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The Role of Math Anxiety and Math Self-Efficacy Levels on High School Equivalency Student Math Performance

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THE ROLE OF MATH ANXIETY AND MATH SELF-EFFICACY LEVELS ON HIGH SCHOOL EQUIVALENCY STUDENT MATH PERFORMANCE

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Abstract

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One of the most predominant measures of a community's appeal is the high school graduation rate. National "best places to live" ratings utilize educational statistics to rank the quality of life in a community (Morse & Brooks, 2020). Additionally, an individual's future prospects depend on a high school credential (HSC) as the minimum needed for postsecondary academics or gainful employment. One hindrance high school equivalency (HSE) students encounter is the inability to perform math sufficiently to earn an HSC due to the affective state of math anxiety and reduced math self-efficacy, particularly under pressure on tests/assessments. This quantitative study, using a stepwise process in multiple regression data analysis, identified a statistically significant relationship exists between an HSE student's math self-efficacy level and their math performance. The data analysis used the Mathematics Anxiety Rating Scale 30-item (Suinn & Winston, 2003), Math Self-Efficacy Survey (Nielsen & Moore, 2003), and math performance data, along with participant demographic data, and determined there exists no difference in levels of math anxiety or math self-efficacy among the different age, gender, or race/ethnicity groups participating in the study.

Keywords: math anxiety, math self-efficacy, high school equivalency, GED, high school credential, math achievement, math performance.

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Chapter 1: Introduction

U.S. News & World Report's (2021) annual "Best Places to Live" and U.S. high school dropout rates are more related than most people think. When searching for a place to live, a homebuyer investigates taxes, crime, and if they have children or plan on having children, the local school system. A person not focusing on high school credentials (HSCs) could be overlooking a key data point of how a community is rated, ranked, and measured (U.S. News & World Report, 2020). Community quality ratings are heavily dependent on an underappreciated metric: the high school graduation rate. According to *U.S. News & World Report*, when calculating community education quality "graduation rates are an important indicator of how well a school is succeeding for all its students" (Morse & Brooks, 2020, "Overall National Rankings," "Graduation Rates" section; U.S. News & World Report, 2020). In news stories featuring a summary of the local area where a news story occurred, invariably the discussion includes some mention of the high school graduation rate as a rationale for why the community is, or is not, cast in a positive light.

In a community where the high school graduation rate hovers in the range of 70% to low 80%, you may find home prices stagnant, unemployment elevated, and wages equally low (Hungerford & Wassman, 2004). A community thrives on an educated population, a population that can earn a living wage through better employment opportunities and possibly earn a trade certificate or enroll in postsecondary school (Hungerford & Wassman, 2004; Murnane et al., 2000). In a nutshell, earning an HSC is a key to a better community.

Similarly, many employers no longer need line workers; they need employees who can think and problem solve and who have a “piece of paper” saying they have the skills necessary to be productive (Charles et al., 2018; Hernandez, 2018). Many employers now value the HSC enough to send their adult workforce back to school to earn a high school equivalency (HSE) or, as a worst-case scenario, terminate workers for not having an HSC, making an HSC conditional for continued employment (Murnane et al., 2000).

These described situations are not extreme or unlikely. As our workforce moves towards more innovation and automation, the labor market leaves behind the uneducated workforce for more advanced cognitive skill sets required in a technological-based marketplace (Hernandez, 2018; Murnane et al., 1995). Where does that leave the high school dropout or adult who, until just a few years ago, did not need a diploma for a living wage? It leaves them aspiring to find an alternative way to get their HSC (Murnane et al., 2000).

HSE students may find themselves feeling a different sense of panic beyond the urgency of making a living wage for themselves or their families. They are suffering from anxiety separate from any other anxious state, which occurs specifically during the performance of one activity: mathematics. Realizing the need to perform math either on the job or on the General Educational Development Test (GED), the math-anxious student has a sudden sense of panic, frustration, pressure, and heightened anxiety (Ashcraft & Moore, 2009; Hembree, 1990; Richardson & Suinn, 1972; Tobias, 1993). The math-anxious student may also find themselves displaying physiological effects such as increased heartbeat, sweating, and nervousness (Faust, 1992; Richardson & Suinn, 1972; Tobias, 1993). Educators might wonder and investigate if this state of math anxiety is prevalent in their student population and what they can do about its effects on their students.

Knowing the importance of an HSC for the school and the community, it is possible to identify those at risk for not earning that credential (Murnane, 2013). For example, if math self-efficacy is a factor of student math performance leading to an HSC, it is important to identify those students who have the ability but not the belief to adequately perform on a high-stakes math assessment. Huang et al. (2018) highlighted how a student's mathematical self-efficacy impacted their performance on a math assessment and in turn their future consideration of math-oriented courses of study in college. Understanding how math anxiety or math self-efficacy affects students assists educators in identifying students with mathematical performance deficiencies. Identifying which affective state, math anxiety or math self-efficacy, has a greater impact on the student's performance, providing clarity on the approaches educators can use to ameliorate the condition. Increasing math self-efficacy or reducing math anxiety is expected to improve achievement outcomes, by extension a successful completion of an HSE program.

Statement of the Problem

An HSC is one of the first major educational achievements a person can earn and, in some communities, is a rite of passage or a major generational achievement having outsized impacts on the community at large (Bandura, 1997; Murnane, 2013). For some students, this achievement remains elusive and unattainable due to their inability to pass the necessary math courses required to meet state high school graduation requirements (North Carolina Department of Public Instruction, 2021). After not finishing high school, students may enroll in the local community college adult education program to finish their high school education as adult basic education (ABE) or HSE-level students. Once reenrolled in an HSE course, adult students returning to school are reminded of the negative emotions they had towards math, in the form of math anxiety (Nolting, as cited in Boylan, 2011; Jameson & Fusco, 2014). A student suffering from math anxiety feels a sense of pressure, nervousness and tension, fear, and thoughts of failure, as if there were an impenetrable wall or as if they were ready to fall off a cliff (Dowker et al., 2016; Gough, 1954; Tobias, 1993). For those HSE students, it is even more difficult to reengage due to the avoidance the student may have exercised over years of math aversion and anxiety (Choe et al., 2019).

