of, and implications of the current action research study, which involves blended learning and its impact upon mathematics achievement and students' attitudes toward mathematics.

Throughout my quarter-century career as a high school mathematics teacher, improving students' mathematics achievement was my primary goal. Over the years I tried enumerable teaching strategies and initiatives with mathematics achievement as my focus. I am not certain of exactly when or why, although advanced degrees, continuous profession development, teaching experience, and a blossoming propensity of reflective journaling likely contributing factors, but at some point, my attention shifted from teaching methodology to students' attitudes toward mathematics. Studies have shown that teaching strategies geared towards positively impacting students' attitudes to mathematics are directly related to mathematics achievement (Alt, 2014; Bandura, 1997; Kingir, Tas, Gok, & Vural, 2013). That adjustment in my thinking and a district-wide push for more technology integration, gave birth to this action research, whose problem of practice was to determine if a specific instructional strategy (blended learning) would positively impact high school students' attitudes towards mathematics and thus their mathematics achievement. This chapter summarizes and draws conclusion to this action research.

During this action research study, which was set at Gulf Coast High School (pseudonym) located in the midlands of South Carolina, in addition to my role as Geometry teacher, I served as an active participant and insider-researcher in the convergent mixed methods research design. Because I conduced this action research within my workplace and more specifically, within my own classroom, I was considered an insider-researcher, an advantage of which is having knowledge about the cultures, norms, traditions, and informal structures of the organization (Coghlan & Brannick 2005; Greene, 2014). The study participants were students enrolled in one of my Geometry classes.

The purpose of the present action research study was to determine if and to what degree blended learning, which is a combination of traditional face-to-face instruction and online instructional delivery, would impact my students' attitudes toward mathematics and their mathematics achievement in my Geometry class, in accordance with the identified problem of practice (PoP) for this dissertation in practice (DiP). This action research was guided by the following research questions:

1) What impact does blended learning have on students' attitudes towards geometry, specifically a unit of study involving triangles?
2) What impact does blended learning have on students' mathematics achievement in a geometry course, specifically during a unit of study involving triangles?

3) How do high school students perceive the impact of blended learning in their geometry class?

I answered my research questions by a convergent mixed methods action research design characterized quantitative and qualitative methods. Quantitative data collection instruments included the Modified Fennema-Sherman Scale, APEX Learning Pretest/Posttest, and the perceptions of blended learning survey. Field notes and semi-structured interviews were the sources of qualitative data.

At the onset of the study, I introduced my students to the concept of action research, explained the purpose this study, provided at brief overview of how the study would be conducted, and defined pertinent vocabulary (i.e. blended learning, online learning, face-to-face instruction). At that point, I began data collection by administering the Modified Fennema-Sherman Attitude Scale (see Appendix A). The following day I introduced and modeled use of the APEX Learning program to the students, guided them through the initial log-in process, and then oversaw their completion of the "Student Getting Started Guide." I then, facilitated my students' two-day trial of APEX, during which time they became familiar with the program. I concluded baseline data collection by administering the APEX Learning pretest, which generated personal study plan that outlined which unit activities each student was required to complete.

During this study's intervention, which took place in their usual classroom, the students were taught an instructional unit on triangle components, relationships, and congruence using the blended learning instructional strategy. On Mondays and Wednesdays, self-paced instruction was delivered via APEX Learning, online curriculum. On Tuesdays and Thursdays, the teacher delivered instruction on specified portions of the unit and incorporated the content needs of the students, as identified during my facilitation of the online instruction. On Fridays the students took part in reflective activities, such as journaling, and engage in cooperative learning opportunities. Field notes were taken through the intervention. At the conclusion of the intervention, the Modified Fennema-Sherman Attitude Scale, the APEX Learning posttest, and the perceptions of blended learning survey were administered. Additionally, semi-structured interviews were conducted with a purposeful sampling of the students, based upon their academic performance in this course.

Findings

Paramount to the definition of blended learning is an online component with some measure of student control, time, place, path, and/or pace (Boelens, et al., 2017; Carman, 2005; McNiff & Whitehead, 2010). "Self-paced, asynchronous learning events add significant value to the blended learning" experience (Carman, 2005, p. 2). This characteristic of blended learning appeared to be important to the students. Eight six percent of the students agreed or strongly agreed with perceptions of blended learning survey (see Appendix B) Question 3: With blended learning I can control how fast or slow I move through lessons. When asked what they liked most about blended learning, Jade indicated that "when working on the computer you are not rushed to complete the assignments" and Hailey stated that she was "not rushed with [the] online work." With 76% of the students ranking blended learning as their first or second instructional choice, with 100% of the students demonstrating growth from pretest to posttest, and finally, with 81% of the students passing the posttest, I conclude that blended learning is a viable instructional strategy for teaching high school geometry.

