

THE EFFECT OF EXPERIENTIAL LEARNING ON MATHEMATICS ACHIEVEMENT  
AND MATHEMATICS ANXIETY OF AFRICAN-AMERICAN STUDENTS

by

Andrew Hanson Wynn

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University

2018

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## ABSTRACT

This study examined whether or not there were any significant differences between the anxiety and achievement levels of African-American students enrolled in College Algebra courses taught using traditional instruction methods and those taught using experiential learning, as used in The Algebra Project curriculum. The classes were taught for the same amount of time for one semester, using the two curricular methods, and student anxiety was measured prior to the course and immediately following the implementation of an experiential learning module. Additionally, student achievement on selected questions focusing on the functions unit from the midterm exam were collected and analyzed to determine any differences in achievement based upon gender and teaching method. This quantitative study utilized a quasi-experimental nonequivalent control-group design. A sample of 102 African-American students, 41 males and 61 females, from a medium-sized university in central Virginia was used, with 30 students in the experiential learning group and 72 in the traditional instruction group. Student anxiety was measured using the Fennema-Sherman Mathematics Anxiety Scale-Revised. A preliminary analysis of covariance was conducted to investigate differences in the anxiety levels of the experiential learning and traditional instruction groups. Student achievement was measured using scores on selected questions focusing on the functions unit from the common midterm exam and was analyzed using an independent samples t-test and a two-way analysis of variance. The results showed that there was no significant difference in anxiety between the experiential learning and traditional instruction groups at the  $p < .05$  level. Additionally, there was no significant difference in the achievement levels between the experiential learning and traditional instruction groups at the  $p < .05$  level.

*Keywords:* Mathematics anxiety, experiential learning, The Algebra Project, traditional instruction methods, College Algebra

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### **Dedication**

This study is dedicated to my wife, children, parents, sister, and the rest of my family. I am beyond thankful for the support that you all have given me in this long journey. Through all of the obstacles I have faced, the periods of frustration and stagnation, you all were there to help me grin and bear it. I am a direct result of the grace of God, and the support of a terrific family. I am sure that you all are proud of me, but you should also be proud of yourselves for encouraging me.

## Acknowledgements

I must first begin by thanking God, who has given me strength to endure this process, Jesus Christ, my savior, who redeemed me, and the Holy Spirit, who has given me wisdom by which I am able to progress. During this program, I have experienced highs and lows, including brain surgery, the birth of my son, new jobs, and the transition of loved ones into eternal life. However, I never walked alone because of the love that God has for me. To my dissertation chair Dr. Kuhne, and my committee members, thank you for taking me on as a student, and for the insight you provided day by day.

Next, I thank my gorgeous wife Dr. Crystal Wynn for sticking to the plan that we set forth, for following my lead, even when I moved slowly. To Angel and Anderson, you two are certainly gifts from God. To my parents, Robert and Brenda, and my sister Sonja, you all set the bar of achievement high, and instilled a desire to learn that will never escape me, and you have been greater supports than I could have imagined. To my grandmother, Minnie, thank you for the visits and for always being excited for my trips to Lynchburg. To Aunt Shelia, Aunt Ann, Uncle Bill, and all the rest of my family, thank you for the joyful times that allowed me a chance to breathe, laugh, and recover.

Next, to my Virginia State University – Math and Economics Department family, thank you. To Dr. Fritz, Dr. Adeyemi, Dr. Burton, Ms. Poarch-Wall, Dr. Agrawal, Mr. Lane, Dr. Eseonu, and everyone who checked in on my progress, a sincere thank you for all of the support and assistance. To my students, thank you for always asking, “Are you done yet?” Last, but not least, to Dr. Jesse and Dr. Gail Ruffin and the members of Prosperity Christian Center, thank you for your encouragement and for teaching me to hear the voice of the Holy Spirit leading and directing me.

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### **List of Abbreviations**

Analysis of Covariance (ANCOVA)

Analysis of Variance (ANOVA)

Fennema-Sherman Mathematics Anxiety Scale-Revised (FSMAS-R)

Grades of D, F, or Withdrawing (DFW rate)

National Assessment of Educational Progress (NAEP)

National Center for Educational Statistics (NCES)

National Council of Teachers of Mathematics (NCTM)

No Child Left Behind (NCLB)

Problem Solving Inventory (PSI)

Race to the Top (RTTT)

Science, Technology, Engineering, and Mathematics (STEM)

## **CHAPTER ONE: INTRODUCTION**

### **Overview**

Mathematics reform is not a new topic. For many years, mathematics reform on all levels has been a challenge, as researchers have sought to identify differences in achievement and comfort with mathematics based upon factors such as gender, ethnicity and race, and geographical location. This study sought to further this field of knowledge by providing insight into the differences that may exist between African-American students taught College Algebra courses using traditional methods versus those taught using experiential learning. This chapter will provide background information about math reform, the purpose of this study, the significance of this study, and the research questions around which this study revolved.

### **Background**

College students are failing their math classes from the earliest stages, especially College Algebra, becoming engrossed in debt, and leaving science, technology, engineering, and mathematics (STEM) jobs unfulfilled. Gordon (2008) acknowledged that close to 50% of students are unsuccessful in College Algebra courses. According to a report by the National Center for Educational Statistics (NCES, 2013), from 1992 to 2009, the average college student's debt rose from \$15,400 to \$24,700 and was expected to continue to rise. The Bureau of Labor Statistics (2015) published a report describing how, over the last decade, many STEM jobs have gone unfilled due to a lack of skilled workers to meet the demands of the labor market. In short, if students continue to fail their math classes, they increase their debt, do not graduate, and are unable to fulfill the many STEM jobs that await them in today's job market.

Data has shown that mathematics performance in the United States has been a concern for many years. Ever since the first national achievement tests were given during the 1960s,

students underperforming in mathematics became a national concern (Mayfield & Glenn, 2008). Students are not meeting the benchmarks for success in their math classes and are unprepared for future math courses which serve as the gateway into STEM careers. According to Gordon (2013), the majority of college educators believe that many freshmen are unprepared for college level mathematics because of a lack of manipulative abilities. This issue of poor performance and lack of preparation, while prevalent throughout the country, impacts minority students, especially African-Americans and women, at a higher rate than their Caucasian and male counterparts. Greene, Marti, and McClenney (2008) suggested that African-American and Hispanic students are outperformed by their counterparts in not just grades, but also in terms of success in reaching goals and persisting in programs. Hence, it is essential that researchers identify the mitigating factors that impact students' abilities to be successful in college level math courses.

There are many dynamics that factor into the lagging mathematics performance of minority students. The circumstances surrounding minority students' enrollment in college may vary dramatically from those of other students. Greene et al. (2008) suggested that minority students are often the first students from their families to attend college, are more likely to begin college academically under-prepared and in need of financial assistance and are more likely to juggle full-time work and family responsibilities with their studies. Additionally, literature suggests that anxiety is one of the key issues that precedes poor math performance and that African-American students, especially females, are often anxious about mathematics (Goetz, Bieg, Ludtke, Pekrun, & Hall, 2013). Mathematics anxiety is defined as "students' feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics" (Fennema & Sherman, 1976, p. 326).

It is suggested that teachers often cause their students to develop math anxiety because the teachers themselves are anxious about their mathematical abilities (Finlayson, 2014). The anxiety that the teachers exhibit, often leads to low expectations for math students, which then leads to students being unsuccessful in their courses. Minority students are often the recipients of such low expectations. Walker (2007) pointed out that consistently, teachers hold lowered expectations for ethnic minorities and inner-city students. Therefore, in order to combat the pervasiveness of math anxiety among students, teachers need to be aware of their students' math anxiety, and the structure of the math courses in which students enroll, must be altered to better benefit the students and to increase expectations for their students. Yet, not enough information is available on techniques that adequately address math anxiety, and more research needs to be conducted into the sphere of reducing math anxiety. For several decades, researchers have shown concern regarding the high levels of math anxiety exhibited by students, and even as far back as the 1970s math anxiety has been a central issue in math education. In fact, Betz (1978) echoed this sentiment stating that based on the pervasiveness and impact of math anxiety, more thought needed to be devoted to strategies for treating math anxiety.

Adequate detection of math anxiety is essential to student success and future outcomes. Núñez-Peña, Guilera, and Suárez-Pellicioni (2014) proposed that recognizing students who exhibit math anxiety in class is critical for educators, so that the educators will have the opportunity to adjust their teaching styles and methods used of assessing students in order to aid students in overcoming their difficulties with mathematics. Teachers need to be aware of the anxiety levels of their students, but also must be equipped with pedagogy that will allow them to have a positive impact on the students' anxiety levels. Often, students who have math anxiety demonstrate lower mathematics achievement and are placed into remedial courses, as remedial



courses are often deemed necessary to augment the lack of skills that students have when entering college. However, remedial courses often do not provide the additional grounding that students need and do little to reduce math anxiety. Benken, Ramirez, Li, and Wetendorf (2015) insisted that while remediation and developmental courses are designed to assist students in becoming better prepared, remedial courses tend to have a negative impact upon students preventing them from progressing academically. Boylan and Nolting (2011) highlighted that remedial courses often have high failure rates, and typically, if students have to repeat the course, they tend to still receive the same type of instruction that originally led to their failure in the first place. Remedial courses are often taught using traditional instruction methods, in which students come to class, listen to an instructor talk about a subject for three hours per week, and then go out to try to complete homework and tests; but, Peters (2012) suggested that especially in teacher-centered classrooms, which often employ traditional instruction methods, minority students score much lower in achievement than their non-minority counterparts. Since remedial and traditional instruction courses are not solving the problem of students stagnating in math classes and college in general, better methods for teaching mathematics may be instituted that will produce greater positive impacts. One such method is The Algebra Project which is based on experiential learning theory.

The Association for Experiential Learning (2015) defines experiential learning as a “philosophy and methodology in which educators purposefully engage with students in direct experience and focused reflection in order to increase knowledge, develop skills, and clarify values” (p. 1). The experiential learning theory is rooted in constructivism and social psychology and was developed by influential figures such as Dewey and Piaget. However, Kolb more recently developed a learning cycle in which students begin with an experience, make

observations, and construct abstract concepts using their observations (Passarelli & Kolb, 2011). This cycle has been widely implemented in education from the elementary to the collegiate levels and shows promise for impacting the mathematics abilities of students. Kolb (2015) suggests that experiential learning methods have become the preferred method for personal development and learning with many students, especially those who are nontraditional students—minorities, the poor, or mature adults. Accordingly, mathematics interventions have been developed that incorporate this experiential learning cycle, and which may prove beneficial in providing a richer and deeper math experience for minority students, and The Algebra Project is one such intervention.

The Algebra Project was founded by civil rights activist Dr. Bob Moses in 1982. Moses was displeased with the math education that his children were receiving, and desired to see equality in both areas of civil rights and mathematics; thus, he formed the idea that mathematics education is a civil right (Silva, Moses, Rivers, & Johnson, 1990). These ideas were then developed into a curriculum to foster change in the urban mathematics classroom. The curriculum starts with the idea that math is a language that needs to be learned, as it provides access to a world of information (Moses & Cobb, 2002). The students begin with a concrete experience within their community. The students then make observations about their experience. Next, students reflect on their experience and observations in order to reach an abstract conceptualization that will be necessary for standardized tests. This cycle causes students to reflect and to incorporate cognition into their daily lives, synthesizing and analyzing what they experience (Checkley, 2001). By restructuring the development of mathematical concepts, students may become more actively engaged in the material beyond that of a traditional classroom, which may relieve stress levels of trying to make sense of completely abstract

concepts, and thereby may improve students' anxiety levels towards mathematics, increase their performance in math courses giving them access to higher-level mathematics, and allow them to accept STEM careers which are highly desirable and necessary in this technological age.

### **Problem Statement**

High math anxiety and low achievement levels have been prevalent throughout all school levels, especially in college level mathematics courses such as algebra, causing students to fail their math classes and to avoid math related fields of study. Students in College Algebra have shown a great deal of anxiety, and College Algebra has traditionally been a great barrier for students. Brown (2012) highlighted that there is a high incidence of students failing or withdrawing from College Algebra across the United States, which has caused educators to consistently research methods for improving student learning in College Algebra. While this issue affects all students, minority students often demonstrate higher levels of anxiety than their peers, and their performance reflects the influence that anxiety has on a wider scale, as there are more failing grades among minority populations. Additionally, Stewart et al. (2017) highlighted that although there is relatively little difference in the mathematics achievement of males and females at the elementary and middle school levels, beginning in high school and extending throughout college, males regularly outperform females on mathematics achievement measures.

While researchers agree that math anxiety is a critical issue, there is little consensus on the best methods for resolving math anxiety and for increasing success for African-American students regardless of gender. Jett (2013) acknowledged that there is a shortage of literature regarding success for the African-American student, and that study is necessary to fill a gap in the existing literature, especially with regard to offering a deeper understanding of success in college mathematics. The Algebra Project seeks to accurately address the issues of African-

American students' low performance and poor attitudes toward mathematics regardless of gender, but as Reimer (2011) highlighted there has been limited accessibility to student data; hence, continued study of The Algebra Project's full effect for students is needful. Thus, the problem is that there is little literature available regarding how experiential learning theory (The Algebra Project) impacts the mathematics anxiety levels and achievement levels of African-American students in College Algebra classes, and what differences exist in the anxiety levels of African-American males and African-American females in College Algebra classes.

### **Purpose Statement**

The purpose of this quantitative, quasi-experimental nonequivalent control-group design study was to examine the impact of the experiential learning theory, as implemented by The Algebra Project, on the mathematics anxiety and achievement levels of African-American students in College Algebra courses. Data was collected from African-American male and African-American female students who were enrolled in College Algebra courses at a medium-sized university in central Virginia. The independent variable was the type of method used to teach algebra. Students were taught the College Algebra curriculum either using traditional instruction methods, which required students to attend lectures given by a mathematics instructor for three hours per week or were taught using experiential learning (The Algebra Project) curriculum, in which students made observations regarding shared experiences and then developed abstract math concepts. The first dependent variable was the students' anxiety levels, which were feelings of dread, nervousness, and associated bodily symptoms related to doing mathematics which was gathered immediately following the administration of the midterm exam during the course. The covariate was the students' pre-existing anxiety levels which were gathered prior to the course. The second dependent variable was the students' achievement

levels as determined by their grades on selected questions regarding functions from a common midterm examination.

### **Significance of the Study**

Many studies to date have either examined the impact of technology interventions on College Algebra students or the effect of experiential learning curriculums for grade school mathematics, but little has been done involving the impact of experiential learning on the anxiety and achievement levels of African-American students in college level mathematics. Benken et al. (2015) investigated the impact of math interventions on the achievement levels of students in developmental mathematics courses and concluded that further investigation needs to be conducted to determine how students' experiences in developmental mathematics courses are augmenting their math content knowledge, abilities, and improving their feelings towards mathematics. Benken et al. (2015) suggested that students can be impacted in positive ways by meaningful interventions; however, they highlight that future research should address the impact that intervention has on students' attitudes which is directly related to anxiety levels in math courses.

Secondarily, examinations into the causes behind the lack of African-American students in STEM related fields of study have been conducted that emphasize the need to use theoretical viewpoints to direct African-American students' learning processes. Riegle-Crumb, Moore, and Ramos-Wada (2010) identified that African-American males have the desire to pursue STEM careers at rates greater than or equal to that of their Caucasian male counterparts, but the African-American males' achievement levels are still lagging behind those of Caucasian males. Since traditional methods have been leaving students with a shallow understanding and a heightened fear of future mathematics, theory should be used in developing and implementing

interventions to reduce the stress that revolves around completing mathematics at the college level. Jett (2013) stated, “African-American men in mathematics should employ theoretical perspectives...to bring issues of race and/or racism to the forefront given that race seems to be a recurring impediment to those seeking to pursue STEM degrees and careers” (p. 203). This study addressed the usage of experiential learning theory, as utilized in The Algebra Project curriculum, in reducing the anxiety levels and increasing the achievement levels of African-American students in a course in College Algebra.

Finally, there was a wealth of information available regarding the history of The Algebra Project, the pedagogical theory that is central to the curriculum, and the impact of the curriculum on elementary and secondary school students. However, there was a definite need to understand how this intervention, with its experiential learning theory, is pertinent for the African-American college math student. The Algebra Project was designed to allow minority students, of any gender, to have fair access to deeper levels of mathematical understanding and math literacy, and through use of experiential and theory-based pedagogy, The Algebra Project seeks to stimulate African-American students into demanding math literacy for themselves (Green, 2013). However, Reimer (2011) advocated that future studies should address how math interventions can prove to be essential in closing the achievement gap when he highlighted that although his study did not produce the desired results, the study accurately provided a portrait of the necessity for researchers and educators to work together in order to implement effective programs and instructional practices for all students. This study addressed one of the key factors that has led to the achievement gap between minority students and their counterparts by assessing whether African-American students’ anxiety was reduced through experiential learning strategies (Algebra Project), and therefore, significantly added to the arena of knowledge regarding how to

effectively alleviate math anxiety, which in turn will have caused students to perform better in mathematics, and will have caused them to seek STEM majors and careers more often.

### **Research Questions**

The research questions for this study were:

**RQ1:** Is there a difference in the mathematics anxiety scores between African-American students being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra while controlling for pre-test math anxiety?

**RQ2:** Is there a difference in the mathematics achievement between African-American students being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra?

**RQ3:** Is there a difference in the mathematics achievement of African-American male students and African-American female being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra?

### **Null Hypotheses**

The null hypotheses for this study were:

**H<sub>0</sub>1:** There is no significant difference in the mathematics anxiety scores between African-American students being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra while controlling for pre-test math anxiety.

**H<sub>0</sub>2:** There is no significant difference in the mathematics achievement between African-American students being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra.

**H<sub>0</sub>3:** There is no significant difference in the mathematics achievement of African-American male students and African-American female students being taught through experiential learning pedagogy (The Algebra Project) in college algebra and those being taught through traditional instruction in College Algebra.