Mathematics anxiety is more debilitating than it sounds. Math anxiety can be compounded by and confused with test anxiety or performance anxiety; however, math anxiety is a separate phenomenon, as it is only exhibited when performing mathematical functions in any context (Tobias, 1993).

Having math anxiety is not the only factor affecting student performance in math. Mathematics self-efficacy is another construct impacting a student's ability to perform mathematical functions, combined with, or in absentia from, math anxiety (Pajares & Miller, 1995). There are exceptions where a student's math self-efficacy remains sound despite a degree of math anxiety present, which differs based on gender and the existence of a growth mindset (Huang et al., 2018). Those students remain confident in their ability to perform mathematical operations despite the dread, fear, and nerves they experience with math anxiety (Huang et al., 2018). For those students seeking an HSC, we ask "is math self-efficacy a stronger factor on math achievement than math anxiety?"

The HSC metrics of a local community provide a quantitative snapshot of the employability of the local citizens, the quality of the local public school system, levels of housing prices, and indicators of mean household income levels and can also be an indicator of the general physical health of the population (Murnane, 2013; Murnane et al., 1995). Similarly, lack of education in a community can also indicate lower than average housing prices, wages, and increased addiction rates (Murnane et al., 1995, 2000). Understanding how the HSC figures into a community's economic, social, and physical health is reason to ensure more students are able to get an HSC. In short, it is of instructional interest to identify if a student is impacted by math anxiety or lowered math self-efficacy and if the math anxiety and math self-efficacy conditions affect student ability to perform well enough on a high stakes math assessment needed to earn their HSC.

Purpose and Significance of the Study

Graduating from high school, or earning an HSE, can have great impacts on student academic success, workforce options, and future physical and mental health. Students who do not earn a high school diploma are finding fewer and fewer jobs to provide a living wage, which impacts their housing, health, and economic future (Bandura, 1997; Murnane, 2013).

The intent of this study was to explore and identify if a relationship exists between mathematical anxiety, math self-efficacy, and the impact of the two constructs on the ability of an HSE student to earn an HSC. Understanding if either of the two conditions of math anxiety or math self-efficacy, either alone or in combination, are impacting HSE students informs instructors in providing interventions to improve math performance for greater HSC rates. Instructors and administrators in kindergarten through Grade 12 (K-12) could utilize the data to better support students needing to improve math performance.

The study participant group included adult students enrolled in an HSE program in five western North Carolina community colleges. HSE students were surveyed using the Mathematics Anxiety Rating Scale 30-item, hereafter referred to as the MARS 30-item (Appendix A; Suinn & Winston, 2003), and the Mathematics Self-Efficacy Survey, hereafter referred to as the MSES (Appendix B; Nielsen & Moore, 2003). For this study, math anxiety is defined as the emotional state exhibited by students when performing mathematical operations, and math self-efficacy is defined as the self-perception of a student’s ability to perform mathematical operations in both classroom and test contexts. Additional data such as participant demographics and elapsed time since attending school and having taken a math course were collected via a demographic survey which was omitted from final data analysis.

The results of this quantitative study aim to provide relevant data to school districts and HSE programs for improving their HSC rates by improving identification of math anxiety or math self-efficacy. A justification for improvement in these two affective conditions will improve math performance and, by extension, high school graduation rates, providing communities with an opportunity to improve residents’ economic, social, and physical health (Bandura, 1997; Murnane, 2013).

The objective of conducting a quantitative study on math anxiety and math self-efficacy effects on math performance supports the use of regression analysis to determine which independent variable, math anxiety or math self-efficacy, has a greater effect on math performance, allowing the study to view the association between the two variables (Urdan, 2017). Further analysis of covariance (ANCOVA) determined if other independent variables such as demographic characteristics were associated with math anxiety and math self-efficacy. The choice of a quantitative study is guided by the choice of quantitative measurement instruments, specifically the MARS 30-item and the MSES (Nielsen & Moore, 2003; Suinn & Winston, 2003). Both survey instruments provide response data suitable to quantitative analysis (Creswell & Creswell, 2018).

Local Context

Western North Carolina has a large number of manufacturing operations in the immediate area with approximately 700 manufacturing employers providing over 18,000 jobs (Asheville Chamber of Commerce, 2021). These companies are needing more educated employees as the regional economy evolves, with an increasing demand for skill sets in communications, engineering, and advanced manufacturing. For a job seeker in the local workforce, having an HSC creates potential for further training and trade certificates to meet the demand for advanced manufacturing jobs (Land of Sky Regional Council, 2015). Understanding the economic and social impacts of an HSC on a smaller community's workforce, specifically on the local employer's ability to hire and retain skilled employees, is a priority for the educational system.

In the North Carolina Community College System (NCCCS), adult education programs include ABE, HSE, and English as a Second Language (ESL) courses. Combined, these adult education programs are comprised of 33% Hispanic/Latinx participants compared to 29% participation of either Black or White students (NCCCS, 2019c); however, most literature referred to in this study addressed racial/ethnicity generally or focused on differences between White and Black populations only, with a dearth of research addressing Hispanic/Latinx adult education HSE students. This gap highlights a major population in North Carolina communities omitted from the literature of HSE math students.