Action Plan

When I began my study of blended learning and subsequently embarked upon this action research, I had no idea how quickly I would put into practice what I was learning. However, in March, 2020, the school year came to a halt because of the onslaught of a world pandemic spurred by Coronavirus Disease 2019 (COVID-19). After a week a week of frantic planning, school resumed in an e-learning platform until the end of the school term.

We began the 2020-21 school year with virtual instruction (which includes a combination of synchronous and asynchronous instruction) and a plan to progress to hybrid learning (students attending school two days per week), and eventually traditional face-to-face instruction, all of which is contingent upon the spread of COVID-19. As discussed in the review of literature, blended learning comes in many shapes and forms. In this action research study, blended learning was comprised of two days of online learning, two days of face-to-face instruction, and one day of reflective and collaborative activities, all from within the classroom setting. Our current virtual model, is a form of blended learning, in the sense that in addition to synchronous class sessions four days a week, the students are responsible for a portion of their learning via online curricular such as ALEKS and Edgenuity.

From my experiences during this action research study and during the previous and present COVID-19-induced instructional changes, I made several observations. In the present action research, I chose the topics for face-to-face instruction based upon my observations, the questions students asked me, and topics students scored poorly on during online instruction. In future studies or practice, I will give students an opportunity to suggest focal points for face-to-face instruction. During this study, I required my students to complete the vast majority of their online learning within the classroom so that I could monitor them more closely and ensure that they remained on task. During the Spring 2020's e-learning and our current virtual learning, I realized that many of my students prefer working late at night. Thus, I would provide students with more opportunities to work outside of the classroom. These two strategies will give students greater ownership, flexibility, and choice, as it regards their learning.

The students in this action research study, were all African American and from low socio-economic community. Statistically, students with those demographics do not perform well in mathematics nor do they pursue (Balentyne & Varga, 2017; Dziuban et al., 2018; Leonard & Evans, 2012). The results of this action research study indicate that blended learning may be a means bridging the educational gap between minorities and non-minorities.

Blended learning is highly dependent up technological equipment, which lends itself to concerns about proficient usage by the teacher and students. Additionally, technical malfunctions adversely impact the delivery of the online content. I found that while my students frequently utilize technology, the use technology for informal purposes such as gaming and social media. At the beginning of this action research study, I introduced my students to APEX Learning and provided them with an opportunity to become familiar with the program. In future studies and practice, that introduction will also provide students with the skills to assist them with formalizing their technology usage. For instance, I would help students with basic computer skills and communication, such as email communications, troubleshooting minor computer issues, attaching files and pictures. Although these skills are not related to geometry curriculum standards, they are essential to successful online navigation, which is a major component of blended learning.

According McNiff and Whitehead (2010), the primary purposes of action research are to improve learning and to improve the practice of educating. It is with this in mind that I developed the following action plan which involved sharing my study findings with others and growing personally. Throughout this action research study, I shared my progress with a couple peers, and as we prepared for e-learning in March, 2020, I discussed my experience with the mathematics department. The department was gathered in my classroom; we had two days to plan for several weeks of e-learning. Given that we had little time to prepare, there had been no frontloading of information to the students, and we were in the midst of a pandemic, tensions and anxiety were high. I was the only team member with blended learning and online learning experience. I shared tips that I had gleaned while conducting this action research study, such as, provide the students with an overview (written and video) of the program(s) that would be utilized, provide clear directions and expectations, provide detailed timelines with planned reminders, and provide opportunities for the students to engage with both the teacher and their peers. I reiterated that it was imperative that the students not feel alienated or disconnected from the learning environment. This action plan is based on more formalized presentations of my findings. My principal has asked me to present my study findings to our faculty and staff and provide insight into how my experiences can assist in strengthening our virtual instruction. Additionally, I intend to present my findings at conferences on both the state and national level, such as the South Carolina

Council of Teachers of Mathematics (SCCTM) and the National Council of Teachers of Mathematics (NCTM).