### **Definitions**

1. *Mathematics Anxiety* – Mathematics anxiety was defined as “students’ feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics” (Fennema & Sherman, 1976, p. 326).
2. *Traditional Instruction Methods* – Teaching mathematics using a lecture-based approach, where students met for three hours of lectures each week, and the instructors assigned online or on-paper homework (Brown, 2012).
3. *Experiential Learning* – Students engaged in shared direct experience and focused reflection in order to increase knowledge, develop skills, and clarify values, by following Kolb’s experiential learning cycle (Checkley, 2001).
4. *Mathematics Achievement* – Students’ scores on selected questions regarding functions from a common, midterm exam within the College Algebra course.
5. *Function* – A rule that assigns to each element  $x$  in a set  $A$  exactly one element, called  $f(x)$  in a set  $B$  (Stewart, 2007).



## **CHAPTER TWO: LITERATURE REVIEW**

### **Overview**

The purpose of this literature review will be to provide insight into the current body of knowledge regarding algebra reform, experiential learning as a framework for reform, the necessity of reform methods on the college level, and the history of The Algebra Project. The information contained in this section provides a basis for the necessity of researching current reform trends, and seeks to highlight an existing gap in the literature regarding the utility of experiential learning as a pedagogical method that is beneficial for previously marginalized groups of students. As this review outlined a gap in the literature regarding math anxiety and achievement for African-American students, the theoretical framework was centered upon Dewey's experiential learning cycle. This chapter provides a basis for experiential learning as the central framework for the study, a history of mathematics reform efforts, efforts to identify ways to mitigate math anxiety, and an introduction to The Algebra Project's history and pedagogy. Finally, the chapter provides a summary of the importance of research that improves the educational landscape for math learners, especially at the level of College Algebra.

### **Introduction**

Mathematics has developed into a critical educational component throughout the United States and around the world, that is relevant to developing a futures-oriented curriculum; however, mathematics also has implications for economic and social stability. Many of the fastest growing and most lucrative career fields in the nation, such as engineering and information technology, are rooted in mathematics. Data shows that in the United States, the highest paying occupational groups were management, legal, and computer and mathematical occupations (Bureau of Labor Statistics, 2015). Yet, many of the aforementioned jobs go

unstaffed due to an ill-prepared workforce. When students enter the workforce, many are unable to perform the mathematics necessary to be successful in these technology related fields, due in part to a lack of ability or confidence in their ability. Overall, only 26% of 12th-grade students in 2013 scored at or above the Proficient level on the math portion of the National Assessment of Educational Progress (NCES, 2013). Additionally, McMullan, Jones, and Lea (2012) reported that among first-year British nursing students, there was as much as a 45% prevalence of math anxiety, which inhibits students from being able to perform the calculations necessary to properly compute medication dosage. Political leaders have taken notice of this critical situation and have enacted legislation such as the No Child Left Behind (NCLB) Act and the Race to the Top (RTTT) initiative to try to combat the issue of students not being STEM ready and have brought math and science education to the forefront of public school policy.

Math anxiety seemingly has had far reaching effects, impacting a diverse population of students who are involved in critical areas of life in the health care, science, and engineering fields. Ashcraft (2002) suggested that one of the most critical and often noted consequences stemming from math anxiety is the tendency to avoid mathematics courses. He highlighted that individuals who exhibited high levels of math anxiety took fewer elective mathematics courses in high school and college, and if they did elect to enroll in math courses, their performance suffered, and they received lower grades than students who had low math anxiety (Ashcraft, 2002). Students are not adequately equipped to perform mathematics at the essential levels; subsequently, the issues of math anxiety and poor math ability and attitudes must be addressed with a sense of urgency.

It is a common occurrence in today's math classrooms to encounter students with high levels of mathematics anxiety. From the elementary grades through college, and even into

adulthood, students often have trouble with mathematics and are anxious about even attempting to learn math. Maloney and Beilock (2012) highlighted that students as early as the first grade report that they have some form of math anxiety which is detrimental to their math achievement, but also leads to negative emotions towards math and in general. It quickly becomes evident that students who develop math anxiety tend to demonstrate negative attitudes towards mathematics. Akin and Kurbanoglu (2011) stated that math anxiety has far reaching consequences, leading to poor self-esteem and low academic achievement. Literature suggests that this anxiety can partly be attributed to the fact that students are often uncomfortable with the mathematics material that they study because they are unable to connect it with their daily lives. Jain and Dowson (2009) implied that math anxiety arises when students lack confidence in working in math related situations but is related to students having been subject to improper mathematics teaching methods.

Math anxiety has far reaching implications, but it also impacts certain groups of students to a greater extent. As students approach the upper levels of mathematics, even during grade school, females report greater math anxiety over a long-term basis than their male counterparts, although they do not necessarily report greater momentary anxiety (Goetz et al., 2013). Hence, it is beneficial to all groups to address mathematics anxiety in the classroom, but addressing math anxiety may be essential to the long-term representation of certain groups in STEM careers, requiring that initiatives to reduce math anxiety receive greater priority in schools.

While much has been concluded regarding the mitigating factors of math anxiety and the effects of math anxiety in other areas such as student achievement, literature has not provided a definitive answer on what pedagogical methods work best to address the problem of mathematics anxiety, at its various levels. Algebra, which studies functions and their properties, is considered

to be one of the first higher-level math courses that students take beyond basic numerical manipulation, and it requires students to understand how to manipulate symbolic representations. This task, however, is a construct that, for many students, is unfamiliar. Nomi and Allensworth (2013) highlighted that even in secondary schools, trying to determine the best way to teach algebra is a daunting task because school districts throughout the country are faced with the need to reduce algebraic failure rates.

Traditional methods of instruction are not equipping students with the skills and abilities necessary to understand the abstract concepts of algebra, and other higher-level mathematics, in a meaningful way so that they are able to make connections to their typical external environments, which may relieve some of the stress associated with mathematics computation and understanding. This is true on all levels of education, but especially in college where students are trained for their future careers. Professors of mathematics courses, including College Algebra and calculus, often employ lectures as the strategy for teaching their classes. However, this form of direct instruction has often left students in a form of disarray. Palincsar (1998) highlighted that one of the major issues regarding why direct instruction seems to be lacking when associated with the mathematics classroom is that direct instruction fails to transfer to higher order cognitive skills among which are reasoning and problem solving. Hence, the theories that drive the mathematics curriculum, along with the methodologies and frameworks used for teaching and instruction in the math classroom must be engaged and reformed effectively in order to improve the educational landscape, by allowing students to make conceptual connections that can improve their performance.

To date, theories that have been provided by many researchers tend to only work for certain students, while leaving masses of other students underprepared, especially minorities and

low-achieving students. Ladson-Billings (1997) realized many years ago that African-American students were being left out by the math curriculum and suggested that research be tailored to finding methods that incorporate a social context for the math curriculum, suggesting that this method best fits this population. Martin (2012) admonished that mathematics education research must be changed because the majority of research over the last 30 years has reflected African-American children and their skills and abilities through a negative lens causing greater harm to that group of students. Mathematics education research, therefore, needs to be expanded in order to provide a framework for educators to incorporate strategies that will benefit all students, and not just a select few. Noble (2011) pointed out that more research that is specifically designed for African-American populations is still developing, and that there is a greater need for results highlighting this subgroup. Finally, Russell (2011) suggested that mathematics research should focus on investigating and applying multicultural education frameworks that capture the essence of each student's culture and the interaction that it plays in student learning to improve outcome. Hence, research that identifies teaching strategies that are beneficial in reducing the math anxiety of African-American students, regardless of gender, and which help to increase their math performance and demonstrate their successes, is of great necessity. This study seeks to augment the existing literature by providing an analysis of whether a particular form of experiential teaching and learning is effective in reducing mathematics anxiety and increasing mathematics achievement among students in College Algebra classes, especially African-American students, which may allow them to access higher levels of mathematics.

### **Theoretical Framework**

An initial review of the literature suggested that students are often uncomfortable with the mathematics material that they study, because they are unable to connect it with their daily

lives. Methods employed within the mathematics classroom, especially at the collegiate level, which seek to involve students' natural surroundings and instincts for learning rather than simply relying on the content to drive student learning, may prove to be beneficial by having a long-term impact. Even early educational researchers believed that grounding educational experiences in students' daily lives was pertinent to improving student comprehension and achievement. Dewey (1938) remarked, "I take it that the fundamental unity of the newer philosophy is found in the idea that there is an intimate and necessary relation between the processes of actual experience and education" (p. 19). Forty years later, Walker (1978) suggested that the most important problem that needed to be addressed in school curricula was the lack of connection between math and everyday life. Historically, many students found math to be an unrelated and disjointed subject area that had no true correlation to what they would encounter throughout their lives. This trend continued throughout the years, and the issue still presents itself today.

Clark, Badertscher, and Napp (2013) proposed the idea that the learning and teaching of mathematics is not a culture-free endeavor. Mathematics needs to be taught in such a way so that students are well aware of the utility of the subject area. Teachers must ensure that students are not merely aware of the content, but rather that students have the knowledge, skills, and abilities that are of necessity for their future place in society, by having learned the content from their environment in the beginning. Often, students will not have a firm basis to make these connections on their own but must be expertly guided in the direction of assessing their surroundings in order to explore and make discoveries of their own through careful and thoughtful observation. Students certainly have a myriad of diverse sources of motivation for learning, but motivation alone may not always assist students in making the fundamental

connections between reflection and cognition. However, there are methods that can aid in meeting the students' needs.

Understanding that there is a need to adjust teaching and learning strategies is not a new concept, as curriculum developers have long known that education needs to be grounded in a broader context rather than simply presenting content. Experiential learning theory, championed by Dewey, along with social inquiry methods have been implemented in many classrooms so that students become fully engulfed in their learning experiences rather than simply taking on the role of spectator. Gergen (1985) highlighted that one of the central ideas incorporated into social constructionist theory is concerned with describing the ways in which people understand and form a perspective of the world. Pavlica, Holman, and Thorpe (1998) suggested that learning should be an ongoing social activity. Accordingly, incorporating theories of learning which engage students socially, even in the mathematics classroom, can have a tremendous effect on students' abilities to make sense of the material presented to them. Smith et al. (2015) highlighted that the National Council of Teachers of Mathematics (NCTM) believes that employing mathematics teaching strategies, which utilize a collaborative group structure, allows students to assume responsibility for their learning while they engage in learning from one another's insights and providing more meaningful reflection. Thus, strategies such as cooperative learning and experiential learning, with roots in social constructivist theory, can have rich rewards for students, especially in the areas of making connections between ideas. Powell and Kalina (2009) pointed out that if students are to gain a richer and more robust understanding, cooperative learning should be incorporated into the learning environment. Hence, interventional techniques that incorporate the critical aspects of experiential learning and social

constructionist theory may impact mathematics teaching so that students are not left to fend for themselves but are piloted expertly into a wealth of knowledge critical for their futures.

Allowing students to experience mathematics in the classroom, rather than just hearing about it from a lecturer and then trying to apply it, allows students the opportunity to move from a concrete experience, to forming a representational structure, finally into constructing an abstract symbolic form, which is critical in algebra and subsequent mathematics courses and will allow access to deeper mathematics which has typically been out of reach for many students, especially minorities. More recently, Kolb (2015) suggested that experiential learning theory is a sound approach to education which is a lifelong process that is firmly established in the constructs of social psychology, philosophy, and cognitive psychology. Kolb went on to form the experiential learning cycle by which a student engages in an experience, makes observations and reflection, then formulates critical abstract concepts through that reflection, which was further developed into an experiential model. Knisley (2001) suggested that Kolb's model of experiential learning is the most applicable learning model when trying to learn mathematics, and highlighted that this model has been effective in enhancing the teaching of engineering concepts in addition to mathematics, which are critical STEM areas. Subsequently, Kolb's adaptation of the experiential learning theory was utilized in this study as the central guiding framework to assess Kolb's experiential learning theory in relation to math anxiety to determine whether there is a true benefit that will lead to lasting impact.

### **Experiential Learning Theory**

Sanchez, Ye, and Zimmerman (2004) suggested that if instructors want to improve students' success in mathematics, they should begin by concentrating their energy on strategies that help change students' attitudes. Causing students to assess their abilities, to observe and



reflect on new content and experiences, and then to develop this knowledge into constructs that allow students to think critically should be one of the central goals of the curriculum. Kolb (2015) identified a theory for building up all students' abilities and reducing anxiety when he stated that experiential learning has become one of the key successful tactics used for educating, especially for minorities and other underserved populations. Experiential learning is an approach to learning that is holistic and integrative in nature that combines experience, perception, cognition, and behavior (Lester, 2007). Experiential learning has its roots in social and cognitive psychology; nevertheless, experiential learning has the ability to influence scientific learning and development as well.

John Dewey is credited as having been one of the most influential developers of the theory, but theorists such as Vygotsky, Piaget, and Rogers each have contributed to the formal development of this mode of teaching and learning in its current state. Dewey (1938) stated his beliefs about experiential learning, suggesting that the core of the philosophy revolves around embracing the connections between actual experience and formal education. Dewey advocated for incorporating the experiences learned on the job or in internships into the curriculum, leading to the idea of what is now termed lifetime learning credit. However, his ideas were key in the development of a process of thought, observation, and reflection known as Kolb's experiential learning cycle. This cycle begins with an experience where observations are made. Russell-Bowie (2013) suggested that this concrete experience is perhaps the most essential stage to Kolb's experiential learning cycle for helping learners increase their confidence and for assisting them in the development of a more positive attitude toward learning content. Once the observations are made, the learner reflects upon what was observed in the experience in order to form a representation that can be further molded into abstract symbolic form. This process not

only allows, but also requires students, to interact within their environments becoming more social in nature than a traditional learning environment that typically employed lecturing techniques.

Seaman and Rheingold (2013) pointed out that experiential learning is always a social accomplishment which is rooted through particular practices and social communities, thus, allowing the learner to make sense of content through a personal lens. The incorporation of more intense social interactions and fellowship facilitates students towards being able to have open discourse which allows them to express their ideas regardless of whether their ideas are reflective of concrete situations or more abstract in nature. Mathematics, especially algebra, requires students to be able to comprehend and manipulate material presented in abstract form, so there is great possibility for improvement by using experiential methods. Hence, interventions organized around the experiential learning theory may show promise for impacting student achievement in mathematics and for enriching their lives in a broader sense by yielding access to the more advanced material necessary for accomplishing goals in a highly technologically advanced society.

### **Social and Economic Issues and Math Achievement Gaps For African-Americans**

African-American students, along with other minority groups, have long been underserved by traditional mathematics curricula, as evidenced by the gaps that exist in the math achievement levels of African-American students when compared to their Caucasian counterparts, and the low representation of African-Americans in STEM careers. According to a study by Else-Quest, Mineo, and Higgins (2013), results from the 2005 National Assessment of Educational Progress (NAEP) mathematics assessment showed that Asian American high school students scored highest, followed closely by Caucasian students, and finally, African-American

and Latino/Latina students scored lowest. While the traditional methods used for teaching mathematics have been ineffective for many students, students included in this ethnic subset appear to have been severely affected. McGee and Spencer (2015) admonished that conditions are often ripe for students of color to fare poorly because of factors such as racialized educational settings which contribute to adverse experiences and outcomes for students of color. With the gaps continuing to grow, many students have developed negative attitudes towards mathematics and tend to opt out of participation in upper-level mathematics. Students begin to believe that they are incapable of performing well in mathematics and thus seek alternative areas to pursue, often in sports and entertainment fields. So not only do minority students start to feel upset when approaching mathematics, but their disposition changes towards the material, and their achievement often suffers. Walker (1978) qualified this sentiment stating that doubtlessly, anxiety and even terror will be present in those students who have a lack of mathematical abilities. It is imperative, therefore, that students become engulfed in meaningful experiences whose sole benefit is not just mathematics content, but that they also understand the greater impact and influence of mathematics in their daily encounters.

The causes of this trend are numerous; however, low expectations and mathematics anxiety are major contributors. Surprisingly, students do not develop this anxiety on their own, it is sometimes learned from their parents or even their teachers. Finlayson (2014) highlighted that some students are adversely affected by their teachers' own anxiety towards mathematics developing a stigma towards the mathematics that they encounter. Walker (1978) believed that peoples' feelings of mathophobia are transferred because of a high level of social acceptability. For the African-American student, this social acceptability of mathematics fear, anxiety, and disdain often extends into the home. Jaret and Reitzes (2009) remarked that many African-

American students are worried about the adequacy of their prior school preparation. Therefore, when these students grow up to become parents of students in math classes, there is a stigma that is preexisting which often becomes acceptability of inadequacy. Weinberg, Basile, and Albright (2011) concluded that students' expectations influence their behavior, yielding a situation wherein, if students believe they will not succeed or are concerned with negative consequences of failure, they are less likely to participate in the activity. If this statement is in fact true, then there will doubtlessly be fewer African-American students seeking out upper-level mathematics classes and will be less successful in the math courses in which they do participate because of the fear of failure.

A secondary issue that has been considered is that African-American students often have not had the same opportunities for learning mathematics as their counterparts because of placement in remedial classes, little access to newer, updated materials, and poorly prepared mathematics teachers. Research has documented that African-American and other marginalized students have been schooled in environments in which there is a lack of funding, little access to highly qualified teachers and upper-level math courses when compared with their middle-class Caucasian counterparts (Jackson & Wilson, 2012). The lack of educational opportunities in mathematics leads to deeper anxiety for African-American students who have, in many cases, subsequently endured little encouragement and constant testing due to federal mandates, which highlights poor math performance all within their classroom environment, which Finlayson (2014) acknowledged as further causes of math anxiety.

Significant attention then, out of necessity, needed to be devoted to improving teaching methods, especially for teaching students who are minorities. Incorporating the cultural aspect that students will inevitably bring to the classroom should also be considered when trying to

improve student achievement, especially for minority students whose culture is often neglected in traditional math texts. Russell (2011) suggested that mathematics education research that seeks to intertwine math achievement reform for minorities with a cultural perspective should be considered as transformative intellectual scholarship, highlighting the critical nature for making connections between life and education. Thus, the educational opportunities presented to African-American students in the field of mathematics should include the cultural association but should also seek to develop students' confidence in their math abilities and when possible, be presented by teachers who are a reflection of the students themselves.