Research Questions

The research questions to be answered by this study were

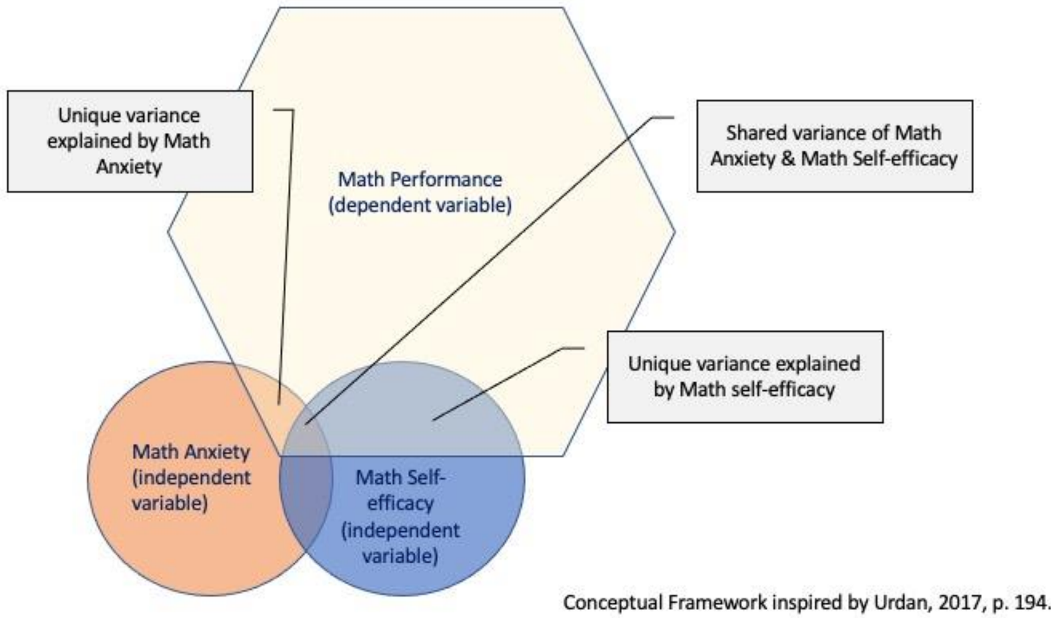
1. What is the relationship between math anxiety, math self-efficacy, and math performance in HSE students?
2. Which factor had a greater impact on HSE student math performance: math anxiety or math self-efficacy?
3. How does math anxiety differ across gender, age, and race groups?
4. How does math self-efficacy differ across gender, age, and race groups?

Conceptual Framework and Theoretical Constructs

The research study is illustrated as a conceptual framework of an adult population of HSE students who are working towards attainment of the GED or High School Equivalency Test (HiSET) HSE credential (Educational Testing Service, 2020; GED Testing Service, 2020). Study participants' math anxiety and math self-efficacy were measured, standardized assessment scores on math performance were collected, and students were surveyed to collect demographic data and further data on individual circumstances of math anxiety. Figure 1 illustrates the overall conceptual framework.

Figure 1

Math Anxiety, Math Self-Efficacy, Math Performance Conceptual Relationship Framework



Note. Conceptual framework adapted from Urdan (2017, p. 194).

The Math Anxiety, Math Self-Efficacy, Math Performance Conceptual Relationship Framework in Figure 1 illustrates the relationships of the study as they are aligned to the research questions and data gathered. The study sample of HSE students was measured using the MARS 30-item and MSES instruments in hard copy form (Nielsen & Moore, 2003; Suinn & Winston, 2003). A survey collecting demographic data such as age, gender, and race/ethnicity plus elapsed time since taking a math course and attending school was utilized (Appendix C). The Math Anxiety, Math Self-Efficacy, Math Performance Conceptual Relationship Framework connects the independent variables of math anxiety or math self-efficacy and their effect on a participant's math performance. The math performance levels were measured on the standard HSE (adult education) Test of Adult Basic Education (TABE) or the Comprehensive Adult Student

Assessment System (CASAS) Goals assessments (CASAS, 2021; Data Recognition Corporation [DRC], 2019a). The relationship of math anxiety levels or math self-efficacy levels was analyzed via multiple variable regression analyses to determine which has a greater effect on the participant's math performance as measured on the CASAS Goals math or TABE math assessment (CASAS, 2021; DRC, 2019a).

Math anxiety, as an affective state that inhibits a student's ability to perform mathematical exercises, is one of the two key variables measured in this study as a possible indicator or predictor of mathematical achievement. Math anxiety is theorized as a separate construct from general anxiety in its specificity to math activities. Math anxiety manifests in the student as a feeling of helplessness, tension, or a sense of panic (Richardson & Suinn, 1972; Tobias, 1993). The intensity, or level, of math anxiety of HSE students was examined as an independent variable on the student's math performance.

Math self-efficacy, an additional but separate affective state a student has of their perceived ability for performing math behaviors, is another variable in this conceptual framework. Math self-efficacy is defined as a person's judgment of their own capabilities (Bandura, 1997). Self-efficacy theory poses a person's self-efficacy, as a judgment of their own abilities, is created through social learning experiences which can include vicarious and direct experiences (Bandura, 1971). This judgment of self-efficacy is similar to but separate from other self-concepts of ability as it is specific to math behaviors (Pajares & Miller, 1995). Math self-efficacy is theorized to have an impact on a student's ability to achieve in math in different contexts (Pajares & Miller, 1995). Levels of math self-efficacy were examined in their relationship to a student's math performance.

Limitations of the Study

Student data are limited to those students who consented to participate. Additional limitations include the number of participant sites that permitted me to solicit adult student participation for research. Five western North Carolina community college sites with HSE programs were solicited; however, only four sites, identified as Sites A, B, C, and E, participated in the study. At the site level, the ability of students to participate was limited by instructor willingness to allow student participation and site Institutional Review Board (IRB) approval to conduct research. Understanding the number of survey items in total, survey fatigue may have been another limitation for participants of this study. The research design described actions to alleviate or prevent survey fatigue in participants. A further limitation may exist in the diversity of participants, which is limited to volunteers willing to participate in this study.

Delimitations of the Study

Conducting a study of HSE program students in a defined geographic region is the most efficient method of assessing a population of adult learners enrolled in similar HSE programs. I have chosen HSE programs in six western North Carolina counties. One delimitation of this study is the study focused only on HSE programs at those sites, understanding the sites offer other programs for adult learners at lower levels. Additionally, a delimitation of participant student age limited participation to students over 18 and considered “adult,” eliminating the need for parental consent and student assent for those under the age of 18.