I have always dreamed of having a blog; that dream became a reality a year ago. Dare to Teach began with a limited readership of close friends and colleagues. With the creation of an Instagram account and email, has led to followers along the east coast of the United States. I will use my blog as a platform for sharing my research findings and engaging in collegial conversations about blended learning. Finally, I would like to increase my knowledge base and improve my teaching practice by earning the online teaching endorsement for the State of South Carolina.

Implications for Further Research

Coghlan and Brannick (2005) described action research as is both a sequence of events and as a problem-solving strategy. They went on to state that blended learning is comprised of "iterative cycles of gathering data, feeding it back to those concerned, analyzing the data, planning action, taking action and evaluating," which results in further data gathering, etc. (p. 4). As I reflected upon the present action research study, in terms of data collection, I made two observations. The perceptions of blended learning survey I created included "neutral" as an answer choice. I wonder how excluding "neutral" as an answer choice would have impacted student responses, and ultimately the quality of data collected. In future studies, I will remove neutral as an option, to force students to make a choice either in favor of or against, to enhance the authenticity of the data collected. While the semi-structured interviewed produced useful data, typical of teenagers, many of their responses were brief and required considerable probing to garner more detailed responses.

Throughout this action research study, I found myself wondering “what if…” and “I wonder what would happen…” Then those wonderings became questions. If this study had been longer, would there have been larger increases in academic achievement? More significant changes in attitude? What, if any, differences would there be if blended learning were applied in an Advanced Placement (AP) course versus a college preparatory one? Is Geometry more adapt to blended learning than other math courses like Algebra 2, or Precalculus? And what about the age of the students involved? Would blended learning be as successful with high school freshmen as with high school juniors or seniors?

From these musings, I devised several prospective research projects that would develop from this present action research study, which lasted six week and took place within a semester-long high school geometry course. First, I would like to conduct blended learning study for the entire length of a course. By doing so the students would have a longer period of time to become acclimated to the blended learning process, multiple topics would be taught using blended learning, and more data would be collected. Additionally, I would like to use blended learning within other mathematics courses that I teach, such as Algebra 2, and in collaboration with teachers in my department. From these experiences, I would glean knowledge about how blended learning works in other courses and learn from the experiences of my peers, particularly those who teach different grade levels and course types. We could compare the use of blended learning with freshmen Algebra 1 students to junior Geometry students or senior Probability & Statistics students. Finally, we could compare the blended learning performances of students enrolled in college preparatory, honors, and Advanced

Placement courses. Ultimately, for a broader more inclusive perspective, we could study blended learning within other disciplines, such as English/language arts, science, and social studies.

Summary

Heartbroken and disillusioned by my students' negative attitudes toward mathematics in general, and their ability to learn mathematics, in particular, I embarked on an action research journey to find a possible solution. Considering access to one-to-one devices and a district-initiative to use an online curriculum, I chose to use blended learning, which is grounded in the constructivist theoretical framework, as the intervention in the convergent mixed methods research study to answer the following research questions: What impact does blended learning have on students' attitudes towards mathematics? And What impact does blended learning have on students' mathematics achievement? I incorporated Mertler's (2017) four-step action research cycle and included the Modified Fennema-Sherman Mathematics Attitude Scale (see Appendix A), the perceptions of blended learning survey (see Appendix B), APEX Learning pretests and unit tests (posttests), field notes and semi-structured interviews (see Appendix C), From my analysis of the study's findings I concluded that although the attitude data was inconclusive, blended learning is a viable means of increasing mathematics achievement in a high school geometry class.

REFERENCES

Abed, M. G. (2015). A consideration to two main ethical issues in educational research, and how may these be addressed. *Journal on Educational Psychology*, *8*(3), 1-14.

Abramovitz, B., Berezina, M., Bereman, A., & Shvartsman, L. (2012). A blended learning approach in mathematics. In A. Ajuan, M. A. Huertas, S. Trenholm, and C. Streegmann (Eds), Teaching mathematics online: Emergent technology and methodologies (pp. 22-42).

Ahmad, W., Shafie, A., and Janier, J. (2008). Students' perceptions towards blended learning in teaching and learning mathematics: Application of integration. Proceedings from: *The Thirteenth Asian Technology Conference in Mathematics, Sauan Sunandha Rajabhat University.* Bangkok, Thailand.