Clark et al. (2013) proposed that there are unique experiences and perspectives which African-American teachers can share with their students and that these teachers could provide a critical component necessary to improve the outcomes of African-American students. If these teachers are able to indeed demonstrate a concern for the growth of their students, then the students' perceptions of themselves as capable and competent doers of mathematics may increase which is essential for their progression in life, not just in the mathematics related fields (Cobb, Gresalfi, & Hodge, 2009). African-American teachers convey to African-American students a sense of purpose for engaging with school mathematics, which may further combat the stigma that African-American students do not like or do well in mathematics (Chazan, Brantlinger, Clark, & Edwards, 2013). Wright (2011) stated that although there is a prevalence of information that highlights minority students as deficient based upon the traditional constructs, there is a tremendous opportunity that lies within the everyday educational landscape to highlight the good aspects of knowledge of African-American students that rivals the usual story regarding STEM education. Research indeed shows, as previously noted, that African-American male students desire to hold careers in STEM areas just as much, if not more than,

their Caucasian male counterparts, but their achievement levels are unable to support the interest that they hold (Riegle-Crumb et al., 2010). There is indeed a chance to emphasize the true nature that exists in African-American students and their abilities to not simply endure mathematics, but to demonstrate a commanding knowledge and expertise that as of yet has not been fulfilled.

### **Gender Differences**

For quite some time, the fields of science, technology, engineering, and mathematics have been stereotyped as Caucasian-male dominated career areas (Riegle-Crumb et al., 2010). This labeling of STEM fields has been allowed to continue because of the gross underrepresentation of females and minorities in STEM areas. There has been progress made in increasing the number of female and minority candidates who seek employment in the STEM fields, but there is still a stark difference in the prevalence of these groups working in the industry when compared to the prevalence of Caucasian male workers. One of the greatest factors which is preventing female workers from entering the STEM field is the gender-achievement gap which has been long-standing in mathematics and science. Although widely accepted as a reality, current research rebuts the idea that the math-gender achievement gap actually exists or that it is as prevalent as it once was (Stewart et al., 2017). Evidence has shown that traditionally, girls were outperformed by boys on standardized tests and that boys indeed sought out careers that relied on math and science as a foundation while girls sought out careers in the service industries or in the social sciences and humanities (Gherasim, Butnaru, & Mairean, 2013). The causes and impacts of this phenomenon have been widely studied, and the results are varied at best.

From elementary school through secondary school, students are directed and driven along a certain path to prepare them for either careers in the workforce, higher education beyond the

secondary level, or military service (Thompson & Allen, 2012). In order to reach the level of preparation necessary to enter these respective fields, students are taught a wide range of material which is deemed to be the standard minimum education that a high school graduate and productive citizen should have. However, during this educational career through which students are guided for the first 17 years of life, there are a variety of factors which impact how the students will perform, adapt, and progress through the course laid out for them. Research has shown that as early as elementary school, gender gaps in mathematics achievement begin to appear and continue to varying levels throughout secondary and post-secondary education (Gherasim et al., 2013).

The differences in math achievement between males and females have been linked to varying differences in perception, support, and environment. The way that individual students process information is a key dynamic in how students learn, and males and females perceive the math classroom differently (Arnup, Murrthy, Roodenburg, & McLean, 2013). A 2013 study by Gherasim et al. highlights several of these differences and alludes to the idea that the perceived difficulty and complexity of learning activities that are associated with the math classroom along with the high probability of failure are highly associated with differences in the math achievement and anxiety levels between boys and girls. Gherasim et al. (2013) revealed that girls who dropped out of math classes shared that they found math classrooms to be unattractive, uncomfortable, and hostile to them, and that teacher and peer support are positively correlated to learning motivation and academic attitudes. Stewart et al. (2017) suggested that this gender gap does not always persist throughout development, however, suggesting that in the early grades, females outperform males, but in some later grades, girls begin to develop a more negative attitude towards mathematics while having similar grades. Arnup et al. (2013) suggested that

males only outperform females on standardized tests, but females outperform males in grades, so there is a chance that the landscape of math achievement is transitioning into a more favorable outcome for females.

There is much support surrounding the idea that the math classroom can be directly impacted in order to have an immediate effect on the achievement and anxiety levels of female students. Educators armed with the understanding that encouragement received and attitude within the classroom help shape girls' performance in mathematics, can adapt their teaching strategies to meet this need for their students (Leaper, Farkas, & Spears Brown, 2012). Gherasim et al. (2013) highlighted that learning in friendly classroom environments enhanced girls' performance in mathematics; hence, being able to foster an environment where students are able to make sense of the material in terms of their own surroundings may be beneficial to all learners, but especially for female students to help encourage them to continue the pursuit of stem education. Stewart et al. (2017) suggested that when girls made errors on math tests, they usually were due in part to using irrelevant rules, misusing spatial information, or choosing wrong operations, while boys' errors were due to formula selection or not seeing a problem out to the end. Arnup et al. (2013) revealed that a large portion of mathematics involves spatial reasoning but that employing an imagery style to the classroom could directly impact a child's ability to effectively handle spatial reasoning. Finally, Bowe, Desjardins, Covington Clarkson, and Lawrenz (2017) produced findings which show that girls benefited from same-sex classrooms and performed similarly to boys on math assessments. Therefore, there is great promise that by adjusting the methods utilized in the mathematics classroom, female students can be given the proper math education that they deserve, enabling them to enjoy their math classes, to be less anxious, and to pursue the careers which so desperately need them.



## College Algebra

Math education research has typically focused directly on performance initiatives, assuming that all students should learn the same material with the same set of skills. Many math educators believe that this assumption is wrong, and in fact, believe that math education needs to be transformed to reflect the reality of the matter that different math skill sets are useful for different careers (Barlow, 2011). Nonetheless, many college course outlines require students to take a foundational course in algebra before advancing to the core courses in the programs. According to Clark et al. (2013), algebra is a course that provides access to richer life experiences and is the entryway into thinking. The College Algebra course has traditionally been a barrier to student success rather than a gateway. Catalano (2010) acknowledged that at many schools around the country, College Algebra was not serving as a gateway to upper-level mathematics but had transformed into a terminal course for most students, leaving upper-level courses in calculus to a select few.

Cortes, Nomi, and Goodman (2013) demonstrated that algebra, for high school students is often a stumbling block, suggesting the theory that low high school completion rates are due in large part to failures in early courses, such as algebra. Cortes et al. (2013) believed that failures in early courses such as algebra interfere with subsequent course work, becoming an insurmountable hurdle for some students, therefore, making graduation quite difficult. This same notion applies to College Algebra. College Algebra is a course that must be successfully completed before engaging in trigonometry or calculus, which are the critical courses for STEM majors. Colleges around the nation have experienced high rates of students withdrawing from College Algebra classes or either receiving a grade of D or F (DFW rates), which causes students to have to repeat the course. The high DFW rate in College Algebra across the United States has

long been and continues to be a major concern (Brown, 2012). Educators and education researchers are persistently studying ways to improve student learning in College Algebra in hopes of reducing the DFW rate.

A secondary issue that persists in mathematics classes, but especially in College Algebra, is that students who take these courses often leave with little to no understanding of how what they have learned in the course will be applicable in their future lives. This is sometimes the case even among those students who successfully pass the courses. Dietz (2013) implied that even the majority of math majors graduate without a true understanding of what pure mathematicians do or are not afforded the chance to form new mathematics within the field. Understanding that students need to be aware of the usefulness and application of the content which they have learned for them to truly be successful in the subject area, leaving students with no real sense of consciousness regarding the true nature of mathematics is a great disservice. Students may certainly become jaded and anxious about a course when they are presented with material and sequences of concepts without a true context for how they will employ what they have learned. It is vital, therefore, that mathematics courses be developed in a manner that will submerge all students into the deep and broad basis which mathematics is founded upon so that they will not only have knowledge and skills, but that they can be prepared to relay pleasant experiences to others who may have to pursue a similar pathway.

### **Need for Intervention**

There is a definite and urgent need for mathematics reform, especially in the United States. Many students, including minorities, are unable to succeed in College Algebra classes because of a lack of readiness and competency in symbolic manipulation, and are often forced to take remedial or developmental courses before being able to move on in their major's

curriculum, placing them further behind their global competitors in the technology related fields. Recognizing the deficiencies that exist, universities' curricula should be designed to augment students' abilities, helping them to develop into active learners who are able to overcome these previous obstacles. Yet, all too often, students who are ill-equipped when entering college remain that way and see little growth because of the curriculum issues that exist. Classrooms are often not student-centered and provide little foundation for recovery of lost skills and advancement to new abilities. Huk (2013) lamented that, "The prevailing perception of the mechanistic-instrumental model of transmitting knowledge has prevented teachers from using any alternatives other than the presentational mode with its flavor of authoritativeness" (p. 103). Students are unable to progress into learning the higher-level mathematics that is required for success in STEM areas leading to deeper social and economic concerns due in large part to the teaching pedagogies utilized in their math classrooms. Galbraith and Jones (2008) underscored this issue by emphasizing that many teachers have missed the mark by not employing methods which provide an enriching educational experience for their students. There must be a concerted effort to understand the needs of the students and to end the marginalization of their ability to contribute to their own learning, by integrating more effective teaching strategies beyond what has been available in traditional classrooms.

In addition to poor achievement for minority students, African-American students and women are severely underrepresented in STEM majors and careers. Else-Quest et al. (2013) provides a statistic that out of all the STEM jobs in the United States, only 8% are staffed by women who are ethnic minorities. From this data, it is immediately apparent that the math achievement gaps that exist in the educational system have far-reaching effects, interfering with the growth of students' understanding and skills outside of mathematics, but also influencing

their future livelihood. One of the major factors that prevents students from advancing in these technology related majors and careers is that they are inconsistent in their performance in college level mathematics, which is often a prerequisite for entry into the core curriculum classes. These students who are unable to progress through college, often end up becoming stagnant and ultimately dropping out. These students may have student loans that must be repaid; yet, they lack the skills necessary to gain employment that will allow them to repay this debt. According to a report by NCES (2013), from 1992 to 2009, the average college student's debt rose from \$15,400 to \$24,700 and was expected to continue to rise. With growing debt and an inability to find meaningful employment, these students will go on to find low-wage jobs which may leave them needing assistance from government subsidy programs. Therefore, finding solutions for the issues of not only math achievement, but also for improving the attitudes and anxiety levels of minority students is crucial to their overall well-being.

Many strategies have been implemented that have only marginally impacted the students' performance and overall well-being and need to be augmented or replaced. Curriculum developers may be unaware of how to effectively relate to the increasingly diverse student body that is entering their institutions. Palincsar (1998) suggested that traditional pedagogy does not provide an accurate picture of the capabilities of minority children, and in fact, tends to limit students in the minority, skewing the reality of their capabilities and restricting the creativity that they might have shown. Additionally, working problems that are simply culturally relevant may not provide students with a basis for understanding, but may merely allow them to more readily recognize some of the vocabulary used. Kalchman (2011) revealed an important notion regarding classes that are designed around cultural competency and not experience in stating that painting a picture of a situation similar to that which students experience, is not the same as

having an authentic situation in real-time where students must reflect and make decisions. Essentially, students need to have engaging experiences that are culturally rich, not just to have culturally associated buzzwords that provide little impetus for engagement. Experiential activity is beneficial in the learning environment as it enhances knowledge and understanding of material, but also provides opportunities for students to be engaged in their own learning which in turn helps students maneuver through the over-filled curriculum (Davidovitch, Yavich, & Keller, 2014). Subsequently, innovative pedagogical methods that allow educators to tap into the true nature of all of their students' abilities must be sought out in order to improve the current educational landscape.

Not all researchers are in favor of experiential learning, however. Kirschner, Sweller, and Clark (2006) advocated that evidence from controlled studies demonstrates that direct instruction from educators is of greater effect to less-skilled learners than student-directed, experiential based learning. They cited that students were often unable to distinguish between general knowledge that was learned versus application specific knowledge that needed to be used. They argued that students who are taught using constructivist-based experiential type learning are often able to produce more elaborate answers, but often make more mistakes in their explanations and provide less concise and coherent answers (Kirschner et al., 2006). However, there is still much evidence suggesting that mathematics reform is necessary, and that experiential learning may prove beneficial for addressing the racial achievement gap that exists in education and in impacting the levels of student anxiety by providing a basis for students to connect their learning with their daily lives.

## **Research on Math Reform**

There has been a plethora of mathematics interventions instituted over the last two decades. From the elementary through collegiate levels, curriculum stakeholders have been seeking the best methods for improving student achievement and reducing anxiety in mathematics courses, in hopes that a greater majority of pupils will have a greater appreciation for and access to upper-level mathematics. Reforms have focused on standards-based instruction, developing better educational technology, increasing the amount of time dedicated to math instruction, and the list goes on. While there have been mixed results from the institution of these interventions, there has been no clearly identified solution to reducing mathematics anxiety. In the subsequent section, a review of national reform initiatives, and a critique of several studies will be presented that highlights the importance of assessing the effect of experiential learning on math anxiety among African-American students.

### **No Child Left Behind**

Educational reform is not a new concept in the United States, as there have been ongoing reform initiatives since the origination of public schools. Even as far back as 1965, the Elementary and Secondary Education Act formed by President Lyndon Johnson sought to place a federal hand in the education of the nation's children; however, much like other educational reform efforts, the lofty goals were never fulfilled to the administration's expectations (Jeffrey, 1978). Therefore, in 2002, President Bush's administration introduced the NCLB Act which was meant to guarantee that children reach and demonstrate a minimum level of aptitude on state standards and assessments (Thompson & Allen, 2012). This legislation further expanded the federal government's role and influence over the public-school systems around the country. Dee and Jacob (2011) highlighted that the motivation behind the act was to improve schools' focus

and productivity through the use of sanctions for underperforming schools. The policy was grounded upon the belief that measurable performance standards should be set for schools to meet with consequences for schools that consistently do not reach the benchmarks set, which will in turn spur schools to produce better student achievement outcomes (Lee & Reeves, 2012). Again, while the premise of the legislation was good, the legislation did little to help improve the educational landscape and in fact may have done more harm than good.

With the introduction of the NCLB legislation, a more critical lens was placed upon the public schools around the nation, placing emphasis on subjects deemed to be more critical to the welfare of the country's interests. States were required to adopt stringent standards for their students from the earliest grades through high school and were tasked with providing proof of student mastery through the implementation of high-stakes standardized tests. Student knowledge, teacher efficacy, and school quality were now based predominantly upon test scores and graduation rates (Thompson & Allen, 2012). Among the many outcomes arising from these new constraints, student performance on tests were mixed at best, and there was increase in the lack of creativity and less teacher autonomy, as districts scrambled to ensure that teachers were teaching to the objectives which would be covered in the tests. Additionally, Dee and Jacob (2011) revealed that in many schools, focus was shifted away from important but non-tested subjects to the core areas of mathematics, science, and reading. Hence, while the legislation itself involved a multistep approach to school reform, it became little more than requiring the production of high test scores.

While the impact of the NCLB Act had far-reaching but mixed results for the nation's schools, the impacts were far more detrimental to those schools which catered to underserved minority populations. With such high standards required for schools to be able to show that they

were providing a worthwhile education for students, many schools faced more severe discipline, were labeled as failing schools, and were typically more likely to hire unprepared teachers (Thompson & Allen, 2012). In some schools, additional moneys were set aside for hard-to-staff incentive programs in order to compensate for the quality of teacher candidates which were interested in teaching in the failing schools. The schools that often received the failing labels were found to serve African-American populations and improvement on high-stakes tests did not always correlate to improvement on low stakes tests or grades (Lee & Reeves, 2012). One researcher even highlighted that many students were promoted despite failing these high-stakes tests, sometimes resulting in students completing high school with a certificate of attendance but unable to receive a diploma because of inadequate results on high stakes tests (Wakefield, 2012). Graduation rates suffered for African-American students, as one report stated that only New Jersey had a significant African-American male population with an on-time graduation rate greater than 65% (Jackson, 2010). Additionally, it was reported that the achievement gap between African-American and Caucasian students actually slowed during the NCLB program's enactment as compared to pre-NCLB rates (Prescher & Werle, 2014). Thus, while NCLB legislation had lofty ideals and well-meaning objectives, it was inadequate in assuring a quality education for all of the nation's public-school population.

### **Race to the Top Initiative**

In an effort to reshape and reform the NCLB Act, President Obama's administration introduced the Race to the Top (RTTT) initiative in 2009. This executive act differed from NCLB in that it was a more executive-led initiative and led by the U.S. Department of Education rather than a congressional act (Howell, 2015). Additionally, money was placed at the discretion of the U.S. Department of Education to a greater extent than it was under NCLB, leading to a



different perspective on how money was obtained, transitioning from a consequence-led system to a reward-based system (McGuinn, 2014). However, this program was still a top-down approach towards education reform which had mixed results, but ultimately did not assist many schools that needed assistance. Hill (2014) admonished that only those states with the greatest capacity to achieve would benefit from RTTT and that those states which needed the funding the most would be still left at a disadvantage.

The RTTT initiative sought to reward the most innovative schools through the utilization of competitive federal grant money (Manna & Ryan, 2011). Prescher and Werle (2014) highlighted, however, that RTTT still relied on high-stakes testing to judge students' and teachers, and because funding was competitive in nature, underperforming schools were still at a disadvantage. Hence, schools which were already struggling to reach all learners because of a limited curriculum which focused on core-subject testing rather than teaching, were placed in a situation where they had to now compete for funding with schools that were outperforming them, necessitating the need for better reform efforts immediately. This was surely a daunting task. In fact, Prescher and Werle (2014) acknowledged that only 29% of the disadvantaged children in the United States perform in the top 25% of the nation's students; thus, RTTT would take funding from schools which served the very groups that the legislation was intended to assist. Thus, while some states did see benefits from the RTTT program, there were still many shortcomings which impacted K-12 education reform efforts, causing some students more harm than good. Regardless of whether it was stringent requirements aligned with penalties, or uneven competition designed to assist but proving detrimental, the role of the federal government in assisting to improve the landscape of math education has been faulty, but there are lessons that

have been learned which are seen in the instructional interventions which have arisen from this reform era.