There are two delimitations pertaining to the choice of research data collection tools available to measure the constructs of math anxiety and math self-efficacy. The MARS 30-item is a delimitation, chosen for this study due to its length of questions, reliability, and its notation as the latest appropriate tool (Suinn & Winston, 2003). This 30-question survey provides enough questions regarding math anxiety without intimidating study participants. Suinn and Winston (2003) conducted a test-retest reliability of the brief version of the MARS with an alpha of .90, nearly equivalent to the .91 rest-retest reliability of the original 98-item instrument. The shorter 30-item instrument has acceptable reliability and validity compared to the original, longer version and was appropriate for the context of this study and the study sample (Suinn & Winston, 2003).

The MSES (Nielsen & Moore, 2003) is another research data collection tool delimitation, chosen to provide quantitative data on student perceptions of self-efficacy related to mathematical thought and performance. The 2003 instrument measures a student's math self-efficacy beliefs across two mathematical contexts of classroom and test contexts. The 9-item, 5-point Likert scale instrument requests student self-perception of their ability in the nine content areas of math, considering their abilities in either the classroom or test context (Nielsen & Moore, 2003). The MSES separate summated scores had high correlations of $r = 0.74$, with an internal reliability of MSES-class and MSES-test Cronbach alphas of 0.86 and -.90 (Nielsen & Moore, 2003).

A demographic survey created for this study, as an additional data collection delimitation, collected student demographic data such as age, gender, and race. The researcher-created demographic survey did not collect any participant identifying data and was provided in both paper and online format for student flexibility of participation, and participants were allowed to decline response to any or all demographic survey items. The item for gender included three categories: female, male, and nonbinary. The survey item for race included the following categories: White/Caucasian, Black/African American, Hispanic/Latinx, Asian American-Pacific Islander (AAPI), and Other/Mixed Race. The survey, included in Appendix C, asked participants to specify the number of years since they last attended school and the number of years since having taken a math class. Order of administration for the three survey instruments was randomized and breaks were provided between surveys to ameliorate possible participant survey fatigue and counterbalance any construct irrelevance related to survey fatigue.

Assumptions of the Study

To conduct this study several assumptions were held. The first assumption was the honesty of participants in responding to the MARS 30-item and MSES. It is assumed participants have provided honest responses when completing the MARS 30-item and the MSES and have completed each instrument in its entirety. It is also assumed participants who volunteered to participate in this study completed the study and did not withdraw before all data collection was completed. The researcher also assumed participants have achieved an adult secondary education (ASE) level score at the National Reporting System for Adult Education (NRS) Level 5 or 6 in order to be enrolled in the HSE program (NRS, 2019). Finally, the researcher assumed math assessment scores obtained through the TABE 11/12 or the CASAS Goals instruments, as scored by the respective sites, provided accurate measurements of participant math skills (CASAS, 2020b; DRC, 2017; Jacobsen, 2020).

Definition of Relevant Terms

High School Credential

An HSC can be either a high school diploma, earned after a student meets the state department of public instruction requirements for high school graduation, or an HSE, which takes the place of a high school diploma. Those credentials include a GED or HiSET (Educational Testing Service, 2020; GED Testing Service, 2020).

High School Equivalency

An HSE is a certification earned outside of the traditional high school that has the same value of a high school diploma, often obtained for eligibility to enroll in postsecondary education and to meet minimum employment requirements. To achieve HSE, the student must pass an exam administered by a recognized agency such as GED Testing and HiSET (NCCCS, 2019c). In some postsecondary academic programs, an HSE is not acceptable for admission.

Mathematics Anxiety

Mathematics anxiety was first discussed by Gough (1954) as a condition called “mathemaphobia.” Gough felt students displayed an intense dislike, complete aversion, or immense debilitating fear when asked to perform mathematical functions. Tobias (1993) further defined the phenomena as mathematical anxiety exhibited through a feeling of helplessness, tension, and a sense of “sudden death” (p. 51). The abbreviated term math anxiety is used interchangeably with mathematics anxiety in this study.

Mathematics Attitude

Mathematics attitude is the emotional feeling a student develops from a combination of confidence in math skills and performance, math anxiety, value and enjoyment of math, and motivation towards math (Tapia & Marsh, 2004).

Math Performance

Math performance in this study is defined as the student's quantitatively measured performance, exhibited by numerical scores, as measured on a standardized math assessment. Math performance in this study includes math scores from the CASAS Goals or TABE 11/12 standardized math assessment as administered by the study participants' sites (CASAS, 2021; DRC, 2019a).

Mathematics Rating Scale

A mathematics rating scale is a measurement tool developed by researchers intended to quantitatively measure a student's math anxiety. A few versions of a math rating scale include the 98-item Likert scale instrument created by Richardson and Suinn (1972) and a revised version by Plake and Parker (1982). A 30-item version of the original MARS, the MARS 30-item is utilized in this study (Suinn & Winston, 2003).

Mathematics Self-Efficacy

Mathematics self-efficacy is an individual's judgment of their capabilities to perform and solve specific math problems and their own perception of their ability to perform in math-related classes or on math tests (Nielsen & Moore, 2003). The abbreviated term math self-efficacy is used interchangeably with mathematics self-efficacy in this study.

Nontraditional Student

Nontraditional students are defined by several criteria including age, family dynamics, and employment status. For this study, a nontraditional student is aged 18-24, has returned to secondary school to earn an HSC, is financially independent, and may have children, spouses, and full-time employment (U.S. Department of Education Statistics, National Center for Education Statistics [NCES], 2020). Participants in this study may meet any of the above criteria, but they must be adults (18+) and actively enrolled in an HSE program at one of the five sites included in this study.