Altuna, J., & Lareki, A. (2015). Analysis of the use of digital technologies in schools that implement different learning theories. *Journal of Educational Computing Research, 53*(2), 205-227.

APEX Learning [Digital Curriculum] (2018). Retrieved from https://www.apexlearning.com/

Balentyne, P., & Varga, M. A. (2016). The effects of self-paced blended learning of mathematics. *Journal of Computers in Mathematics and Science Teaching, 35*(3), 201-223.

Balentyne, P., & Varga, M. A. (2017). Attitudes and achievement in a self-paced blended course. *Journal of Online Learning Research*, *3*(1), 55-72

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W. H. Freeman and Company.

Boelens, R., De Weaver, B., & Voet, M. (2017). Four key challenges to the design of blended learning: A systemic literature review. *Educational Research Review, 22*, 1-18.

Borba, M. C., Askar, P., Engelbrecht, J., Gadanidis, G., Linares, S., & Aguilar, M. S. (2016). Blended learning, e-learning and mobile learning in mathematics education. *ZDM: The International Journal on Mathematics Education*, *48*(5), 589-610.

Bourke, B. (2014). Positionality: Reflecting on the research process. *The Qualitative Report*, *19*(33), 1-9.

Carman, J. M. (2005). Blended learning design: Five key ingredients Retrieved from http://www.agilantlearning.com/pdf/BlendedLearningDesign.pdf

Chou, S., & Liu, C. (2005). Learning effectiveness in a web-based virtual learning environment: A learner control perspective. *Journal of Computer Assisted learning*, *21*(1), 65-76.

Coghlan, D. & Brannick, T. (2005). *Doing action research in your own organization* (2nd ed.). Thousand Oaks: SAGE Publications.

Creswell, J. W., & Miller, D.L. (2000). Determining validity in qualitative inquiry. *Theory into practice, 39*(3), 124-130.

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.). Los Angeles: SAGE Publications

Creswell, J. W., Plano Clark, V. L., Gutmann, M. L., & Hanson, W.E. (2003). Advanced mixed methods research designs. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of mixed methods in social and behavioral research* (pp. 209–240). Thousand Oaks, CA: Sage. Dallas Independent School District. (2016). A study of the impact of APEX Learning digital curriculum on original credit student achievement. Retrieved from http://cdn.apexlearning.com/al/dallas-original-credit-efficacy-study.pdf

Dana, N., & Yendol-Hoppey, D. (2014). *The Reflective Educator's Guide to Classroom Research.* Thousand Oaks, CA: Sage.

de Barros, A. M., Simmt, E., & Maltempi, M. V. (2017). Understanding a Brazilian high school blended learning environment from the perspective of complex systems. *Journal of Online Learning Research,* 3(1), 73-101.

de Kock, A., Sleegers, P., & Voeten, M. J. M. (2004). Learning and classification of learning environments in secondary education. *Review of Educational Research, 74,* 141–170

Dewey, J. (1938). Experience & Education. New York, NY. Free Press.

Dictionary.com (n.d.). Retrieved from https://www.dictionary.com/browse/blend?s=t

Doepken, D., Lawsky, E., & Padwa, L. (nd). Modified Fennema-Sherman attitude scales. Retrieved July 1, 2018 from http://www.woodrow.org/teachers/math/gender/08scale.html

Driscoll, M. (2007). Blended learning: Let's get beyond the hype. Retrieved from https://www-07.ibm.com/services/pdf/blended_learning.pdf

Dziuban, C., Graham, C. R., Moskal, P. D., Norberg, A., & Sicilia, N. (2018). Blended learning: The new normal and emerging technologies. *International Journal of Educational Technology in Higher Education, 15,* 1-16.

Elçi, A. (2017). Students' attitudes towards mathematics and the impacts of mathematics teachers' approaches on it. *Acta Didactica Napocensia, 10*(2), 99-108.

Ertmer, P. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development, 47*(4), 47–61.

Ertmer, P. A., & Newby, T. J. (2013). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly, 26*(2), 43-71.

Fennema, E., & Sherman, J. (1976). Fennema-Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for Research in Mathematics Education, 7*(5), 324-326.

Foote, M. Q., & Bartell, T. G. (2011). Pathways to equity in mathematics education: How life experiences impact researcher positionality. *Educational Studies in Mathematics 78*(1), 45-68

Foster, J., Rzhetsky, A. & Evans, J. (2015). Tradition and innovation in scientists' research strategies. *American Sociological Review, 80*(5), 875-908.