### **Instructional Interventions**

One instructional intervention that has seen some widespread usage is increasing extended math courses or double mathematics periods. In this type of intervention, students typically attend their normal mathematics course, and then are scheduled for a second mathematics course period during the school day in which supplemental material is incorporated. Cortes et al. (2013) studied one such instance of this type of intervention that occurred at high schools in Chicago in which students were homogeneously sorted by previous math abilities, and found that students who had below normal performance improved in their success rate after taking the double course algebra class; however, students who had above normal performance prior to the course, actually had declining success rates. Additionally, the researchers concluded that while higher academic demand benefited students by increasing test scores, there were adverse effects on overall pass rates and the intervention was ultimately deemed a failure (Cortes et al., 2013). The results of this study highlight an important issue: the success of students with below average performance through the use of intervention, may come at the expense of students with above average performance. For an intervention to truly be successful, it needs to benefit all children without detrimental results. Additionally, while the intervention was promising for increasing accessibility to courses, there was little gain towards understanding whether or not students' anxiety levels were impacted; hence, long-term gains in mathematics ability were not observed.

A second study of interest focused on the structure of the teaching methods in an algebra class consisting of mostly minority students (Walker & Senger, 2007). The students were taught

using either traditional instruction methods or with the aid of a computer-based learning program that accompanied their textbook. The study was conducted over a two-semester time span with students in a developmental algebra course at a historically African-American university. Students in both the control and experimental groups received instruction and were allowed to work together on homework assignments; however, the experimental group was allowed to utilize the software as a supplemental material. Walker and Senger (2007) acknowledged that there was not a significant difference between the achievement levels of the students in the experimental and control groups, but stated that both groups did show similar levels of achievement. Additionally, Walker and Senger (2007) suggested that students' apprehension to the material and to the computer software may have played a role in the restriction of the results. This study is significant in many ways in that it seeks to understand the impact of differentiated instruction on minority College Algebra students and focuses on technology augmentation along with a social construct, focusing on group interaction. A critical idea that arises is that student anxiety still appears to be a confounding factor when differentiated instruction is utilized. Hence, it is still necessary to try to reduce anxiety through instructional methods, which the present study seeks to accomplish.

The next study that provided empirical evidence regarding the necessity of reform, focused on the technological aspect through a mathematics emporium model (Brown, 2012). This experiment compared a racially diverse group of College Algebra students who received instruction using traditional instruction methods with a group of College Algebra students who received instruction in an emporium format where they received access to one-on-one assistance and computer-aided instruction to determine whether students performed better in the experimental course and whether the rate of students who withdrew or failed the course

decreased in the experimental design. Brown (2012) highlighted that there were differences between the performance of the two groups with the group taught through the emporium model performing significantly better, and that the rate of withdrawal and failures did in fact decrease in the experimental course. While these differences did exist, they were not found to be significant. Additionally, Brown (2012) admitted that this study is limited because differences between the groups could be attributed to the fact that students in the experimental group had an extended amount of instructional time in addition to the varied instruction. Nevertheless, this study provides greater hope that there are indeed interventions that can benefit all students regardless of race or prior abilities. Students who are able to remain engaged in the material may remain enrolled in their courses and see greater success. This is critical in the fight against low mathematics achievement. The results of the study support the ideal that tailored instruction is beneficial for students in mathematics. By providing instruction that allows students' questions to be directly addressed allows students time to develop their ideas more fully. However, this study still does not assess the critical role that anxiety plays in achievement, and more research is needed to determine whether differentiated instruction can reduce the amount of anxiety that students experience. Additionally, the question still remains of whether or not tailoring instruction through experiential learning is beneficial towards increasing achievement and reducing anxiety levels.

In a recent study, Smith et al. (2015) compared the performance on mathematics application problems of college students in algebra courses who were taught using traditional instruction methods with that of students taught using mathematics reform methods and found that students taught using reform methods were better able to perform on application problems. In the traditional methods class, students listened to a professor teach mathematics concepts and

students interjected questions regarding homework assignments or concepts in sporadic intervals throughout the course. In the mathematics reform group, students were situated in small groups at tables and were presented with a real-world situation which required problem solving skills. Students were allowed a period of time to explore the situation and then had to present their results to the class. Students in this group often were able to detect flaws in the arguments and the teacher only stepped in to refine any ambiguous information left by the presenters (Smith et al., 2015). Finally, both groups of students were administered a common exam and a series of common tests to measure mathematical understanding at both the procedural and application levels. The control group and experimental group did not differ significantly on the procedural level; however, the experimental group significantly outperformed the control group on the application level problems, showing promise that mathematical reform methods may prove beneficial in increasing students' abilities to apply mathematics concepts without sacrificing their procedural knowledge and intellect.

Another recent study demonstrated that there may be some correlation between students' ability to obtain problem solving mastery and their exposure to experiential learning methods (Bansal, 2014). A sample of 260 students was observed and each participant was taught secondary level problem solving strategies and content using either traditional teaching methods or experiential learning pedagogy. The mean scores of students who received instruction through experiential learning methods were significantly higher on the Problem Solving Inventory (PSI) than those students who were taught using traditional pedagogical methods (Bansal, 2014). This study was conducted in an international location and demonstrates that experiential learning methods are not beneficial for simply training American students to

compete against one another, but that this pedagogical model may possibly improve the global stature of American students in problem solving and mathematics or quantitative reasoning.

While each of these research studies provide a wealth of information regarding the critical nature of mathematics education reform, there is still much that needs to be considered. Although the current trends in education have been focused on standardized test performance and meeting benchmarks, focusing solely on achievement covers over the actual problem, that students are often scared of mathematics and shy away from the rigor involved in mathematics courses if at all possible. Therefore, if researchers are able to identify teaching practices that reduce or remove math angst, then they can possibly have influence on the long-term effects of anxiety, causing more students to become interested and engaged in mathematics. There is literature that seeks to address the issue of mathematics anxiety which will be presented in the next section.

### **Research on Math Anxiety**

The current research on mathematics anxiety is inconclusive at best. The various studies that have been published reveal that there is widespread disagreement among researchers regarding the root causes of anxiety, the effects of math anxiety, and even what mathematics anxiety is. Akin and Kurbanoglu (2011) suggested that some researchers view math anxiety as just another form of test anxiety that is specific to the math content areas. However, other researchers reveal that math anxiety extends far beyond just testing and the classroom. Zakaria, Zain, Ahmad, and Erlina (2012) suggested that mathematics anxiety is present in any situation regarding mathematics, not just when being tested on solving problems. The discord among researchers is transparent; hence, additional research must occur to help provide a more definitive solution to math anxiety which will be successful among all populations.

Much of the literature relating to mathematics apprehension focuses on the links between students' attitudes towards mathematics, their sense of self-efficacy, and math anxiety. One such study highlights that a significant relationship exists between math attitudes, self-efficacy, and math anxiety. Akin and Kurbanoglu (2011) reported that math anxiety relates negatively with positive attitudes towards mathematics and self-efficacy and relates positively with negative attitudes towards mathematics and self-efficacy. This study connects students' feelings of self-worth and ability to do mathematics with apprehension when performing mathematical computations. Certainly, math curriculum stakeholders could take interest in these findings as they suggest that math anxiety can be predicted by attitudes, and additional supports could be put in place for students who are susceptible to math anxiety. However, this study does not identify the proper support that should be available in a curriculum or in addition to the curriculum in order to address the needs of those students who do have high levels of math anxiety. Additionally, while this specific study centered on a group of college students, the student body in universities has become more diverse and needs to be further studied (Akin & Kurbanoglu, 2011).

A second study conducted regarding the impact and causes of mathematics anxiety was conducted using a group of preservice teachers. Gresham (2007) indicated that the levels of mathematics anxiety which preservice teachers experience is severe and is comparable to that of clients in math anxiety clients. Knowing that these students will eventually be expected to teach mathematics to somebody else, she admonished that steps be taken to adequately address math anxiety by implementing pedagogical methods in the preservice math classes in which these students will enroll (Gresham, 2007). Her study observed the changes in mathematics anxiety levels of preservice teachers who completed a preservice math methods course which integrated

manipulatives, journal logs, and discussions. The results of this study indicated that this type of mathematics methods course can help significantly reduce the levels of math anxiety among preservice educators (Gresham, 2007). Some of the critical factors that the students believed assisted in reducing their anxiety were their instructor's attitude, the concrete experiences, and the journaling that they did. This yields a new perspective on what aspects of the traditional curriculum need to be adjusted in order to lessen the pervasiveness of math anxiety. Yet, this study does not indicate whether the same results could be expected with the general college population or with minority students who demonstrate math anxiety in their college math courses and who are not presented with a methods course in mathematics.

There has been research that studied the link between mathematics anxiety and future mathematics performance. In one recent study, the impact of second graders' math anxiety on their future third-grade mathematics performance was examined. In this study, the authors sought to specifically determine whether or not third grade math performance could be predicted by math anxiety levels in the second grade (Vukovic, Kieffer, Bailey, & Harari, 2013). The authors concluded that certain aspects of students' future performance were impacted by their math anxiety, namely their calculation and reasoning skills, but not all aspects (Vukovic et al., 2013). This study is important in that it helps to establish the importance of reducing math anxiety because students will indeed be called upon to perform calculations and to exhibit reasoning skills as they progress into higher-level mathematics courses. Therefore, there is a requirement to immediately treat anxiety through better pedagogical methods.

One final study that may be profitable to math education reformers utilized students from Malaysia (Zakaria et al., 2012). This study adds an international perspective for understanding mathematics anxiety. In this study, Zakaria et al. (2012) implied that there is no significant



difference in the math anxiety levels of boys and girls but that the more significant achievement differences occur among groups with varying levels of math anxiety. These findings are significant to the knowledge base because they help answer the question of whether or not math anxiety is restricted to a certain gender who may be underrepresented in mathematics related fields. Understanding that math anxiety is not simply a national problem or a gender problem, but it is truly an issue which affects all students, regardless of nationality becomes of great importance. In spite of this information, there is still a significant gap in the literature regarding what methods of pedagogical intervention will best serve in finding a remedy to heightened levels of math anxiety among college students, especially minorities.

From the existing research, there is a clearly defined gap in the literature. The issue at hand is whether or not experiential learning methods coupled with social constructivist principles are able to have a substantial impact in reducing the math anxiety levels of African-American students in college math courses, especially at the foundational level of algebra. The Algebra Project is one such organization which provides curriculum materials that are based upon experiential learning and which utilize social constructivist theory to teach mathematics. Through the implementation of The Algebra Project materials, this study sought to assess the impact that experiential learning had on the math anxiety levels of African-American students in College Algebra courses.

### **The Algebra Project**

The Algebra Project was founded by civil rights activist Dr. Bob Moses in 1982. Moses was raised in a poor family but demonstrated strong academic abilities; hence, he attended a competitive high school, and went on to pursue a master's degree from Harvard. Having a background as a civil rights activist, Moses developed a craving to see equality in both areas of

civil rights and mathematics, and thus formed the idea that mathematics education is a civil right (Moses & Cobb, 2002). He pursued the ideal that it is the communities' duty to ensure that students who have been underserved and underrepresented receive the instruction and critical knowledge that is due to them by the educational system.

Moses, Kamii, Swap, and Howard (1989) suggested that "Those who are concerned about the life chances for historically oppressed people in the United States must not allow math-science education to be addressed as if it were purely a matter of technical instruction" (p. 423). He advocated that high-quality math instruction should be given to all students, not just those who have traditionally performed well, and treated with the level of significance that civil rights would receive. Ladson-Billings (1997) captured the essence of Moses' beliefs when she stated that even as far back as 1990, he offered the thought that because of the critical position of algebra courses as the foundational mathematics course that serves as both a curricular and career gatekeeper by preventing poor performing students from entering higher order mathematics and from entering STEM careers, urban students cannot continue to be tracked out of it.

Wynne and Moses (2008) suggested that when children are provided with the proper curriculum, pedagogy, and support, all children can participate in and understand higher-level mathematics. Therefore, Moses developed his ideas into a curriculum to foster change in the urban mathematics classroom. Doing much of his early work in classrooms in Mississippi, Moses was able to affect students firsthand as a math teacher. He encouraged his students that they deserved the best in education and that learning algebra would be a critical determining factor of how successful they would be in the future by teaching them that learning mathematics was as important as voting. Wahman (2009) noted that Moses felt "while algebra and the vote

may not appear to be drastic or dramatic enough factors to fundamentally alter the structures of oppression, they are as radical as sit-ins and marches—even more so in that they are more likely to achieve long-standing results” (p. 8).

In order to reach the level of advanced mathematics which Moses felt had become a necessity, he decided that students would have to become math literate. Minority students should be as well versed in mathematics as their counterparts, if they were to be competitive, and if the students were to reach equality. Therefore, The Algebra Project advanced with a main purpose of acclimating students with algebra in middle school so that by the time they completed high school and entered college, they would have been able to reach upper-level mathematics courses and would have developed the skills necessary to move beyond remedial and developmental courses. This alone would begin to affect the achievement gap that had existed because in order to reach the advanced mathematics, students would have to have a firm grasp of the more basic algebraic concepts that would be experienced in lower grades. However, Moses needed to understand the factors that could immediately alter the state of math accessibility for African-American and other minority students.

### **The Algebra Project’s Present State**

The Algebra Project, through a grant from the National Science Foundation, developed a mathematics curriculum for high school algebra and geometry courses, to be piloted in sites in Virginia, South Carolina, and California. Mathematicians from around the country joined Moses in creating materials that were based upon the initial Algebra Project pedagogy. This material has been further developed for usage in college level mathematics classes, especially College Algebra, trigonometry, and calculus, covering topics such as functions, prime factorization, and differential calculus. Influenced by the work of Dewey and Piaget, the curriculum begins with

the thought that math is a language that needs to be learned, as it provides access to a world of information (Wahman, 2009). The Algebra Project follows a curriculum whose central theory and contextual structure is Kolb's experiential learning cycle (Silva et al., 1990). The material has been implemented in many locations around the country and has been influential in improving access to upper-level mathematics and in improving students' participation in these courses, perhaps reducing the amount of anxiety that students experience in the math classroom.

The curriculum begins with a concrete experience within the local community, which could be the school, the classroom, or even the surrounding neighborhood. Students record observations about their experiences during the experience. Next, students reflect on their experience by having group discussions and engaging in whole-class debrief sessions, then synthesizing their observations in order to reach an abstract conceptualization that will be necessary making sense of the material. This cycle causes students to reflect and to incorporate cognition into their daily lives, synthesizing and analyzing what they experience. The experiences afforded by participating in The Algebra Project allow students to move beyond simply working problems that are taken from the context of their daily life, and actually immerse them in the process of understanding the mathematics that they need. Therefore, students may become more actively engaged in the material beyond that of a traditional classroom, which may relieve stress levels of trying to make sense of completely abstract concepts, and thereby may improve students' attitudes towards mathematics, reducing the anxiety that has long pervaded math classrooms.

While The Algebra Project material has seen reincarnations over the past 30 years, there have been many implementations of the material at all educational levels. The curriculum originally was designed for middle school mathematics, but has been reinvented for usage in

elementary school, secondary school, and even in collegiate mathematics. Currently, there are experiments utilizing The Algebra Project's curriculum around the country including at a university in Virginia. Positive results emanating from the usage of The Algebra Project pedagogy have been observed thus far, and Wynne and Moses (2008) highlighted that students in The Algebra Project perform at a higher level of understanding in their math classes. However, there is an acute lack of literature regarding the efficacy of The Algebra Project pedagogy at the collegiate level. In fact, there were only a few unpublished manuscripts readily available which addressed the significance of The Algebra Project's work in middle and high schools, and none relating to collegiate implementations. Reimer (2011) conducted a study in partial fulfillment of the requirements for a doctoral degree, regarding the efficacy of The Algebra Project on student performance and attitudes at the high school level. His results showed that students who were taught using The Algebra Project methods had more positive attitudes towards mathematics (Reimer, 2011). However, this study did not assess the impact that the curriculum could have for college students who are engaged in a more rigorous level of mathematics. Hence, there is a need to better understand the influence that the experiential learning methods employed in The Algebra Project curriculum have on college students' levels of math anxiety, and the empirical evidence found in this study will augment the literature regarding experiential learning and social constructivist theory.

### **Summary**

Much time has been devoted to better understanding how students learn and how to improve math performance by identifying the factors that influence math anxiety and negative attitudes towards mathematics. Vigdor (2013) pointed out that "At midcentury, the new math movement sought, unsuccessfully, to bring rigor to the masses, and subsequent egalitarian

impulses led to new reforms that promised to improve the skills of lower-performing students” (p. 43). This pressure to improve performance for all students, many times at the risk of neglecting high performing students along with minorities, has had negative effects, as teaching methodologies have led students to be more apprehensive towards mathematics. According to Finlayson (2014), literature conclusively correlates math anxiety to the teaching style of mathematics which is employed in the classroom. Therefore, when seeking methods to impact math anxiety and negative mathematics attitudes, it is not enough to simply consider the issues that arise from the students’ performance. The social and economic factors oblige researchers and curriculum developers to examine the pedagogy utilized in teaching the classes, and to assess the implications of incorporating different educational theories into the curriculum, including experiential learning, to improve students’ prospects for success in the future.

## **CHAPTER THREE: METHODS**

### **Overview**

This chapter provides details regarding the research design that was utilized for this study. The research questions and null hypotheses will be revisited, and descriptive information regarding the participants, setting, and sampling procedure will be provided. Next, reliability and validity data for the instruments used, the Fennema-Sherman Math Anxiety Scale-Revised (FSMAS-R) and the common midterm examination is presented. Finally, the sequential procedure that was utilized to complete this study is explained.