Test Anxiety

Test anxiety is an affective condition that is presented only during test or assessment situations. Test anxiety is not subject matter specific and presents itself under assessment situations where there is considerable pressure to perform well on the assessment (Zeidner, 1998).

Organization of the Study

In this section, I outline the plan for the study of the relationship between math anxiety, math self-efficacy, and the ability to earn an HSE. I justified conducting the study by including the relevance of earning an HSC for not just the student but also the larger community. For instructors, the pertinence for this study may be a greater realization that math anxiety and math self-efficacy have crucial impacts on their students' success to earn an HSC. In Chapter 2, I review the literature on math anxiety, math self-efficacy, and their impacts on various aspects of performance. I address the characteristics of the two conditions of math anxiety and math self-efficacy as constructs separate from other psychological conditions such as generalized anxiety and general self-efficacy. The literature also addresses differences in these conditions for gender, age, or racial/ethnic backgrounds. In Chapter 3, I discuss the methodology I employed in collecting and analyzing data. I explain my target study population, the quantitative measurement instruments selected, data collected from those instruments, and the data analysis methodology utilized. In Chapter 4, I present the data collected throughout the study and present an analysis of the data collected. The discussion of the data, including the analysis and any other findings of note regarding gender or race disparities, is included in Chapter 5. I also provide, based on the data analysis, recommendations for instructors of the HSC populations to enhance their ability to earn an HSC.

Chapter 2: Literature Review

The purpose of this study was to examine the relationship between participants' math anxiety levels, math self-efficacy levels, and math performance. The literature review has two main areas of focus corresponding to math anxiety and math self-efficacy and their separate or combined relationships with student math performance in multiple academic settings. I provide further exploration of literature examining math anxiety and/or math self-efficacy on demographic variables such as gender, race, and age.

To examine literature related to the constructs of math anxiety and math self-efficacy, I searched for current, peer-reviewed articles falling within the time frame of 2010-2020 via the Gardner-Webb University library. Databases utilized included Academic Search Complete, ERIC, JSTOR, Proquest Central, Proquest Dissertations and Theses Global, PubMed, and Sage Journals online access. Google Scholar was also used for open-access articles. The following search terms were used to locate articles specific to this study: math anxiety, math self-efficacy, math performance, adult education, high school equivalency, student math achievement, graduation attainment, math anxiety rating sale, math self-efficacy survey, gender bias, stereotype threat, and self-concept. Variations of these terms were used to ensure exhaustive search results.

Theoretical Foundations

Students who suffer from the psychological effects of math anxiety may perceive themselves to be the only student experiencing this high level of anxiety. Those students who suffer from math anxiety suffer debilitating emotions affecting their performance on math assessments or in math activities. After having progressed to high school, or even once they are in postsecondary coursework, math-anxious students have a well-developed math anxiety solidified over many years. For many of these students, they may be able to recall their first incidence of math anxiety and also may be able to recall a specific time or place when they understood math was something to be feared or disliked. Whatever level of their math anxiety, the student may wonder why these "full-fledged syndromes of anxiety and avoidance" (Tobias, 1993, p. 32) developed. Math-anxious students experience psychological and physiological effects as a result of their math anxiety, feeling like they are "falling off a cliff" (Tobias, 1993, p. 51) or experiencing sudden death. Others experience feelings of tension and frustration and even shed tears (Ashcraft & Moore, 2009; Young et al., 2012). More importantly, students experiencing math anxiety often have lower degrees of math performance in both test and classroom situations resulting from pervasive anxiety, ultimately interfering with their manipulation of numbers and math problem solutions (Dowker et al., 2016). The condition of abject fear of performing math under a high-stakes situation results in less-than-desired performance on tests and reduction in the ability to learn and sabotages the student's confidence in their own abilities, known as their self-efficacy (Bandura, 1986, 1997; Dowker et al., 2016).

In addition to understanding math anxiety and how it impacts mathematical performance, it is equally important to understand the impacts related to a person's level of mathematical self-efficacy. General self-efficacy is a person's understanding of their own ability (Bandura, 1997). Often a person's belief in their own ability can positively, or, in the case of belief in inability, negatively impact their performance in the attempted task (Bandura, 1997). In the specific situation of math self-efficacy, how does a person's belief in their own mathematical abilities impact their mathematical performance?

Our role as educators has always been to prepare students for a productive life outside of school and with the current workforce requirements; it is important for educators to ensure their students have the mathematical skill sets required to perform work in these job sectors. Historically, education during the industrial revolution focused on skill sets of rule-following, repetitive tasks, and written and verbal communication with very little focus on problem-solving, critical thinking, or abstract concepts (Wagner & Dintersmith, 2016). With more technological advances, a more globally connected society at large, and much more emphasis on research, science, and medicine, educators must adjust instruction to meet those desired skill sets for a modern workplace (Friedman & Mandelbaum, 2011; Wagner & Dintersmith, 2016). Mathematical skills such as reasoning, number sense, problem-solving, and abstract thinking are becoming increasingly important in education as they are increasingly crucial in current employment sectors (Hernandez, 2018). The jobs for mathematicians and statisticians and other technical careers that include numeracy skills and critical thinking are expected to grow 30% in the next 10 years. This job growth is faster than the average job growth for all other occupations, as employers need employees who can not only perform and think mathematically but can provide analysis of data (U.S. Bureau of Labor Statistics, 2021b; Hernandez, 2018).

Can the average person who suffers from math anxiety simply ignore it and choose a different career field to avoid math altogether? Unfortunately, mathematical skill sets are no longer reserved for the select few who have a “math brain” or “math gift” (Boaler, 2016, p. 5) but are applicable in all job sectors and have thus created a greater priority in overall education and workforce development (Tobias, 1993).

In this section, I present the research literature to date which studied the causes of math anxiety, its relationship to math self-efficacy, and how those two affective domains affect student achievement. The discussion reviews literature studying the relationship of math anxiety and math self-efficacy levels as impacted by student demographics such as age, gender, and race. Understanding this literature helps the researcher and reader form a cohesive picture of literature already published, noting areas of concern not yet explored.