Galia, M. (2016). Constructivist-based approach in teaching mathematics: A quasi experimental study. *Research Journal of Educational Sciences, 4(*10), 1-4.

Greene, M. J. (2014). On the inside looking in: Methodological insights and challenges in conducting qualitative insider research. *The Qualitative Report, 19*(29), 1-13

Harasim, L. (2012). *Learning theory and online technology*. New York: Routledge Press.

Hoffman, B. (2010). "I think I can, but I'm afraid to try": The role of self-efficacy beliefs and mathematics anxiety in mathematics problem solving efficiency. *Learning and Individual Differences*, 20, 276-283.

Hoover, A. L. (2008). Educational learning theories: Informing the fundamentals of instruction. *International Journal of Applied Aviation Studies*, *8*(2), 363-370.

Ichinose, C., & Bonsangue, M. (2016). Mathematics self-related beliefs and online learning. *Learning Assistance Review (TLAR)*, *21*(1), 55-70.

Karam, R., Pane, J., Griffin, B., Robyn, A., Phillips, A., & Daugherty, L. (2017). Examining the implementation of technology-based blended algebra I curriculum at scale. *Educational Technology Research & Development, 65*(2), 399-425.

Kingir, S., Tas, Y., Gok, G., & Vural, S. (2013). Relationships among constructivist learning environment perceptions, motivational beliefs, self-regulation and science achievement. *Research in Science & Technological Education, 31*(3), 205-226.

Korstiens, I., & Moser, A. (2018). Series: Practical guidance to qualitative research. Part 4: Trustworthiness and publishing, *European Journal of General Practice*, *24*(1), 120-124.

Lim, S. & Chapman, E. (2013). An investigation of the Fennema-Sherman mathematics anxiety subscale. *Measurement and Evaluation in Counseling and Development, 46*(1), 26-37.

Lin, Y., Tseng, C., & Chiang, P. (2017). The effect of blended learning in mathematics course. *EURASIA Journal of Mathematics, Science & Technology Education, 13*(3), 741-770.

Mayes, T. & de Freitas, S. (2004) Review of e-learning theories, frameworks and models. Retrieved from http://www.jisc.ac.uk/whatwedo/programmes/elearningpedagogy/outcomes.aspx

Mayes, T. & de Freitas, S. (2007) Learning and e-learning: The role of theory. In H. Beetham & R. Sharpe (Eds.), *Rethinking pedagogy for a digital age: Designing and delivering e-learning* (pp.13-25). New York, NY: Routledge.

McNiff, J. & Whitehead, J. (2010). *You and Your Action Research Project.* New York, NY: Routledge.

Mergel, B. (1998). Instructional design & learning theory. Retrieved from https://etad.usask.ca/802papers/mergel/brenda.htm

Mertler, C. A. (2017). *Action Research: Improving Schools and Empowering Educators.* Los Angeles, CA: Sage.

Mills, G. (2014). *Action Research: A Guide for the Teacher Researcher.* Upper Saddle River, NJ: Pearson.

Mumcu, H. Y., & Aktas, M. C. (2015). Multi-program high school students' attitudes and self- efficacy perceptions toward mathematics. *Eurasian Journal of Educational Research,* (59), 207. doi:10.14689/ejer.2015.59.12

Murray, E. (2015). Improving teaching through collaborative reflective teaching cycles. *Investigations in Mathematics Learning, 7*(3), 23-29.

O'Connor, C., Mortimer, D., & Bond, S. (2011). Blended learning: Issues, Benefits and Challenges. *International Journal of Employment Studies, 19*(2), 62-82.

Ortlipp, M. (2008). Keeping and using reflective journals in the qualitative research process. *The Qualitative Report*, *13*(4), 695-705.

Pajares, F., & Miller, M. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology*, *86*(2), 193-203.

Palinkas, L., Horwitz, S., Green, C., Wisdom, J., Duan, N. & Hoagwood, K. (2013). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and Policy in Mental Health and Mental Health Services Research, 42*(5), 533-544.

Peterson, L., & Scharber, C. (2017). Lessons from a one-to-one laptop pilot. *Computers in the Schools*, *34*(1/2), 60-72. doi:10.1080/07380569.2017.1296328

Philippi, J., & Lauderdale, J. (2018). A guide to field notes for qualitative research: Context and conversation. *Qualitative Health Research 28*(3) 381–388.