### **Design**

This quantitative study utilized a quasi-experimental nonequivalent control-group design. According to Gall, Gall, and Borg (2007), this design was most appropriate for determining the differences between the experiential learning and traditional instruction groups because the participants were not randomly assigned to the experiential learning and traditional instruction groups, and both groups took a pre-test and a post-test. This study generally compared the pre-test and post-test anxiety scores of College Algebra students from the experiential learning and traditional instruction groups, as evidenced by results from the FSMAS-R. The independent variable was the type of instruction received, instruction using experiential learning from The Algebra Project curriculum which was a five-step experiential learning curricular process that begins with a shared physical experience and builds into abstract concepts, or instruction via traditional instruction methods. Brown (2012) defined traditional instruction methods as those courses consisting of students listening to three hours of math lectures by their instructor weekly. The dependent variables were the levels of mathematics anxiety and the students' achievement levels on select questions from a common midterm examination. Fennema and Sherman (1976)

defined math anxiety as “students’ feelings of dread, nervousness, and associated bodily symptoms related to doing mathematics” (p. 326). Finally, the covariate for this study was pre-test anxiety scores.

### **Research Questions**

The research questions for this study were:

**RQ1:** Is there a difference in the mathematics anxiety scores between African-American students being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra while controlling for pre-test math anxiety?

**RQ2:** Is there a difference in the mathematics achievement between African-American students being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra?

**RQ3:** Is there a difference in the mathematics achievement of African-American male students and African-American female being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra?

### **Null Hypotheses**

The null hypotheses for this study were:

**H<sub>0</sub>1:** There is no significant difference in the mathematics anxiety scores between African-American students being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra while controlling for pre-test math anxiety.



**H<sub>0</sub>2:** There is no significant difference in the mathematics achievement between African-American students being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra.

**H<sub>0</sub>3:** There is no significant difference in the mathematics achievement of African-American male students and African-American female students being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra.

### **Participants and Setting**

The participants for this study were drawn from a sample of African-American college students located at a university in Virginia during the Spring semester of the 2017-2018 school year. The students all attended math classes at a small, state-supported university located in central Virginia that had a total enrollment of approximately 4,600 students. The University's student body was approximately 93% African-American, 3% Caucasian, 2% Hispanic, and 2% identifying as other. Of the 4,600 students enrolled during the Fall 2015 semester, 60% were female and 40% were male, with 90% of students receiving need-based financial aid, and 92% of graduates receiving student loans (State Council of Higher Education of Virginia, 2015).

For this study, a convenience sample of 175 students was sought which would have exceeded the required minimum for a medium effect size. According to Gall et al. (2007), 166 students was the required minimum for a medium effect size with statistical power of .7 at the .05 alpha level for the analysis of covariance (ANCOVA) test. At the university during the Spring semester of the 2017-2018 academic year, during the first week of classes, there were seven College Algebra classes, with six meeting face-to-face, and one meeting online. In total, the university had 208 students enrolled in College Algebra among the seven sections, with 168

enrolled in face-to-face sections. Approximately 99% of the students enrolled in College Algebra classes self-identified as African-American, with less than 1% identifying as Caucasian, Hispanic, or other.

The sample used was comprised of students from all six of the face-to-face College Algebra classes offered by the university that semester and originally had 144 participants. There was a fairly high mortality rate, though, as 23 participants were excluded for not completing all questions, 10 withdrew from the course, 8 left the university, and one student switched to a higher-level course. After consideration of attrition and exclusions, the final sample used consisted of 102 participants, all of whom were African-American, and of which 61 were female and 41 were male. According to Gall et al. (2007), this sample still met the minimum sample size necessary for a medium effect size with statistical power of .7 at the .05 alpha level for the independent samples t-test which was also used to analyze the results. Approximately 69% of the participants were first-time freshman who had less than 15 credit hours completed at the beginning of the semester, and 31% were sophomores, juniors, or seniors who had between 28 and 104 credit hours completed at the beginning of the semester.

For the experiential learning group (The Algebra Project), there were a total of 30 African-American students who completed both the pre-test and post-test instruments. Of these students, 14 were females and 16 were males. The average age of the students in the experiential learning group was 21 years old. Approximately 63% of the students were first-time freshman, and 37% were sophomores, juniors, or seniors.

In the traditional instruction group, there were a total of 72 African-American students who completed both the pre-test and post-test instruments. Of this number, there were 47 females and 25 males. The average age of the students in the traditional instruction group was

19 years old with 71% of the students in the traditional instruction group being first-time freshman, and the other 29% being sophomores, juniors, or seniors.

The university had previously planned to implement The Algebra Project curriculum during the 2017-2018 academic year and had previously held trainings for instructors on The Algebra Project pedagogy. Of the six face-to-face classes selected, two sections were taught using The Algebra Project curriculum and the other four sections were taught using traditional instruction methods because only one of the instructors had been trained in The Algebra Project pedagogy. There was a total of five different mathematics instructors who taught the six face-to-face sections. The instructor, who had previously been trained in The Algebra Project pedagogy from a prior implementation during the fall 2012 semester, volunteered to teach using The Algebra Project pedagogy again. The instructors' training was led by professional development consultants from The Algebra Project or Southern Initiative Algebra Project, and consisted of attending a two-week faculty development workshop, along with periodic professional development opportunities sponsored by The Algebra Project in which they engaged in learning the materials associated with The Algebra Project pedagogy. The instructors each had a minimum of 7 years of teaching experience with 27 years of experience as the maximum. There were two male instructors and three female instructors. There were four African-American instructors, no Caucasian instructors, and one instructor who identified as Other.

The students pre-registered for classes during spring registration, prior to assignment to either the experiential learning or traditional instruction groups. The mathematics department decided which of the course sections would be taught using The Algebra Project curriculum and which would be taught using traditional instruction methods prior to student enrollment, and the students gave their consent in order to complete the pre-test and post-test. The instructors agreed

to only use The Algebra Project pedagogy with the experiential learning group. There were 24 students who objected to completing the surveys. The university caps enrollment in all College Algebra classes at 30 students, and each course section began with between 27-30 students on the roster and met for three hours per week. However, due to students not completing validation, opting not to complete the survey, or withdrawing from the class, only 102 of the 168 students who were originally enrolled in the courses participated in the experiment.

### **Instrumentation**

The instrument used to assess anxiety for this study was the Fennema-Sherman Mathematics Anxiety Scale-Revised (FSMAS-R). This instrument was utilized for both the pre-test and post-test assessment and was completed both times by each student. The FSMAS-R included two subscales measuring participants' mathematics anxiety and ease with mathematics. The anxiety subscale (FS-ANX) was comprised of six items and measured students' feelings of anxiety, dread, nervousness, and associated bodily symptoms stemming from performing mathematical tasks (Fennema & Sherman, 1976). The subsequent ease subscale (FS-EASE) included six items and measured participants' comfort level when they were engaging in mathematics activities. This was a shortened version of the Fennema-Sherman Mathematics Attitude Scale which is comprised of nine subscales measuring domain specific attitudes related to learning mathematics, including anxiety. See Appendix A for instrument.

Although the instrument has subscales, it was recommended that the total anxiety score be used from the instrument. The authors granted permission to use the shortened version of the scale (Lim & Chapman, 2013). See Appendix B for permission to use instrument. The FSMAS-R has been utilized in several studies (e.g., Betz, 1978; Hackett & Betz, 1989; Lim & Chapman, 2013). This instrument consisted of 12 items using a 5-point Likert-type scale, from 1 being

strongly disagree, to 5 being strongly agree. The first six items were positively worded and the last six negatively worded. For scoring, the positively worded items were reversed so that a high score indicates high anxiety. Scores could thus range from 12 (low level of math anxiety) to 60 (high level of math anxiety). Cooper and Robinson (1989) reported that there is a correlation of 0.70 between the FSMAS-R and the full-scale Mathematics Attitude Scale. Lim and Chapman (2013) reported that exploratory and confirmatory factor analyses support a two-factor model. A Cronbach's alpha of  $\alpha = 0.91$  for the complete FSMAS-R was obtained with  $\alpha = 0.92$  for the FS-ANX subscale and  $\alpha = 0.82$  for the FS-EASE subscale (Lim & Chapman, 2013). A 1-month test-retest reliability was also computed with  $r_{xx} = 0.87$  and  $0.77$ ,  $p < 0.01$  for the FS-ANX and FS-EASE subscales, respectively.

The instrument required approximately 10 minutes to complete and was administered on paper by the researcher during the first week of classes and during the week immediately preceding administration of the midterm examinations. In order to measure mathematics achievement, nine select questions regarding the properties of functions from the common, coordinated departmental midterm exam were utilized. College Algebra is a coordinated course at this university which ensures that all students enrolled in the course were tested on the same material. The questions on the midterm exam were consistent with the learning objectives stated in the course syllabus, and the midterm exam had been used for at least the last 10 years as a portion of a student's midterm advisory grade for the course. Corcoran, Halverson, and Schindler (2014) reported a Cronbach's alpha of  $\alpha = 0.65$  for midterm exam as an indicator of student success. Jenson and Barron (2014) reported a Pearson's r-coefficient of  $r = 0.83$ ,  $p < 0.0001$  for midterm as an accurate predictor of final grade in a course. See Appendix E for a sample midterm exam. The university utilized a 10-point grading scale with a grade of D

beginning at 60 and ending at 69, a C ranged from 70 to 79, a B ranged from 80 to 89, and an A was any grade 90 or greater. This test accurately measured the objectives that were taught within the course and hence was utilized as an achievement measure.

### **Procedures**

After Institutional Review Board (IRB) approval was obtained, and approximately two weeks before the semester began, the researcher met corporately during a 30-minute meeting with all College Algebra instructors at the school to determine who would be implementing the experiential learning curriculum. The Mathematics and Economics Department at this university planned to implement the curriculum in select classes during the 2017-2018 school year independently of this project. Volunteers for teaching the course were obtained, and they were asked to determine which sections of their courses would be taught using which curriculum. Additionally, instructors were asked to agree to only use The Algebra Project pedagogy with the experiential learning sections of the course. Approximately one week prior to beginning the functions chapter of the textbook, the instructors were given consent forms for the students to sign agreeing to be taught using the experiential learning curriculum (The Algebra Project) or traditional curriculum and consenting to complete the surveys. See Appendix C for consent forms. Additionally, instructors were given a copy of the FSMAS-R to look over before students arrived.

At the subsequent class meetings, the instructors explained the study to their students with the researcher present to answer any questions. Students were given consent forms by the researcher, and any questions regarding the nature of the study were answered by the instructors and researcher. Students were instructed to give their consent during that class period and the pre-test for anxiety was administered at that time to all students who consented. Students who

opted out of the study remained in the classroom and were asked to complete other classwork while they waited, and those students were not given a survey. The researcher handed out a paper copy of the FSMAS-R, pencils, and envelopes to each student, and as students completed the survey, they put their survey in their envelope and sealed it, then handed the envelope back to the researcher. The survey collected student demographic data such as name, ethnicity, and classification solely for matching purposes, and students were assured that no parties other than the researcher would have access to their demographic data, and that data will be destroyed after five years. After 20 minutes, the researcher left the classroom and the class resumed.

Up until the fourth week of class, both the experiential learning and traditional instruction groups were taught the same material using lectures. On the fourth week of class, the instructors began teaching the function section of their courses. For the experiential learning sections, the instructor began teaching from The Algebra Project module by having students build cities according to the Road Coloring module. For a copy of The Algebra Project modules, please see The Algebra Project, Inc.'s website. For the control sections, the instructors used traditional instruction methods to teach the function concept. The Algebra Project module was taught for the next three weeks of class, while the traditional instruction classes completed the functions chapter using traditional methods for the next three weeks. See Appendix D for course syllabus. After the Functions - Algebra Project module was completed, the researcher returned to each of the course sections to administer the post-test. Again, students who opted out remained in the classroom and were asked to complete other classwork and were not given a survey. The researcher handed out a paper copy of the FSMAS-R to each student, along with pencils, and envelopes to each student, and as students completed the survey, they put their survey in their envelope and sealed it, then handed the envelope back to the researcher. After 20 minutes, the

researcher left, and the classes resumed. On the following week, students took their midterm exams, and on the last day of midterm exams, the researcher obtained midterm exams and class rosters from the College Algebra instructors. The researcher then spent the next four months coding the data from the pre-test and post-test, entering midterm exam scores on questions related to functions into SPSS, and analyzing the results.

### **Analysis**

An ANCOVA was conducted to determine whether there was a significant difference in the post-test anxiety scores of African-American students who were either taught using the experiential learning (The Algebra Project) method or the traditional instruction method while controlling for pre-test anxiety. This analysis technique was appropriate because “the ANCOVA provides a way to assess whether mean outcome scores differ across treatment groups when a statistical adjustment is made to control for different participant characteristics across groups” (Warner, 2013, p. 689). Preliminary data screening was conducted to ensure the quality of analysis. Examination of data for outliers was conducted using box and whisker plots for the experiential learning and traditional instruction groups. Next, the assumption of normality was tested using the Kolmogorov-Smirnov test. Then, a series of scatter plots were created to test for linearity and bivariate normal distributions, between the pre and post-tests. Homogeneity of slopes was examined by running a preliminary ANCOVA performed using SPSS GLM to determine whether there was significant interaction between the variables. Finally, Levene’s Test of Equality of Variances was conducted to ensure that the data had equal variances. After preliminary data screening and assumptions tests were completed, it was noted that the assumption for homogeneity of regression slopes was violated; therefore, ANCOVA was not



applicable for the data, and main effect interactions were examined. Significance for the tests were set at the  $p < .05$  level.

Next, an independent samples t-test was conducted to determine whether there was a significant difference between the mathematics achievement of African-American students in College Algebra classes taught using experiential learning pedagogy and African-American students in College Algebra classes taught using traditional methods. This analysis technique was appropriate because the independent samples t-test is utilized for comparing the means between-subjects when there are exactly two independent groups (Warner, 2013). Preliminary data screening was conducted, first to test for the assumption of normality by creating histograms. Secondly, homogeneity of variance was tested using Levene's Test for Equality of Variances. After preliminary data screening and assumptions tests were completed, an independent samples t-test was conducted. Significance for the test was set at the  $p < .05$  level.

Finally, in order to determine whether there was a significant difference in the mathematics achievement between African-American males and African-American females in College Algebra classes taught using experiential learning methods or traditional methods, a two-way between-groups analysis of variance (ANOVA) was completed. This statistical test is appropriate when a researcher wants to compare means on a quantitative Y outcome variable across two grouping variables (Warner, 2013). Preliminary data screening was conducted to identify any outliers and to ensure normality. Testing for the assumption of normality was completed using histograms, and outliers were assessed using box-and-whisker plots. Next, Levene's Test for Equality of Variances was completed to ensure that there were no serious violations of the assumption of homogeneity of variances. After preliminary data screening and

assumptions tests were completed, a two-way between-groups ANOVA was conducted, with significance for the test set at the  $p < .05$  level.

## CHAPTER FOUR: FINDINGS

### Overview

The intent of this chapter was to report the results of this study. The research questions and null hypotheses are revisited along with detailed descriptive statistics from the study. The chapter concludes with a discussion of each of the results along with determinations about the null hypotheses.

### Research Questions

The research questions for this study were:

**RQ1:** Is there a difference in the mathematics anxiety scores between African-American students being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra while controlling for pre-test math anxiety?

**RQ2:** Is there a difference in the mathematics achievement between African-American students being taught through experiential learning pedagogy (The Algebra Project) in college algebra and those being taught through traditional instruction in college algebra?

**RQ3:** Is there a difference in the mathematics achievement of African-American male students and African-American female being taught through experiential learning pedagogy (The Algebra Project) in college algebra and those being taught through traditional instruction in College Algebra?

### Null Hypotheses

The null hypotheses for this study were:

**H<sub>0</sub>1:** There is no significant difference in the mathematics anxiety scores between African-American students being taught through experiential learning pedagogy (The Algebra

Project) in College Algebra and those being taught through traditional instruction in College Algebra while controlling for pre-test math anxiety.

**H<sub>0</sub>2:** There is no significant difference in the mathematics achievement between African-American students being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra.

**H<sub>0</sub>3:** There is no significant difference in the mathematics achievement of African-American male students and African-American female students being taught through experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught through traditional instruction in College Algebra.

### **Descriptive Statistics**

During the spring semester of the 2017-2018 school year, a group of students enrolled in College Algebra courses at a university in central Virginia. There were six face-to-face sections of the College Algebra course at the school during the semester and one online class. Only the students enrolled in the face-to-face sections of the course were recruited for this study. These students selected their math instructor, and the instructor decided whether the course would be taught using experiential learning or using traditional methods. Students had the option to switch sections if they did not agree with the pedagogy used in the course. The six sections were formed into two groups by teaching method: the experiential learning group and traditional instruction group. The experiential learning group was enrolled in a course that was taught using experiential learning, The Algebra Project pedagogy, as the main curriculum. The traditional instruction group was enrolled in a course that was taught using traditional methods of teaching, which did not involve The Algebra Project pedagogy.

After the first week of classes, there were 168 total students enrolled among the six face-to-face College Algebra courses. One week after midterm exams, 8 of the students had withdrawn from the university, 10 students had withdrawn from the College Algebra course, and 1 student tested out of College Algebra into a Calculus I course. Of the remaining 149 students, 24 students opted to not participate in this study, and 23 students were excluded from the study because they did not complete both the pre-test and post-test. There was a total of 102 individuals utilized for analysis. The minimum age of students enrolled was 17 and the maximum age of students enrolled was 50, with a mean age of 19.88 years old. Statistical tables display the descriptive statistics for the study. They are presented in tabular form to assist the reader in comparing the data.

Preliminary data analysis was conducted on demographic data from the participants. A total of 102 students were utilized in completing the study with 30 in the experiential learning group and 72 in the traditional instruction group. The participants from the experiential learning group had a greater mean age than students in the traditional instruction group; however, it is important to note that the experiential learning group had an outlier, as the oldest participant was 50 years old. Table 1 presents information regarding the mean ages of students in both the experiential learning and traditional instruction groups along with the sample size for each group.