I discuss studies examining the relationship of stereotype threat through the lenses of gender, age, or race as variables between math anxiety, math self-efficacy, and math performance as they relate to my current study. However, while stereotype threat exists in gender, age, or racial identities, my discussion centers on the relationship, if any, of those variables on math performance (Beilock et al., 2007; Boaler, 2016; Jameson & Fusco, 2014; Steele, 2010; Steele & Aronson, 1995).

Theories of Mathematics Anxiety

Mathematics anxiety was first explored as a phenomenon as early as the 1950s as mathemaphobia by Gough (1954), followed by Richardson and Suinn (1972) in the 1970s, and by Tobias (1993) and Ashcraft and Faust (1994) in the 1990s. Math anxiety research focused on math anxiety as a valid psychological state worthy of reliable measurement in educational research. Tobias (1993) wrote *Overcoming Math Anxiety* seeking to manage, prevent, or overcome the debilitating condition for math-anxious students and adults.

Mathematics anxiety was theorized as an anxiety separate from other psychological anxieties such as test anxiety or social anxiety, and researchers sought to quantitatively measure math anxiety and determine relationships between math anxiety, math achievement, or math attitudes. Richardson and Suinn (1972) thus created the first math anxiety instrument to measure levels of math anxiety (Ashcraft & Moore, 2009; Dowker et al., 2016; Hembree, 1990). The MARS initially developed by Richardson and Suinn provided one of the first valid and reliable instruments for measuring math anxiety across a broad population through a 95-item survey, allowing researchers the ability to analyze a relationship between math anxiety and math performance. Subsequent variations of the MARS instruments, including the instrument to be used in this study, the MARS 30-item are considered similarly psychometrically valid and reliable (Suinn & Winston, 2003). Other researchers developed instruments based on the initial MARS to fit various populations such as children or adolescents or have adjusted the MARS to be shorter and easier to administer. Bai (2010), Baloglu (2002), Chiu and Henry (1990), and Hopko (2003) developed variations of the original MARS to accommodate the age or focus of the population being surveyed.

Considering math performance and subsequent achievement is of increasing importance in academic and professional settings, educators must examine ways in which math performance is affected, either by examining student levels of math anxiety or by other factors such as math attitudes and math self-efficacy, to improve student math performance (Luttenberger et al., 2018). Further studies focused not on whether math anxiety existed but more on the conditions creating math anxiety and situations when math anxiety negatively affected math performance, math achievement, college major, and career path decisions (Luttenberger et al., 2018; Tobias 1993). It is this research on the effects of math anxiety that is of importance to educators: the effects of mathematical anxiety on student math performance.

A meta-analysis of data in studies focusing on the early development of math anxiety and variables such as mathematical processes in the upper elementary grades showed that math anxiety had a negative impact on performance of tasks measuring conceptual knowledge and application of mathematical operations (Luttenberger et al., 2018). This meta-analysis also found teachers, parents, and other important adults influenced children's math attitudes early in their academic experience, further affecting math performance (Luttenberger et al., 2018). Specifically, the study found teachers fostered positive or negative math attitudes when communicating their own attitudes towards math to the students in the classroom. In middle school (upper elementary years), the introduction of mathematical reasoning and abstract thinking could further exacerbate math anxiety (Odom, 2010). Over a student's math education, mathematical reasoning is introduced in kindergarten with numeracy and number sense. Counting and concepts of addition and subtraction develop in those early years, along with the understanding of mathematical operations such as multiplication and division in subsequent grade levels (U.S. Department of Education, 2010). Acquisition of multiplication and division skills in the second and third grades transitions student math conceptual understanding from concrete to more abstract reasoning and larger number sets (Dowker et al., 2016; U.S. Department of Education, 2010; Wu et al., 2012). Studies such as Luttenberger et al. (2018) and Odom (2010) provided a developmental background to the development of math anxiety and math anxiety's impact on future math performance.

Theories of Mathematics Self-Efficacy

Bandura (1997) discussed self-efficacy as a social-cognitive construct, defining it as a different psychological construct than self-perception, self-concept, and self-esteem.

Self-efficacy is the belief, built through experiences, individuals hold of their abilities. Self-efficacy beliefs often provide the baseline motivation for how individuals further act and behave (Bandura, 1971, 1997). Self-efficacy affects everything we do, influencing our motivations towards an activity, including math. Once leaders in the field of math instruction accepted there could exist a psychological state separate from other affective domains, math anxiety could be examined in its relationship to how students viewed their own ability or self-efficacy. Some students were shown to have higher levels of self-efficacy, unaffected by any math anxiety they experience, and other students had serious impacts on their self-efficacy as a result of math anxiety (Richardson & Suinn, 1972). In mathematical achievement terms, a person's math self-efficacy meant they had the skills and abilities to control how they engaged in mathematical thought and action, thereby having the self-efficacy to control their math achievement and performance (Bandura, 1997).

A person's self-efficacies can vary in their robustness or strength and their generality. For example, a student's self-efficacy can vary depending on the topic in math, such as fractions or geometry. A student may have a high level of self-efficacy at basic geometry, but this self-efficacy can wane as the geometry becomes more complex. A student's math self-efficacy is independent of their beliefs in their abilities to perform other tasks; in other words, a student's math self-efficacy is specific to math but may also be specific to a particular domain in math such as algebraic thinking, linear equations, or geometry (Bandura, 1997). Student self-efficacy is developed through four main avenues: verbal clues or encouragement, actual experienced successes of any magnitude, vicarious exposure to others' successes in the same task, and the physiological cues the body provides the student (Bandura, 1997). The physiological cues of sweaty palms, increased heart rate, or rapid breathing can often be misinterpreted by the student as a negative affective reaction due to stress, nerves, or anxiety. The body's response to a positive interaction, such as a date with someone very attractive or the anticipation of getting ready for a big event such as an important football game, is often the very same physiological response as anxiety: sweaty palms, increased heart rate, and increased respiratory rate. It is the misinterpretation of the similar physiological response, as a negative sign may be interpreted by the math student as a signal of a potentially negative event or negative emotions, leading to evaluation of the physiological response as indicating lack of confidence from inability (Bandura, 1997; Herts & Beilock, 2017; Jamieson et al., 2010).