Physics Catalyst (2019). Meaning of learning in education with its concept and definition. Retrieved from https://physicscatalyst.com/graduation/meaning-of-learning

Picciano, A. G. (2017). Theories and frameworks for online education: Seeking an integrated model. *Online Learning, 21*(3), 166-190.

PowerSchool [Computer software]. (2018). Retrieved from www.powerschool.com

Robinson, K. (2016). The effect of technology integration on high school students' literacy achievement. *Teaching English With Technology*, *16*(3), 3-16.

Sachs, J. & Leung, S. (2007). Shortened versions of Fennema-Sherman Mathematics Attitude Scales employing trace information. *Psychologia, 50*, 224-235.

Saldaña, J. (2009). *The coding manual for qualitative researchers*. Los Angeles: SAGE Publications.

Samuelsson, J. & Granstrom, K. (2007). Important prerequisites for students' mathematical achievement. *Journal of Theory and Practice in Education, 3*(3), 150-170.

Sandelowski, M. (2000). Combing qualitative and quantitative sampling, data collection, and analysis techniques in mixed methods studies. *Research in Nursing and Health, 23*(3), 246-255.

Smith, J., & Suzuki, S. (2015). Embedded blended learning within an Algebra classroom: A multimedia capture experiment. *Journal of Computer Assisted Learning, 31*(2), 133-147.

Suri, H. (2011). Purposeful sampling in qualitative research synthesis. *Qualitative Research Journal 11*(2), 63-75.

Tannebaum, R., Hall, A., & Deaton, C. (2013). The development of reflective practice in American Education. *American Educational History Journal*, *40*(1/2), 241-259.

Tenenbaum, G., Naidu, S., Jegede, O., & Austin, J. (2001). Constructivist pedagogy in conventional on campus and distance learning practice: An exploratory investigation. *Learning and Instruction, 11*, 87–111.

Thomas, D. (2006). A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation, 27*(2), 237- 246.

Torrisi-Steele, G. (2010). Blended learning primer. Retrieved from https://www.researchgate.net/publication/286597284_Blended_learning_primer

Ultanir, E. (2012). An epistemological glance at the constructivist approach; Constructivist learning in Dewey, Piaget, and Montessori. *International Journal of Instruction, 5*(2), 195-212.

U.S. Department of Education. (2010). Evaluation of evidence-based practices in online learning: A meta-analysis and review of online learning studies. Washington, DC: Office of Planning, Evaluation, and Policy Development.

Williams, T., & Williams, K. (2010). Self-efficacy and performance in mathematics: Reciprocal determinism in 33 nations. Journal of Educational Psychology, 102(2): 453–466.

Yáñez-Marquina, L. & Villardón-Gallego, L. (2016). Attitudes towards mathematics at secondary level: Development and structural validation of the Scale for Assessing Attitudes towards Mathematics in Secondary Education. *Electronic Journal of Research in Educational Psychology, 14*(3), 557-581.

Yapici, I., & Akbayin, H. (2012). High school students' views on blended learning. *Turkish Online Journal of Distance Education, 13*(4), 125-139.

Yasar, M. (2016). High school students' attitudes towards mathematics. *Eurasia Journal of Mathematics Science and Technology Education, 12*(4), 931-945.

Yilmaz, K. (2011). The cognitive perspective on learning: Its theoretical underpinnings and implications for classroom practices. *The Clearing House, 84*(5), 204-212.

Yudt, K., & Columba, L. (2017). The effects of blended learning in pre-service elementary mathematics teachers' performance and attitude. *National Teacher Education Journal, 10*(1), 17-25.

Yushau, B. (2006). The effects of blended e-learning on mathematics and computer attitudes in precalculus algebra. *The Montana Mathematics Enthusiast, 3*(2), 176-183.

APPENDIX A

MODIFED FENNEMA-SHERMAN MATHEMATICS ATTITUDE SCALE

Please rate how strongly you agree or disagree with the following statements about mathematics. Circle the letter that corresponds to the appropriate rating, which range from strongly agree (A) to strongly disagrees (E). If you strongly agree, with a statement, circle A. If you agree, but not so strongly, or you only "sort of" agree, circle B. If you disagree with the sentence very much, circle E for strongly disagree. If you disagree, but not so strongly, circle D. If you are not sure about a statement or you can't answer it, circle C.