Table 1

*Mean Age of Students in Experiential Learning vs. Traditional Instruction Group*

	N	M	Min.	Max.
Experiential Learning Group	30	21.367	18.0	50.0
Traditional Instruction Group	72	19.264	17.0	31.0

Table 2 shows the distribution of students in the experiential learning and traditional instruction groups by classification. Both the experiential learning and traditional instruction groups consisted of mostly freshman, with the experiential learning group having a makeup that was approximately 63% freshman compared to the traditional instruction group which was made up of approximately 71% freshman. Additionally, each group consisted of approximately 23% sophomores. The rest of the experiential learning group was comprised of 3% juniors and 10% seniors compared to 4% juniors and 3% seniors for the traditional instruction group.

Table 2

*Distribution of Students by Classification and by Instructional Group*

	Freshman	Sophomore	Junior	Senior
Experiential Learning Group	19	7	1	3
Traditional Instruction Group	51	16	3	2

Preliminary data analysis, reported in Table 3, showed that the experiential learning group was comprised of approximately equal amounts of males and females, with males accounting for approximately 47% and females accounting for 53% of the group participants. The traditional instruction group, however, was very disproportionate with females making up approximately 65% of the participants and males making up only about 35% of the participants.

Table 3

*Distribution of Students by Gender and by Instructional Group*

	N	Males	Females
Experiential Learning Group	30	14	16
Traditional Instruction Group	72	25	47

Descriptive statistics regarding the pre-test anxiety score are presented in Table 4. Pre-test anxiety scores on the FSMAS-R were computed for all participants because pre-test anxiety was used as a covariate for the study. Scores on the FSMAS-R could range from a minimum anxiety score of 12 to a maximum anxiety score of 60. The mean group pre-test anxiety score for students in the experiential learning group was 36.667 demonstrating a moderate amount of anxiety.

Table 4

*Mean Anxiety Pre-test Scores by Instructional Group*

	N	M	S.D.
Experiential Learning Group	30	36.667	11.514
Traditional Instruction Group	72	38.792	12.181
Total	102	38.167	11.971

Post-test anxiety scores on the FSMAS-R were computed for all participants. Scores on the FSMAS-R could again range from a minimum anxiety score of 12 to a maximum anxiety score of 60. The mean group post-test anxiety score for students in the experiential learning group was 35.600 demonstrating a moderate amount of anxiety. The mean group post-test

anxiety score for the traditional instruction group was 38.153, also demonstrating a moderate amount of anxiety. The post-test anxiety score for the traditional instruction group was greater than that of the experiential learning group, as evidenced in Table 5.

Table 5

*Mean Anxiety Post-test Scores by Instructional Group*

	N	M	S.D.
Experiential Learning Group	30	35.600	12.339
Traditional Instruction Group	72	38.153	11.937
Total	102	37.402	12.052

To measure achievement levels for the participants, nine questions regarding functions were selected from the midterm College Algebra exam. Table 6 shows the mean number of questions answered correctly by group. The experiential learning group had a mean score of 4.70 out of 9.0 questions answered correctly. The traditional instruction group had a mean score of 5.30 out of 9.0 questions answered correctly.

Table 6

*Mean Number of Functions Questions Correct by Instructional Group*

	N	M	S.D.
Experiential Learning Group	30	4.700	2.054
Traditional Instruction Group	72	5.306	2.026
Total	102	5.127	2.043

Table 7 presents the mean number of functions questions from the midterm exam answered correctly by males and females in both the experiential learning and traditional



instruction groups. Females in the traditional instruction group answered the most functions questions correctly with a mean score of 5.36 out of 9.0 questions answered correctly. Next, the males in the traditional instruction group answered a mean of 5.20 out of 9.0 questions correctly. Next, females in the experiential learning group answered a mean of 4.714 out of 9.0 questions correctly. Finally, males in the experiential learning group answered the least number of functions questions correctly with a mean score of 4.69 out of 9.0 questions answered correctly.

Table 7

*Mean Number of Functions Questions Correct by Gender and Instructional Group*

		N	M	S.D.
Males	Experiential Learning Group	16	4.688	1.991
	Traditional Instruction Group	25	5.200	2.255
Females	Experiential Learning Group	14	4.714	2.199
	Traditional Instruction Group	47	5.362	1.916
Total		102	5.127	2.043

## Results

### Null Hypothesis One

The first null hypothesis stated that there is no significant difference in the mathematics anxiety scores between African-American students being taught with experiential learning pedagogy in College Algebra (The Algebra Project) and those being taught with traditional instruction in College Algebra while controlling for pre-test math anxiety. A one-way ANCOVA was planned. The independent variable, type of instruction, included two groups: the experiential learning group, taught using experiential learning with The Algebra Project

pedagogy, and the traditional instruction group, taught using traditional instruction methods. The dependent variable was the post-test anxiety score, and the covariate was the pre-test anxiety score. Preliminary data analysis was conducted using box and whisker plots to determine whether there were any outliers, and none were found. Normality was tested using the Shapiro-Wilk test for significance and found that the assumption of normality was tenable on the independent variable for both the experiential learning group and traditional instruction group ( $p = .413$  for group experiential learning group,  $p = .154$  for traditional instruction group). The assumption of linearity was tested visually through observation of scatter plots, and this assumption was found tenable for both groups.

A preliminary analysis was conducted to evaluate homogeneity of slopes between the covariate and the dependent variable across groups, an assumption lying ANCOVA. The partial  $\eta^2$  for the interaction was .052, signaling that in the sample, the mean differences in post-test anxiety scores among the groups varied significantly as a function of the pre-test anxiety score ( $p < .05$ ). As demonstrated in Figure 1, the regression line was less steep for the traditional instruction group versus the experiential learning group. However, the interaction effect was nonsignificant,  $F(1, 98) = .130$ ,  $MSE = 56.325$ ,  $p = .719$ .

Based upon the results of the partial  $\eta^2$ , simple main effects tests were conducted that allow for heterogeneity of slopes rather than ANCOVA. Simple main effects tests were conducted to assess the differences between the groups at low level (one standard deviation below the mean), medium level (the mean), and high level (one standard deviation above the mean) values of the covariate. A  $p$  value of 0.017 ( $0.05/3$ ) was required for significance for each of these tests. If any single simple main effects was significant, pairwise comparisons were evaluated at the same level ( $p < 0.017$ ) as the simple main effects test.

The simple main effects test was not significant at the low level of pre-test anxiety (26.2, one standard deviation below the mean),  $F(1, 98) = .130$ ,  $p = 0.019$ , partial  $\eta^2$  of 0.55. Next, at the medium level of pre-test anxiety ( $M = 38.167$ ), the simple main effects test was not significant,  $F(1, 98) = .130$ ,  $p = 0.719$ , partial  $\eta^2$  of 0.001. Finally, the simple main effects test was not significant at the high level of pre-test anxiety (50.1, one standard deviation above the mean),  $F(1, 98) = 1.855$ ,  $p = 0.176$ , partial  $\eta^2$  of .019.

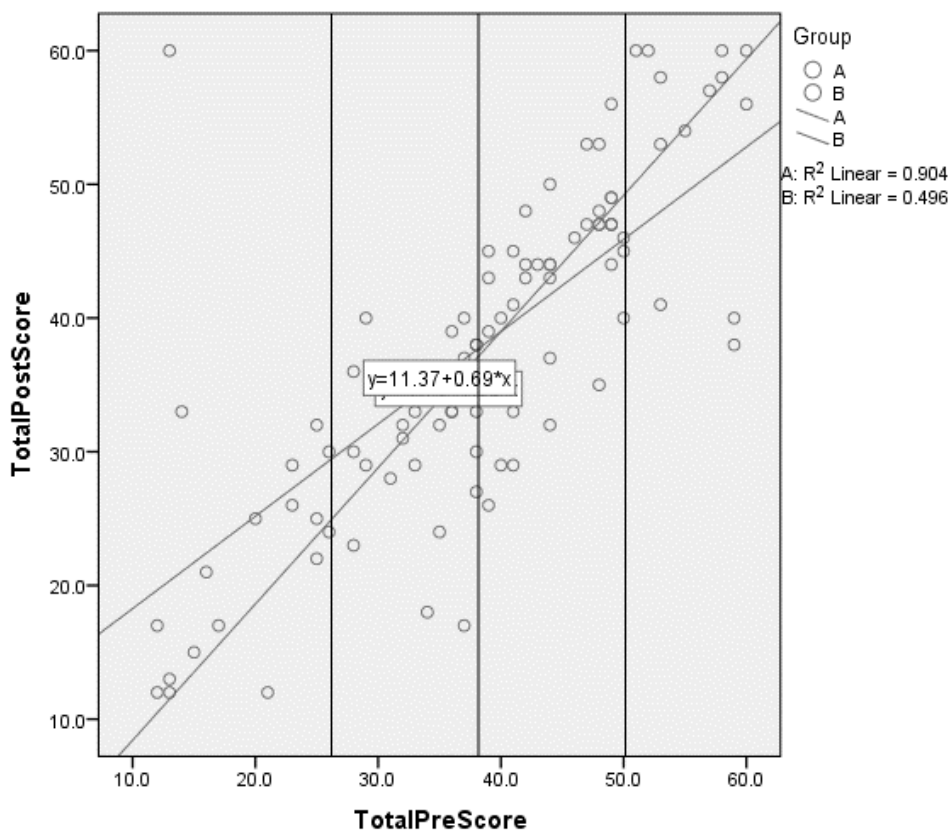


Figure 1. Scatterplot showing regression slopes for post-test anxiety scores.

Table 8 shows the mean post-test anxiety score based upon instructional method for those participants who had a low level of pre-test anxiety, one standard deviation below the mean. The experiential learning group had a lower level of post-test anxiety compared to the traditional instruction group ( $p = 0.048$ ), but this result was nonsignificant at the  $p < 0.017$  value.

Table 8

*Post-Test Anxiety by Instructional Group for Low Levels of Pre-Test Anxiety*

	N	M	Difference
Experiential Learning Group	30	24.936	-4.522
Traditional Instruction Group	72	29.459	4.522

Table 9 shows the mean post-test anxiety score based upon instructional method for those participants who had a medium level of pre-test anxiety, at the mean score. The experiential learning group had a lower level of post-test anxiety compared to the traditional instruction group ( $p = 0.719$ ), but this result was nonsignificant at the  $p < 0.017$  value.

Table 9

*Post-Test Anxiety by Instructional Group for Medium Levels of Pre-Test Anxiety*

	N	M	Difference
Experiential Learning Group	30	37.128	-0.593
Traditional Instruction Group	72	37.721	0.593

Table 10 shows the mean post-test anxiety score based upon instructional method for those participants who had a high level of pre-test anxiety, one standard deviation above the mean score. The experiential learning group had a greater level of post-test anxiety compared to the traditional instruction group ( $p = 0.176$ ), but this result was nonsignificant at the  $p < 0.017$  value.

Table 10

*Post-Test Anxiety by Instructional Group for High Levels of Pre-Test Anxiety*

	N	M	Difference
Experiential Learning Group	30	49.327	3.338
Traditional Instruction Group	72	45.988	-3.338

Having determined that there were no significant differences seen in the post-test anxiety scores between the experiential learning group and traditional instruction groups as evidenced by the simple main effects test, the researcher failed to reject the null hypothesis that there was no significant difference in the mathematics anxiety scores between African-American students taught using experiential learning pedagogy in College Algebra (The Algebra Project) and those taught with traditional instruction in College Algebra while controlling for pre-test math anxiety.

**Null Hypothesis Two**

The second null hypothesis stated that there is no significant difference in the mathematics achievement between African-American students taught with experiential learning pedagogy (The Algebra Project) in College Algebra and those taught using traditional instruction in College Algebra, and this hypothesis was tested using an independent samples t-test. During preliminary data analysis, the first assumption that was tested for was outliers in the dependent variable, which was Total Functions Score. Box and whisker plots for both the experiential learning and traditional instruction groups were observed and the researcher found that there were no outliers in either group. Next, the assumption of normality was tested using a Shapiro-Wilk test. The assumption of normality was found to be violated; however, the departure from normality was not judged serious enough to require the use of a nonparametric test. Finally, the

assumption of homogeneity of variances was tested using the Levene's Test,  $F = .191$ ,  $p = .663$ ; this indicated that there was no significant violation of the equal variance assumption.

According to the independent samples t-test, there was no significant difference in the mean total functions score between the experiential learning and traditional instruction groups,  $t(100) = -1.37$ ,  $p = .174$ , two-tailed. The mean number of functions correct for the experiential learning group ( $M = 4.700$ ,  $SD = 2.054$ ) was about 0.6 questions lower than the mean number of functions questions correct for the traditional instruction group ( $M = 5.306$ ,  $SD = 2.026$ ). The effect size, as indexed by  $\eta^2$ , was .017, which is a small effect size (Warner, 2013). The 95% confidence interval for the difference in sample means ranged from -1.497 to .286. Based upon the confidence interval and effect size, this study suggests that there was not a significant difference in understanding functions in College Algebra based upon being taught using traditional instruction or experiential learning. Hence, there was not enough evidence to reject the null hypothesis, and the researcher failed to reject the null.

In addition to the testing the dependent variable, Total Functions Score, the researcher also tested the individual functions questions to determine if there were any significant differences per group. See Appendix E for functions questions. Preliminary data analysis was completed on each functions question. See Table 11 for results.

Table 11

*Independent Samples T-test Results for Individual Function Questions*

	Mean Difference	Standard Error Difference	t	df	p-value
Question 1	.122	.101	1.217	58.998	.229
Question 2	0.17	.108	.154	100	.878
Question 3	-.258	.106	-2.435	100	0.17
Question 4	-.067	.105	-.637	100	.526
Question 5	-.183	.108	-1.698	100	.093
Question 6	-.042	.101	-.413	100	6.80
Question 7	-.067	.109	.609	100	.544
Question 8	-.083	.107	-.780	100	.437
Question 9	-1.78	.096	-1.846	100	0.68

There were no outliers as evidenced by box and whisker plots. Next, normality was tested for each functions question. The Shapiro-Wilk test indicated that each of the functions questions were found to not deviate from a normal distribution except for question 1 and question 8; however, these did not deviate enough to warrant a nonparametric test. Next, each functions question was tested for homogeneity of variance using Levene's test. Equal variances were assumed for each of the functions questions except for question 1 ( $F = 7.073, p = .009$ ) and question 9 ( $F = 9.254, p = .003$ ). Results from the independent samples t-test for each function question indicated that only one question had a significant difference, and this was functions question 3 ( $t(100) = -2.435, p = .017$ ). There was a significant difference in the percentage of students from the experiential learning group ( $M = .367, SD = .490$ ) who answered this question

correctly when compared to the traditional instruction group ( $M = .625, SD = .488$ ). Almost 63% of the traditional instruction group answered this question correctly compared to only 37% of the experiential learning group who answered this question correctly. The effect size, as indexed by  $\eta^2$ , was .055, which is a medium effect size (Warner, 2013). The 95% confidence interval for the difference in sample means ranged from -.472 to -.048. This confidence interval along with there being a medium effect size suggested that the method of teaching, traditional instruction or experiential learning, made a difference in the students' abilities to answer that particular question.

### **Null Hypothesis Three**

The third null hypothesis stated that there is no significant difference in the mathematics achievement of African-American male students and African-American female students being taught with experiential learning pedagogy (The Algebra Project) in College Algebra and those being taught with traditional instruction in College Algebra. A 2x2 factorial ANOVA was performed using SPSS GLM to assess whether there was a significant difference in achievement, as assessed by the mean number of functions questions correct, based upon students' gender and the method of teaching used in the course, traditional instruction or experiential learning. The means and standard deviations for mean number of functions questions correct as a function of gender and teaching method are presented in Table 7. Preliminary data analysis was conducted to ensure that the necessary assumptions for an ANOVA were not significantly violated. First, a series of box and whisker plots was analyzed on the mean number of functions questions correct for each group, in order to check for outliers. There were no significant outliers in any of the groups. Next, the assumption of normality was tested using the Shapiro-Wilk test. The assumption of normality was found to be violated for each group, but normality was not violated



enough to require data transformation. Finally, Levene's test was used to evaluate the assumption of homogeneity of variances,  $F = .417, p = .741$ , which indicated that the assumption of homogeneity of variances was found tenable.

Results from the ANOVA are presented in Table 12. The ANOVA indicated that there was no significant interaction between teaching method and gender,  $F(1, 101) = .022, p = .882$ , partial  $\eta^2 = .000$ . Additionally, there were no significant main effects for either teaching method,  $F(1, 101) = 1.635, p = .204$ , partial  $\eta^2 = .016$ , or gender,  $F(1, 101) = .043, p = .836$ , partial  $\eta^2 = .000$ . The teaching method main effect comparison of the means indicated that students in the traditional instruction group had a greater mean number of functions questions answered correctly, but the difference in mean scores between students in the traditional instruction group and students in the experiential learning group was not significant. Therefore, the researcher failed to reject the null hypothesis that there is no significant difference in the mathematics achievement of African-American male students and African-American female students taking an experiential learning course (The Algebra Project) in College Algebra and those taking a traditional course in College Algebra.

Table 12

*ANOVA for Achievement with Factors of Gender and Instructional Type*

Source	Type III Sum of Squares	Df	Mean Square	F	p-value	Partial Eta Squared
Teaching Method	6.892	1	6.892	1.635	.204	.016
Gender	.182	1	.182	.043	.836	.000
Teach. Met. * Gender	.093	1	.093	.022	.882	.000

## **CHAPTER FIVE: CONCLUSIONS**

### **Overview**

This chapter will discuss the conclusions, implications, and limitations of this study. The findings of this study are discussed around the three research hypotheses which guided the study. Additionally, this chapter will present the researcher's recommendations for future research.