Nash and Kallenbach (2009) discussed the use of self-efficacy as a tool to encourage adult learners to persist in their education and how instructors of adults can tap into adult student agency, motivation, and feelings of self-determination to build student self-efficacy in ABE. Ultimately, the key to ABE student motivation and persistence in math was self-efficacy.

How math self-efficacy differs from self-perception and self-concept is how self-efficacy in math relates to the actual math performance demonstrated (Bandura, 1997; Pajares & Miller, 1995; Skaalvik & Skaalvik, 2004, 2006). Skaalvik and Skaalvik (2004) studied how math self-efficacy and self-perception were related to math achievement. Skaalvik and Skaalvik (2004) defined math self-efficacy not as a source of action but as a product of a variety of influences, such as math achievement results combined with a person's self-perception of their mathematical skill. Further, Skaalvik and Skaalvik

(2006) defined math self-efficacy as a product of a person's math self-perception, and math self-perception was influenced by a person's achievement in math, not the other way around. While a person's mathematical self-efficacy affects everything related to their activities, thoughts, and motivations in math, self-efficacy beliefs are more complex than math self-concept because they can vary within math and in varying levels of self-efficacy (Bandura, 1997). For instance, a student may have high self-efficacy with geometric concepts but low self-efficacy about algebraic equations or word problems.

The Relationship of Mathematics Anxiety and Math Self-Efficacy

Mathematics self-efficacy is addressed in key studies by Pajares and Miller (1995), Skaalvik and Skaalvik (2004), and Skaalvik and Skaalvik (2006). In Pajares and Miller's study of self-efficacy across multiple academic environments, they found when you consider math anxiety as an emotional construct influenced by the student's self-efficacy beliefs, you begin to see there may be a reciprocal relationship between math self-efficacy and math anxiety (Pajares, 1996, 2002b; Pajares & Miller, 1995). Pajares and Miller went further to draw the lines between how a math-anxious person experiencing low self-efficacy could develop the thought process that certain subjects–math in this case–are tougher than they really are. For the math-anxious students, having a low self-efficacy may further exacerbate math anxiety, generating more intense doubt of the student's own math abilities. Pajares and Miller posited self-efficacy beliefs, such as a student's low or high math self-efficacy, are strong determinants and predictors of a student's mathematical accomplishment. Low self-efficacy in math, due to high math anxiety levels, further sets up the student to expect poor math performance; however, Pajares (1996) specifically stated studies correlating math self-efficacy beliefs to math expectancy have been inconclusive, and most results are ambiguous. Pajares and Miller ultimately determined the difference in math self-efficacy and math performance was dependent on the student's gender; males exhibited more math self-efficacy which did not directly correspond to their math performance, while females who had lower math self-efficacy demonstrated greater math performance (Pajares, 2002a; Pajares & Miller, 1995).

In more recent studies of the relationship of math anxiety and math self-efficacy, Federici et al. (2015) denoted math anxiety as an emotional state distinct from the state of test anxiety. Their study highlighted a negative relationship of math anxiety to math self-efficacy, a relationship that was specific to the student goal settings. The results inferred math anxiety had a more significant effect when students were focused on achieving performance goals, i.e., test results, compared to students focusing more on concept mastery (Federici et al., 2015). Their study largely focused on student motivation and how math anxiety influenced student math self-efficacy (negatively) and further impacted student motivation to persist in math.

Similarly, according to Siebers (2015), there is a solid relationship between a student's math anxiety levels and their subsequent achievement. While Bandura (1997) highlighted how generalized anxiety relates to generalized self-efficacy in his studies in social-cognitive development, Ashcraft and Moore (2009), Bai (2010), and Larson et al. (2015) drew correlations specific to math anxiety and its specific effect on math self-efficacy.

My study endeavored to understand if a relationship exists between a student's math self-efficacy and mathematical anxiety level and mathematical performance, with possible relationships between math anxiety and math self-efficacy variables between gender, age, and race/ethnicity demographic groups. The purpose of this research was to determine if these relationships impacted adult HSE student math performance, ultimately affecting the ability to achieve an HSE credential (Ashcraft & Moore, 2009).

Theories on Factors Affecting Math Performance

A trend in the employment market is the increasing importance of mathematical knowledge for postsecondary jobs and employee wages (Murnane et al., 1995). Since the 1970s, technological growth in the job market has dictated students develop more mathematical and analytical skill sets to meet the growing demand in the postsecondary workforce and educational pursuits (Betz, 1978; Murnane et al., 1995). Growing analytical skill needs in the job markets become more pertinent with the shift away from U.S. manufacturing jobs to more innovation and technology jobs (Friedman & Mandelbaum, 2011; Hernandez, 2018; Wagner & Dintersmith, 2016). As a result, the educational systems have placed more and more emphasis on mathematical skills and mathematical achievement in elementary and secondary schools to prepare students for an evolving job and academic market (Wagner & Dintersmith, 2016). A stronger focus on mathematical reasoning skills is demonstrated in the multiple curriculum programs developed by the U.S. Department of Education, such as No Child Left Behind, Race to the Top, and its companion, the Common Core State Standards. These programs all emphasize improving U.S. student skills in reading and math, with further emphasis on college and career readiness (U.S. Department of Education, 2020).

The relationship of math self-efficacy and its effects on motivation, persistence, and math achievement is reliant on the degree to which math anxiety influences those individual belief systems (Bandura, 1986, 1997; Boaler, 2016; Federici et al., 2015; Pajares, 1996). Similarly, gender and gender bias and how a person's self-efficacy in math can be affected by outside prejudices of what they should and should not be adept at doing can also affect motivation and persistence in math (Boaler, 2016).