1. I am sure that I can learn math. A B C D E

2. My teachers have been interested in my progress in math. A B C D E

3. Knowing mathematics will help me earn a living. A B C D E

4. I don't think I could do advanced math. A B C D E

5. Math will not be important to me in my life's work. A B C D E

6. Males are not naturally better than females in math. A B C D E

7. Getting a teacher to take me seriously in math is a problem. A B C D E

8. Math is hard for me. A B C D E

9. It's hard to believe a female could be a genius in mathematics. A B C D E

10. I'll need mathematics for my future work. A B C D E

11. When a woman has to solve a math problem, she should ask a man for help. A B C D E

12. I am sure of myself when I do math. A B C D E

13. I don't expect to use much math when I get out of school. A B C D E

14. I would talk to my math teachers about a career that uses math. A B C D E

15. Women can do just as well as men in math. A B C D E

16. It's hard to get math teachers to respect me. A B C D E

17. Math is a worthwhile, necessary subject. A B C D E

18. I would have more faith in the answer for a math problem solved by a man than a woman. A B C D E

19. I'm not the type to do well in math. A B C D E

20. My teachers have encouraged me to study more math. A B C D E

21. Taking math is a waste of time. A B C D E

22. I have a hard time getting teachers to talk seriously with me about math. A B C D E

23. Math has been my worst subject. A B C D E

24. Women who enjoy studying math are a little strange. A B C D E

25. I think I could handle more difficult math. A B C D E

26. My teachers think advanced math will be a waste of time for me. A B C D E

27. I will use mathematics in many ways as an adult. A B C D E

28. Females are as good as males in geometry. A B C D E

29. I see mathematics as something I won't use very often when I get out of high school. A B C D E

30. I feel that math teachers ignore me when I try to talk about something serious. A B C D E

31. Women certainly are smart enough to do well in math. A B C D E

32. Most subjects I can handle OK, but I just can't do a good job with math. A B C D E

33. I can get good grades in math. A B C D E

34. I'll need a good understanding of math for my future work. A B C D E

35. My teachers want me to take all the math I can. A B C D E

36. I would expect a woman mathematician to be a forceful type of person. A B C D E

37. I know I can do well in math. A B C D E

38. Studying math is just as good for women as for men. A B C D E

39. Doing well in math is not important for my future. A B C D E

40. My teachers would not take me seriously if I told them I was interested in a career in science and mathematics. A B C D E

41. I am sure I could do advanced work in math. A B C D E

42. Math is not important for my life. A B C D E

43. I'm no good in math. A B C D E

44. I study math because I know how useful it is. A B C D E

45. Math teachers have made me feel I have the ability to go on in mathematics. A B C D E

46. I would trust a female just as much as I would trust a male to solve important math problems. A B C D E

47. My teachers think I'm the kind of person who could do well in math. A B C D E

APPENDIX B

PERCEPTIONS OF BLENDED LEARNING SURVEY

Grade level ___________

Gender ___________

Age __________

Please rate how strongly you agree or disagree with the following statements about blended learning. Place an X in the box to indicate your response.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Compared to traditional, face-to-face instruction, blended learning helps me better understand mathematics.					
Blended learning enables me to become more involved in the learning process.					
With blended learning I can control how fast or slow I move through lessons.					
I am satisfied with my interactions with my teacher during blended learning,					
I am satisfied with my interactions with my classmates during blended learning.					
Compared to traditional, face-to-face instruction, blended learning is a more effective instructional strategy.					

I would recommend that other students take blended learning course.					
Blended learning is an effective way to learn mathematics.					
Compared to traditional, face-to-face instruction, generally, I am more engaged during blended learning.					
Given a choice, I would take another blended learning course.					
In general, I am satisfied with blended learning instructional strategy.					

Rank the following instructional strategies 1 thru 3, according to your individual preferences.

_____ Traditional, face-to-face instruction

_____ Online instruction

_____ Blended learning

APPENDIX C

BLENDED LEARNING INDIVIDUAL INTERVIEW QUESTIONS

1) What do you like most about blended courses?

2) What do you like least about blended courses?

3) How did the online component of blended learning contribute to your understanding of course content?

4) How did the face-to-face component of blended learning contribute to your understanding of course content?

5) How does blended learning compare to traditional, face-to-face instruction?

6) What advice would you give to a student new to blended courses?