### **Discussion**

The purpose of this quantitative, quasi-experimental nonequivalent control-group design study was to examine the impact of the experiential learning theory, as implemented by The Algebra Project, on the mathematics anxiety and achievement levels of African-American students in College Algebra courses. The researcher assessed anxiety levels of both the experiential learning and traditional instruction groups, using the FSMAS-R. Participants' anxiety levels were observed at the beginning of the course and again immediately following the administration of the midterm examination. Additionally, achievement levels for the experiential learning and traditional instruction groups in the College Algebra course were tested using select functions questions from the common midterm examination. To control for participants' pre-existing math anxiety, an ANCOVA was planned; however, due to violation of the assumption of homogeneity of regression slopes, an analysis of main effects was conducted instead. Assessment of achievement was conducted through the usage of independent samples t-test and factorial ANOVA.

### **Research Question One**

Is there a difference in the mathematics anxiety scores between African-American students taking an experiential learning course (The Algebra Project) in College Algebra and those taking a traditional course in College Algebra while controlling for pre-test math anxiety?

### **Null Hypothesis One**

There is no significant difference in the mathematics anxiety scores between African-American students taking an experiential learning course in College Algebra (The Algebra Project) and those taking a traditional course in College Algebra while controlling for pre-test math anxiety.

For the first research question, an analysis of main effects was completed rather than ANCOVA because of the violation of the homogeneity of regression slopes. The result of these analyses showed that although the experiential learning group demonstrated an overall lower level of math anxiety, there was no significant difference in the math anxiety of students who took a traditional College Algebra class and those students who took a College Algebra course taught using experiential learning theory from The Algebra Project; hence, the researcher failed to reject the null hypothesis. These results are consistent with prior studies which have had mixed results following the usage of experiential learning.

Kirschner et al. (2006) identified that students who were taught using methods that did not include direct guidance, as with experiential learning, tended to develop incomplete learning, which left them with a greater amount of anxiety. Yet, Gherasim et al. (2013) identified that classrooms are perceived differently by students, and classrooms that allow learners to make sense of material in their own way proves to be beneficial. Arnup et al. (2013) additionally confirmed the sentiment that students in experiential learning class fare better, as they found that students' perceptions in the math classroom vary, and students who are engaged through experiential learning are able to make better sense of material, which makes them less anxious about approaching problems. The mixed findings presented in these prior studies thus help to explain why this study had mixed results, and that the difference in anxiety levels was not

significant, as the students in the experiential learning group who started with low or medium levels of math anxiety finished with less math anxiety than their peers in the traditional instruction group, but students in the experiential learning group who started with high levels of math anxiety, finished with higher levels of math anxiety than their peers in the traditional instruction group. Research indeed shows that there are some students who benefited from experiential learning, but that there may be some unintentional consequences that arise from such pedagogical methods.

### **Research Question Two**

Is there a difference in the mathematics achievement between African-American students taking an experiential learning course (The Algebra Project) in College Algebra and those taking a traditional course in College Algebra?

### **Null Hypothesis Two**

There is no significant difference in the mathematics achievement between African-American students taking an experiential learning course (The Algebra Project) in College Algebra and those taking a traditional course in College Algebra.

For the second research question, independent samples t-tests were performed to determine whether there were significant differences in the achievement levels of African-American students in College Algebra courses taught using experiential learning and College Algebra courses taught using traditional methods. The results of this analysis demonstrated that overall achievement, as measured by select functions questions on the midterm exam, was not significantly different between those students enrolled in College Algebra courses taught using experiential learning and those taught using traditional instruction, although the percentage of

students who answered one particular functions question was significant. Therefore, the researcher failed to reject the null hypothesis.

The results from this analysis are somewhat inconsistent with previous studies. Davidovitch et al. (2014) observed that students who were taught using experiential learning are often able to maneuver through the curriculum and to achieve at high levels because they are able to learn in their own environment. During the present study, the difference in teaching only lasted four weeks, although The Algebra Project pedagogy could have been taught for a longer amount of time. The limited time nature of the reformed methods of teaching that were utilized may help to explain some of the disagreement between the two studies. Additionally, Smith et al. (2015) found that students who were taught using reform methods tended to outperform their peers who have been taught using traditional methods on mathematics application questions. The functions questions that were used on the midterm exam, however, did not align with an application format, but were more theoretical in nature. Since students who are taught using experiential learning are supposed to develop learning through common observed experiences, it is logical to believe that the students would be able to make connections between their learning and certain life experiences. Hence, it is possible that if the students in both the experiential learning and traditional instruction groups were given more application problems, the results may have had greater significance. Finally, Huk (2013) highlighted that often, teachers have been forced to adhere to a presentational mode of teaching, and that students have become accustomed to that method of instruction. Therefore, students may not have had enough time to become acclimated to such a diverse pedagogical method as experiential learning, which in turn, prevented them from achieving as much as they could have.

### **Research Question Three**

Is there a difference in the mathematics achievement of African-American male students and African-American female students taking an experiential learning course (The Algebra Project) in College Algebra and those taking a traditional course in College Algebra?

### **Null Hypothesis Three**

There is no significant difference in the mathematics achievement of African-American male students and African-American female students taking an experiential learning course (The Algebra Project) in College Algebra and those taking a traditional course in College Algebra.

In order to assess the third research question, a 2x2 factorial ANOVA was conducted to ascertain whether there was a significant difference in the achievement levels of African-American female students and African-American male students who took a College Algebra course using either experiential learning or traditional instruction methods. The results from the ANOVA showed that African-American female students had a higher level of achievement than African-American male students in both the experiential learning and traditional instruction groups. Females in the traditional instruction group had the greatest number of questions correct, followed by males in the traditional instruction group, then females in the experiential learning group, and finally males in the experiential learning group. However, these results were not significant. Thus, the researcher failed to reject the null hypothesis.

The results of this analysis align with recent studies which have shown that the achievement gap between boys and girls is not as prevalent as it once was, and that in many cases, girls are outscoring boys in mathematics, on many measures. Stewart et al. (2017) admonished that current research has shown that the gender-math gap does not exist, or at least, is not as prevalent as it once was. Gherasim et al. (2013) found that the math achievement gap

between genders varies by grade level, all the way up through postsecondary education. Thus, while there may be some differences that exist in the mathematical achievement levels of males and females, changes in pedagogical methods appear to have aided in reducing the mathematics achievement gap that has persisted for so long. However, in contrast to the current study, Bansal (2014) found that both male and female students in experiential learning classes outperformed male and female students in traditional instruction classes, and also developed greater problem-solving ability. This finding may actually be consistent since the results of the ANOVA were not significant, and students were not tested on problem-solving ability but mainly on computation; subsequently, future research should test the differences in students' problem-solving ability.

### **Implications**

Over the years, many researchers have sought to understand the significance that experiential learning can have on students enrolled in mathematics classes. Kirschner et al. (2006) concluded that experiential learning is not effective as a reform method because it leaves the students in an unguided state, where misconceptions about the content frequently develop. However, no study had previously been completed that examined the effects of experiential learning, as implemented in The Algebra Project curriculum, on the anxiety and achievement levels of African-American students enrolled in College Algebra classes. Therefore, determining if pedagogical techniques as implemented through experiential learning, could effectively assist educators in making the experiences had by African-American students in higher-level math classes was of great necessity. Wynne and Moses (2008) lamented that too often, students of color are deterred from participating in upper-level mathematics classes, and that there is a need

to improve the access that these students have to upper-level math classes by increasing the success that the students experience in algebra classes.

The first implication of this study is that students who were enrolled in College Algebra classes taught using experiential learning did not have a significantly higher amount of anxiety than students in traditional instruction classes. Although the results were not significant at the  $p < .05$  level, this finding is important for educators who are looking to reform their classrooms so that students will be more willing to engage in complex mathematics courses. Bowe et al. (2017) admonished that helping minority students improve their perceptions of their learning environment can augment the amount of success that these students experience. By reducing the amount of anxiety that students have surrounding the content that they are learning, and by embedding their experiences in a familiar environment as The Algebra Project does, educators can reduce the math anxiety that students experience, and open up a new horizon of educational opportunity. This is especially essential for African-American students who traditionally have been marginalized in mathematics, often being relegated to developmental math courses and being stigmatized by stereotypes that stated that they were less interested in math (Chazan et al., 2013).

A second implication of this study is that African-American females who were taught using experiential learning, as implemented by The Algebra Project, experienced success in mathematics at the same or greater levels than males in the same group. Fryer and Levitt (2010) found that female students lagged behind male students in mathematics achievement within the first few years of starting school and identified that a key factor behind the development of this gender gap was that female students did not spend as much time studying mathematics. However, using experiential learning methods, girls are immersed in learning math and can



develop a greater understanding of the content firsthand, rather than simply listening to their instructor recite information. Additionally, since the females in this study were able to achieve mathematical understanding at the same levels as their male counterparts, it is possible that the female students may enroll in higher-level math classes at similar rates as the male students as well. Subsequently, schools that would like to have a greater impact on the math achievement of African-American female students could use experiential learning as utilized in The Algebra Project curriculum to augment their curriculum.

The final implication of this study is that although the results were not significant at the  $p < .05$  level, students taught using experiential learning did not lag behind their peers who were taught using traditional instruction methods. Essentially, there were no detrimental effects from experiential learning. The students completed the same midterm examination, and both groups performed at approximately the same level, even though the students in the experiential learning classes only completed a portion of the recommended curriculum. Knisley (2001) identified that there are many areas for which math instruction needs reform and suggested that experiential learning may benefit students who come with a myriad of learning styles. Hence, experiential learning as implemented by The Algebra Project may serve well as a teaching method that captures the interest of students and amplifies their natural abilities to understand and perform mathematics, as students in the experiential learning group performed just as well as their counterparts from the traditional instruction group.

### **Limitations**

There were a few limitations to this study that related to the setting and sample size of the study, the implementation of the teaching methods, and the time frame of the study. The first limitation is that this study took place at a single university over a one-semester period. All

participants in the study were enrolled in College Algebra courses during the spring 2018 semester. During the spring semester, there are typically fewer College Algebra class sections offered at the university. Conducting the study at multiple universities with similar student demographics would have provided more generalizable results.

The second limitation of this study is the relatively small sample size that was used for the experiential learning group. The experiential learning group consisted of less than half the number of participants than the traditional instruction group. This was due in part to the lack of instructors who were trained in experiential learning pedagogy. During the spring 2018 semester, only three instructors in the mathematics department at the university had been trained in The Algebra Project pedagogy. Of these three instructors, only one was assigned to teach College Algebra during the spring 2018 semester. Thus, the participants in the experiential learning group all were volunteers from the two sections of College Algebra that the instructor taught. The results of this study may have changed drastically if there had been multiple instructors teaching the participants from the experiential learning group, and the sample size may have increased as well.

A final limitation of this study was that the experiential learning curriculum was only implemented over a four-week period during the course of the semester. Although The Algebra Project's experiential learning curriculum consists of modules designed to be taught over a full-semester, the university was only implementing one of the modules which centered on the functions concept. The time constraints of the study may have significantly affected participants' anxiety levels as they may not have had enough time to become acclimated with such a drastically radical form of teaching and learning. If students had received a full-length College Algebra course taught with experiential learning, they may have become more

comfortable with that method of teaching, and their anxiety levels may have been impacted in a significant way.

### **Recommendations for Future Research**

Future research is necessary to determine whether or not experiential learning, as utilized in The Algebra Project curriculum, impacts the anxiety levels and achievement levels of African-American students in College Algebra courses. The researcher recommends the following suggestions:

1. Collect a larger sample size of students taught using experiential learning.
2. Assess the problem-solving abilities of students taught using experiential learning with those taught using traditional instruction methods.
3. Assess the anxiety levels of students in College Algebra courses that are taught using the full implementation of The Algebra Project curriculum with students in the experiential learning group.
4. Collect achievement data for the experiential learning and traditional instruction groups based upon a common final examination rather than midterm examination in order to allow for full implementation of the curriculum.
5. Implement experiential learning with a variety of instructors to determine whether or not specific instructors have a significant impact on the students' achievement.
6. Collect data from implementations of experiential learning from multiple universities which have students of similar demographic backgrounds.

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**APPENDIX A: Fennema Sherman Mathematics Anxiety Scale-Revised**

Name \_\_\_\_\_ Gender \_\_\_\_\_

Classification (Freshman, Sophomore, Junior, Senior) \_\_\_\_\_

Ethnicity \_\_\_\_\_ Age \_\_\_\_\_

*For each of the statements below, please select the number that best represents the extent to which you agree with each statement. For statements one through six, let one be strongly agree, with two being agree, three being undecided, four being disagree, and five being strongly disagree. For questions seven through twelve let one be strongly disagree, with two being disagree, three being undecided, four being agree, and five being strongly agree.*



Label	Full Item Statement					
Item 1	Mathematics doesn't scare me at all.	5	4	3	2	1
Item 2	It wouldn't bother me at all to take more mathematics courses.	5	4	3	2	1
Item 3	I usually don't worry about my ability to solve mathematics problems.	5	4	3	2	1
Item 4	I almost never get uptight while taking mathematics tests.	5	4	3	2	1
Item 5	I have usually been at ease during mathematics tests.	5	4	3	2	1
Item 6	I have usually been at ease in mathematics courses.	5	4	3	2	1
Item 7	Mathematics makes me feel uncomfortable and nervous.	1	2	3	4	5
Item 8	Mathematics makes me feel uncomfortable, restless, irritable, and impatient.	1	2	3	4	5
Item 9	I get a sinking feeling when I think of trying hard mathematics problems.	1	2	3	4	5
Item 10	My mind goes blank and I am unable to think clearly when working mathematics.	1	2	3	4	5
Item 11	A mathematics test would scare me.	1	2	3	4	5
Item 12	Mathematics makes me feel uneasy and confused.	1	2	3	4	5

Note: Fennema-Sherman Mathematics Anxiety Scale-Revised

**APPENDIX B: Permission to Use Instrument**

July 10, 2016

Siew Yee Lim

Dear Siew Yee Lim:

My name is Andrew Wynn, and I am a doctoral student from Liberty University writing my dissertation tentatively titled **THE EFFECT OF EXPERIENTIAL LEARNING ON MATHEMATICS ACHIEVEMENT AND MATHEMATICS ANXIETY OF AFRICAN-AMERICAN STUDENTS** under the direction of my dissertation committee chaired by Dr. Gary Kuhne. I would like your permission to adopt and reproduce to use your Revised version of the Fennema-Sherman Mathematics Anxiety Scale as the survey instrument in my research study. I would like to use the survey online and print your survey under the following conditions:

I will use this survey only for my research study and will not sell or use it with any compensated or curriculum development activities.

I will include the copyright statement on all copies of the instrument.

I will send my research study and one copy of reports, articles, and the like that make use of these survey data promptly to your attention.

If these are acceptable terms and conditions, please indicate so by signing one copy of this letter and returning it to me by e-mail at [awynn1@liberty.edu](mailto:awynn1@liberty.edu) or [wynn\\_ah@yahoo.com](mailto:wynn_ah@yahoo.com)

Sincerely,

Andrew Wynn  
Doctoral Candidate

---

Signature

Expected date of completion  
08/01/2017

Re: Request to Adopt Instrument  
Siew Yee Lim <lim.siewyee@gmail.com>  
Wed 8/17 Wynn, Andrew

Hi Andrew,

So sorry for my delayed response.

Yes, you have my permission to use the instrument for your study.

All the best!

Cheers!  
Siew Yee

## APPENDIX C: Consent Form

### Consent Form

**Study Title:** THE EFFECT OF EXPERIENTIAL LEARNING ON MATHEMATICS ACHIEVEMENT AND MATHEMATICS ANXIETY OF AFRICAN-AMERICAN STUDENTS

**Principal Investigator:** Mr. Andrew Wynn

“Your child is being asked to take part in a research study. This form has important information about the reason for doing this study, what we will ask your child to do, and the way we would like to use information about your child if you choose to allow your child to be in the study” (University of Chicago, 2015).

#### **Why are you doing this study?**

Your child is being asked to participate in a research study about the impact that experiential learning, using the Algebra Project mathematics intervention, has on African-American college students’ math anxiety. The purpose of the study is to determine if the intervention is beneficial for African-American students enrolled in Algebra classes.

#### **What will my child be asked to do if my child is in this study?**

Your child will be asked to complete two surveys in which he/she describes his/her experience in the math class and describe anxiety experienced throughout the course. Children’s names and social security numbers will not be used. The survey will be administered in the beginning and end of the semester.

We would like to video record [or audio tape] your child as he/she participates in the class to ensure proper implementation of the treatment. Students will be able to review the video before submission to ensure accuracy. The researchers will keep these tapes and surveys locked in the research lab at the central office and they will only be used by the researcher, the students’ teachers will not be allowed to access student surveys. We will only video record [or audio tape] your child if you and your child give us permission. Audio/Video recording is required for participation in this study. If you or your child do not wish to be recorded, it is not possible for your child to be in this study. Therefore, if you decide to decline participation, your child will be excluded from the study.

#### **What are the possible risks or discomforts to my child?**

The students will be introduced to the researcher in the beginning of the school year and will be interacting with the researcher within the classroom to ensure their comfort. The researcher will be screened and have a background check completed by the university before interaction with students or staff. Therefore, to the best of our knowledge, the things your child would be doing in this study have no more risk of harm than the risks of everyday life. However, your child may be uncomfortable with some of the questions and topics on the survey. If your child is uncomfortable, they are free to not answer or skip to the next question.

#### **What are the possible benefits for my child or others?**

Your child is not likely to have any direct benefit from being in this research study. This study is designed to learn more about the importance of the mathematics intervention for African-American students in Algebra classes. The study results may be used to help other people in the future.

**How will you protect the information you collect about my child, and how will that information be shared?**

Results of this study may be used in publications and presentations. However, no identifiable information will be utilized in the publications but student names will not be utilized.

Video/Audio recording will only be obtained by the researcher(s) and external auditors who will ensure accuracy and quality.

**Financial Information**

Participation in this study will involve no cost to you or your child. Your child will not be paid for participating in this study.

**What are my child's rights as a research participant?**

Participation in this study is voluntary. Your child may withdraw from this study at any time -- you and your child will not be penalized in any way or lose any sort of benefits for deciding to stop participation. If you and your child decide not to be in this study, this will not affect the relationship you and your child have with your child's school in any way. Your child's grades will not be affected if you choose not to let your child be in this study.

If your child decides to withdraw from this study, the researchers will ask if the information already collected from your child can be used.

**Who can I contact if I have questions or concerns about this research study?**

If you have any questions about your child's rights as a participant in this research, you may contact the researcher, Andrew Wynn, at (804)524-5949 or awynn1@liberty.edu.

**Parental Permission for Child's Participation in Research**

I have read this form and the research study has been explained to me. I have been given the opportunity to ask questions and my questions have been answered. If I have additional questions, I have been told whom to contact. I give permission for my child to participate in the research study described above and will receive a copy of this Parental Permission form after I sign it.

Initial one of the following to indicate your choice:

\_\_\_\_\_ (initial) I agree to...

\_\_\_\_\_ (initial) I do not agree to...

\_\_\_\_\_  
Parent/Legal Guardian's Name (printed) and Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Name of Person Obtaining Parental Permission

\_\_\_\_\_  
Date

Parents, please be aware that under the Protection of Pupils Rights Act (20 U.S.C. Section 1232(c)(1)(A)), you have the right to review a copy of the questions asked of or materials that will be used with students. If you would like to do so, you should contact [Principal Investigator] to obtain a copy of the questions or materials.

**APPENDIX D: Institutional Review Board Approval****LIBERTY UNIVERSITY**  
INSTITUTIONAL REVIEW BOARD

October 11, 2017

Andrew H. Wynn

IRB Approval 2982.101117: Impacting African-American Students' Mathematics Anxiety and Achievement through Experiential Learning

Dear Andrew H. Wynn,

We are pleased to inform you that your study has been approved by the Liberty University IRB. This approval is extended to you for one year from the date provided above with your protocol number. If data collection proceeds past one year, or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. The forms for these cases were attached to your approval email.

Thank you for your cooperation with the IRB, and we wish you well with your research

project. Sincerely,

**G. Michele Baker, MA, CIP**

*Administrative Chair of Institutional Research*

**The Graduate School**

**LIBERTY**  
UNIVERSITY.

*Liberty University | Training Champions for Christ since 1971*

## APPENDIX E: Sample College Algebra Syllabus

### Math 120: College Algebra COURSE SYLLABUS Fall 2015

**Instructor's Name:** \_\_\_\_\_ **Office:** \_\_\_\_\_  
**Instructor email:** \_\_\_\_\_ **Office Phone:** \_\_\_\_\_  
 Lecture Section \_\_\_\_\_ Days: \_\_\_\_\_ Time: \_\_\_\_\_ Room: \_\_\_\_\_  
 ALE Section #: \_\_\_\_\_ Days: \_\_\_\_\_ Time: \_\_\_\_\_ Room: \_\_\_\_\_

Instructor's Office Hours:

Monday	Tuesday	Wednesday	Thursday	Friday

#### Course Description:

Math 120 is a pre-calculus course in College Algebra. This course presents algebraic topics through integrated technology as well as applications to real-world contexts, requiring collaborative problem solving strategies. Content emphasis is on the following functions: linear, quadratic, polynomial, rational, exponential and logarithmic. Systems of equations are also addressed.

#### Attendance Policy:

The University absence policy will be adhered to, and applied equally to all students. This means that if a student is absent from class for a total of **one week's** worth of class meetings (for example, missing two lecture sessions and 1 ALE class), their grade will drop by **ONE WHOLE LETTER GRADE**. The same penalty applies to one full week of missed classes, or 4 class hours missed at various times through the semester. Note that an absence from an ALE session is a class hour missed. If a student is absent from class for 8 class hours, their grade will drop by **TWO WHOLE LETTER GRADES**, and so on. Refusal or failure to participate as directed by the instructor shall be counted as an absence. Missing more than 15 minutes of class (for example, coming late or leaving early) counts as 1/3 of an absence; missing more than 30 minutes of a class counts as an absence. An absence may be excused if the instructor deems the situation necessary. Missing class because of a "**Family emergency**" does not count as an excused absence.

**Late Assignment Policy:** MyMathLab and other assignments will NOT be accepted late except in exceptional circumstances, **at the instructor's discretion**. Any assignments the instructor allows to be submitted late may be assigned a penalty.

#### **Classroom Management Policies:**

- Set all cell phones to "**OFF**" or "**SILENT**" upon entering the class. (*DO NOT* set the phone to "**VIBRATE**".) **Then put your cell phone completely out of sight for the entire duration of the class!** No cell phone communication of any kind will be allowed during class for any reason. **Text messaging, sending email, internet usage, etc.** during class are *NOT ALLOWED*. You *MAY NOT* leave the



- classroom to answer a cell phone call. **Instructors may penalize students for cell phone usage.**
2. The computer lab in Room 22E HM is available for all students to do *MyStatLab* assignments on Monday-Friday from 9:00 a.m. to 5:00 p.m.
  3. **Disruptive behavior and cursing will not be tolerated at any time.** All students are expected to show respect to their instructors and classmates at all times. You should use the restroom PRIOR TO entering the classroom. Once class has begun, you should only leave the classroom for an extreme emergency and on very rare circumstances.

Class will begin and end promptly as scheduled. You should remain in your seat until class has been officially dismissed.

### **Required Course Materials**

Black Board account

Graphing Calculator: TI-83, or TI-84 (any edition, such as TI-84 Plus or TI-84 Plus Silver Edition, is suitable)

Notebook: a binder notebook, at least 1" wide, is required. Have this notebook to record notes during lectures, forums, and lab sections of Math 120 (do not use separate notebooks); do not use this notebook for any other courses or activities. The instructor may check your notebook periodically; part of your classwork grade may depend on the quality of your notes.

Optional Text: A electronic copy of the textbook is available in the MyMathLab course which you get automatically with this course. You will be able to access any materials that you would need through MyMathlab, including assignments from the textbook. However, if you would like a hard copy of the text, it is available in the Bookstore and possibly the Library.

The text is: Algebra, 9th Edition, by Michael Sullivan

### **Learning Outcomes:**

The essential objective for students in Math 120: College Algebra is to understand the relations between quantities in the real world. This means that a successful student will demonstrate their ability to:

- *comprehend the meaning* of data, presented in various forms;
- apply mathematical techniques to describe the relationship between data sets to *produce predictions, theories, and quantitative results*; and
- *interpret results* to the situation at hand, grasping the real world meaning of what they've produced.

The above outcomes require several prerequisite attitudes and abilities; a successful student will demonstrate the following problem solving tactics:

- a developed "intuition" in terms of what to do when presented with a problem;
- exploiting his or her understanding of the nature of a problem and its context to guide him or her to a solution;
- reflective thinking about the problem solving process;
- consciously applying the most efficient technique available;
- connecting new topics, problems, and situations with prior knowledge and understanding;
- experimentation, particularly trying an approach without being sure if it'll work;
- adapting to a new situation: constructing a new plan when the current technique isn't working; and

- finding and understanding mistakes, both to successfully solve the problem at hand and as a learning technique.

**Abilities**--a successful student should, after completing this course, be able to:

1. Construct a model based on a verbal description.
2. Given a table or graph of (discrete or continuous) data, choose an appropriate class of function to model the data, and transform a standard example function to align it to the data set.
3. Explain the implications of a model's formula and/or graph on the real-world situation being modeled. This includes making predictions based on the model, and critically describing the virtues and limitations of the model.
4. Use reading and writing to describe mathematical concepts.
5. Translate a graph or formula into a verbal description.
6. Outline a strategy for approaching, analyzing, and solving a given nontrivial problem.
7. Use MyMathLab, Smarthinking, and other technologies to engage in self-learning

**Skills**-- a successful student should, after completing this course, be able to:

1. Find the slope and equation of a line, given two points.
2. Evaluate a function at a given input value.
3. Given a graph of a function, classify the function (as one of the types in Knowledge Item 5), and describe its properties (those listed in Knowledge Item 4).
4. Given a graph of an invertible function, sketch the inverse function.
5. Find the zeros of polynomial and rational functions.
6. Solve linear systems of two equations in two unknowns.
7. Use a graphing calculator to graph a function and determine its properties, given a formula.
8. Use a graphing calculator to compute a linear, quadratic, or exponential regression, given a table of values.
9. Translate a graph into a table of numeric values and vice versa.
10. Simplify exponential and logarithmic expressions.
11. Given an exponential equation, write an equivalent logarithmic equation, and vice versa.
12. Change the base of a logarithmic expression.
13. Solve exponential and logarithmic equations.
14. Learn how to write technologically.

**Knowledge**-- a successful student should, after completing this course:

1. Know the slope formula and the slope-intercept form of a line.
2. Understand the concepts of function, graph, model, inverse function, and function composition.
3. Know the meaning of these function properties: formula, zeros, asymptotes, domain, range, intervals of increase/decrease, maxima and minima.
4. Know the form and properties of linear, polynomial, rational, exponential, and logarithmic functions.
5. Understand that mathematical problems are generally solved by consciously applying problem solving techniques and not by magic, strokes of genius, or rote memory.
6. Understand that the language of mathematics is constructed to be unambiguous.

7. Understand terminology used in algebraic problems, including distinguishing between solving (an equation), simplifying (an expression), and evaluating (a function)

**Evaluation and Grading:** The student's grade is computed as follows:

Midterm Grade:

Tests (2, 12.5% each)	25%
MyMathLab (Homework, Quizzes, and Study Plan)	20%
Class Participation, in-class homework and in-class quizzes	20%
Group Activities	20%
Midterm Exam	15%
<b>Total</b>	<b>100%</b>

\*: MyMathlab work has three online components: Homework, Quizzes and Study Plan. These components are weighted as follows: Homework 75%, Quizzes: 20% and Study Plan 5%. This is a cumulative score: as the semester continues, further work will increase the score from toward 100.

At the instructor's discretion, the percentages may be adjusted. Notice will be given to students if this occurs.

The online MyMathLab work is MANDATORY and a score of less than 25 of the 100 points at midterm results in an F. If the student achieves at least 25 MyMathLab points, the Midterm Average is determined as follows:

**Midterm Average**=  $.125(\text{Test 1}) + .125(\text{Test 2}) + 0.20(\text{MyMathLab points}) + .20(\text{Class Participation}) + .20(\text{Group Activities}) + .15(\text{Midterm Exam})$

Final Grade:

Tests (4 total, 10% each)	40%
MyMathLab (Homework, Quizzes, and Study Plan)	15%
Class Participation, in-class homework and in-class quizzes	10%
Group Activities	15%
Final Exam	15%
Midterm Exam	5%
<b>Total</b>	<b>100%</b>

\*: Achieving 50 of the 100 MyMathLab points is MANDATORY and not completing it results in an F. Achieving 90 of the 100 MyMathLab points is SUFFICIENT and completing it and passing ( $\geq 60\%$ ) the Final Exam results in at least a D grade. (This is not the only way to get a D; if the weighted average is greater than 60%, the student will get an appropriate passing grade.) If the student achieves 50 or more MyMathlab points, then the Final Average is determined as follows:

**Final Average**=  $.10(\text{Test 1}) + .10(\text{Test 2}) + .10(\text{Test 3}) + .1(\text{Test 4}) + .10(\text{Quizzes}) + .15(\text{MyMathLab points}) + .15(\text{Group Activities}) + .10(\text{Class Participation}) + .15(\text{Final Exam}) + .05(\text{Midterm Exam})$

The grading scale is: A ( 90 - 100 ) ; B ( 80 - 89 ) ; C ( 70 - 79 ) ; D ( 60- 69 ) ; F (59 and below). If the Final Average produces a grade of F, but the student achieved 90 of the 100 MyMathlab points AND scored at least 60% on the Final Exam AND does not have grade deductions due to absences, the Final Grade assigned will be a D instead.

**Important Note:** Students with documented disabilities are entitled to reasonable accommodation in accordance with the Americans with Disabilities Act. If this applies to you, first contact the Students with Disabilities Program, then privately inform the instructor so that appropriate instructional arrangements can be made. If you are not sure if this applies to you, or want more information, read the statement by the Students with Disabilities Program.

**Course Coordinator:**

## My Math Lab and Other events

Week and Events	Chapters Covered	Due on My Math Lab that week (Must do the Quiz)
Week of Aug 18 – Aug 22	Chapters R-2: Reviewing	Wed: Pre Quiz, Thurs.: HW #1, Fri: HW #2
Week of Aug 25 – Aug 29 <b>(Test 1)</b>	Chapter 3: Functions and Their Graphs	Mon: Quiz #1, Tue: HW #3, Wed: HW #4, Thurs.: HW #5, Fri: No homework
Week of Sept. 1 – Sept. 5 <b>(closed on Sept. 1)</b>	Chapter 3: Functions and Their Graphs	Mon: No quiz, Tue: HW #6, Wed: HW #7, Thurs.: HW #8, Fri: HW #9
Week of Sept. 8 – Sept. 12	Chapter 3: Functions and Their Graphs	Mon: Quiz #2, Tue: HW #10, Wed: HW #11, Thurs.: HW #12, Fri: HW #13
Week of Sept. 15 – Sept. 19 <b>(Test 2)</b>	Chapter 4: Linear and Quadratic Functions	Mon: Quiz #3, Tue: HW #14, Wed: HW #15, Thurs.: HW #16, Fri: HW #17
Week of Sept. 22 – Sept. 26	Chapter 4: Linear and Quadratic Functions	Mon: Quiz #4, Tue: HW #18, Wed: HW #19, Thurs.: HW #20, Fri: HW #21
Week of Sept. 29 – Oct. 3 <b>(Midterm Exams)</b>	Chapter 4: Linear and Quadratic Functions	Mon: Quiz #5, Tue: HW #22, Wed: HW #23, Thurs.: HW #24, Fri: HW #25
Week of Oct. 6 – Oct. 10	Chapter 5: Polynomial and Rational Functions	Mon: Quiz #6, Tue: HW #26, Wed: HW #27, Thurs.: HW #28, Fri: HW #29
Week of Oct. 13 – Oct. 17	Chapter 5: Polynomial and Rational Functions	Mon: Quiz #7, Tue: HW #30, Wed: HW #31, Thurs.: HW #32, Fri: HW #33
Week of Oct. 20 – Oct. 24 <b>(Test 3)</b>	Chapter 5: Polynomial and Rational Functions	Mon: Quiz #8, Tue: HW #34, Wed: HW #35, Thurs.: HW #36, Fri: HW #37
Week of Oct. 27 – Oct. 31	Chapter 6: Exponent and log Functions	Mon: Quiz #9, Tue: HW #38, Wed: HW #39, Thurs.: HW #40, Fri: HW #41
Week of Nov. 3 – Nov. 7 <b>(Test 4)</b>	Chapter 6: Exponent and Log Functions.	Mon: Quiz #10, Tue: HW #42, Wed: HW #43, Thurs.: HW #44, Fri: HW #45

Week of Nov. 10 – Nov. 14	Chapter 8: Systems of equations	Mon: Quiz #11 , Tue: HW #46, Wed: HW #47, Thurs.: HW #48, Fri: HW #49
Week of Nov. 17 – Nov. 21 <b>(Final Exams)</b>		

### Math 120: College Algebra Syllabus Contract

Name: \_\_\_\_\_

Section: Math120-16

Semester: Fall

Year: 2015

I have read and understand the Course Syllabus. I understand that I am responsible for adhering to the policies described in the syllabus, and that failure to do so may affect my grade.

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

Email: \_\_\_\_\_ Phone: \_\_\_\_\_

Major: \_\_\_\_\_

## APPENDIX F: College Algebra Midterm Exam

### MATH 120 Midterm Exam Form A

Name: \_\_\_\_\_

*Pledge: On my honor, I have neither received nor given aid on this test.*

Signature: \_\_\_\_\_

#### Part 1: Multiple Choices. Please circle the correct answer.

1. Find the average rate of change,  $\frac{f(b) - f(a)}{b - a}$  of  $f(x) = 5x^2 + 2x - 3$  from  $a = -2$  to  $b = 2$ .

- (a) -3      (b) 5      (c)  $\frac{-3}{2}$       (d) 2

2. Find the domain of  $f(x) = \sqrt{1-x}$

- (a)  $[1, \infty)$       (b)  $(-\infty, 1]$       (c)  $(-\infty, 1) \cup (1, \infty)$       (d)  $(-\infty, \infty)$

3. For the function  $g(x) = -3x^3 + 1$ , find  $g(-5)$ .

- (a) 376      (b) -374      (c) 374      (d) -376

4. Simplify  $(2x^2)^4$ .

- (a)  $8x^8$       (b)  $8x^6$       (c)  $16x^8$       (d)  $16x^6$

5. Find the line that contains the points (0, 8) and (3, 2).

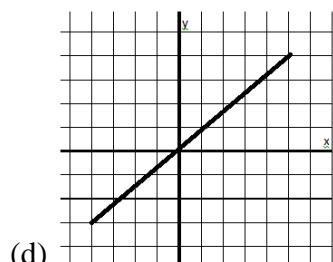
- (a)  $y = -2x + 8$       (b)  $y = 8x - 2$       (c)  $y = x + 8$       (d)  $y = 10x$

6. Determine whether the line function  $f(x) = -\frac{2}{3}x + 8$  is

- (a) Increasing      (b) Decreasing      (c) Constant

7. Circle the ones that are functions: (*There is more than one correct answer*)

- (a)  $y = 2$       (b)  $x = -4$       (c)  $\{(1, 2); (2, 3); (3, 2); (4, 3)\}$



**Part 2: Solve each problem and show your work in the space provided**

8. Using  $f(x) = 5x - 4$ , find the following:

a)  $f(x + 6) =$

b)  $f(x + h) =$

c)  $\frac{f(x+h) - f(x)}{h} =$

9. Using this function  $f(x) = 2x^2 + 3x - 5$  to find the following:

a) Domain: \_\_\_\_\_ b) Does it contain the point (1, 2)? \_\_\_\_\_

10) Tell the domain of  $f(x) = \frac{3x}{5x+6}$  in both interval and set-builder notation.

11) Given  $f(x) = x^2 + 9$ , find the following:

a)  $f(x - 4) =$

b)  $f(x + h) =$

c)  $\frac{f(x+h) - f(x)}{h} =$