Many studies examined in the literature review connected a student's math anxiety to further math achievement and math performance; however, few studies discussed how students could be impacted on the first clear educational certificate: the high school diploma.

In the mid-19th century, the high school diploma was the baseline requirement for many jobs providing a living wage (Murnane, 2013). With and since the industrial growth in technology, the high school diploma is no longer "good enough" to get a good wage job for the rest of your life. The high school diploma is typically the minimum requirement to obtain a low-wage job, with further education needed to earn a living wage (Murnane, 2013; Rose, 2013). High-wage factory jobs not requiring a high school diploma are decreasing in number; and as an adult education instructor, I have seen multiple students arrive in the ABE program aiming to get a GED because their employers require a high school diploma or its equivalent for continued employment.

At the time of this study, high school diploma requirements include algebraic reasoning and computational skills for high school graduation. In North Carolina, there are two types of high school diplomas: the traditional high school diploma and the Occupational Course of Study (OCS) diploma. The OCS diploma differs from a traditional high school diploma by certifying OCS graduates have demonstrated basic minimum academic and life skills such as being able to report to work, read a clock, and demonstrate functions necessary for independent living (North Carolina Department of Public Instruction, 2021). The OCS diploma prohibits the graduate from enrolling in curriculum coursework at a community college but allows the student to obtain employment in positions requiring a high school diploma as a condition for employment. The third option for an HSC is an HSE such as the GED or HiSET (Educational Testing Service, 2020; GED Testing Service, 2020). These programs enable the student to work at their own pace to gain the basic skills needed to earn the equivalent of a high school diploma studying English/language arts, social studies, science, and math coursework. HSE programs usually attract students who have dropped out of high school or may have been incarcerated before high school graduation (Rose, 2013).

What is important in discussions of a high school diploma and HSE is awareness of changes/growth in technology in the manufacturing sector. The high school diploma is now a minimum credential a student needs to gain employment. Even with a minimum credential, high school graduates are not likely to earn as much in their lifetime with the same high school diploma as in the past (McLendon, 2017; Murnane et al., 1995, 2000; Rose, 2013). Trends in technological industry and workforce readiness are of greater importance in school curriculums, making problem-solving and analytical mathematical skills crucial for graduation and further gainful employment (McLendon, 2017). Overall impacts on a society when the general populace is more educated, gainfully employed, and socially stable are enormous (Murnane et al., 2000; Rose, 2013; U.S. Department of Education, NCES, 2019).

Over the years, the high school diploma and the HSE requirements have changed to meet the growing demand of critical thinking and college and career readiness mandates from the federal government (U.S. Department of Education, 2010). These requirements are the result of pressure on the U.S. to increase its global standing compared to other countries, as highlighted in recent decades by the Program International Student Assessment which ranks a sample of students from each country according to their reading, mathematics, and science skills as demonstrated by the assessments (Organisation of Economic Cooperation and Development [OECD], 2019). Politically, this motivates U.S. leaders to create higher standards for our educational system, which regularly attracts foreign students who pay full tuition to our colleges and universities (Institute of International Education, 2020; OECD, 2019). Economically, a thriving and challenging academic environment in the U.S. provides approximately $36.9 billion to our general economy and with that, hundreds of thousands of jobs (Younger, 2018). A strong academic foundation is economically good for our national economy through its attraction to international students.

The resulting changes in requirements for high school graduation create pressure to increase the level of math skills needed to graduate high school or earn a GED, skills that are more advanced than the mathematical abilities required for graduation 3 decades ago (Murnane, 2013; Murnane et al., 1995). Increasing the required mathematical performance further puts pressure on elementary and middle school schools to introduce algebraic thinking earlier in the curriculum than previously done (Boaler, 2016; Erturan & Jansen, 2015; Siebers, 2015). This pressure has been associated with higher levels of math anxiety in students which, according to Ashcraft and Moore (2009), begins in elementary school and grows to affect math performance in the middle school years (Boaler, 2016; Siebers, 2015).

Mathematics anxiety or any anxiety, including test anxiety, exists and is measurable. As constructs, we can also draw correlations to how math anxiety affects math performance. We also understand math self-efficacy to be impacted by math anxiety and know the impacts compound as students get older and enter the high school years. The high school years are typically when mathematical thinking and abstract reasoning become foundational skill sets necessary for high school math coursework. A resulting increase in math anxiety or decrease in math self-efficacy over years can be assumed to affect a student's ability to complete high school and earn a high school diploma or, in the environment of the HSE classroom, can affect the student's ability to earn that credential. In this study, I address those relationships through my research questions:

1. What is the relationship between math anxiety, math self-efficacy, and math performance in HSE students?
2. Which factor had a greater impact on HSE student math performance: math anxiety or math self-efficacy?
3. How does math anxiety differ across gender, age, and race groups?
4. How does math self-efficacy differ across gender, age, and race groups?

Math Anxiety, Math Self-Efficacy, and Its Relationship to Math Performance

Math anxiety first became understood in the mid-1950s when Gough (1954) wrote about a phenomenon called mathemaphobia, which was described as a "disease" (p. 290) likened in its prevalence to the common cold. Gough sought to provide some solutions to the issue of mathemaphobia, or math anxiety, in the classroom through instructional support to the emotion. Gough likened many of the math-phobic or math-anxious students as having had a negative experience that created ever-increasing insidious anxiety over years, culminating in a distaste for, and avoidance of, anything related to math.

Richardson and Suinn (1972) created the MARS to be able to measure this previously nonquantifiable emotion for math. Since that time, the MARS has been modified, abbreviated, revised, and translated–from the original 98 question MARS (Richardson & Suinn, 1972) to 25 questions by Alexander and Martray (1989), to Spanish by Brown and Sifuentes (2016), and a form appropriate for children by Carey et al. (2017).

In general, math anxiety is now considered a legitimate, measurable psychological state under consideration for its effects on math achievement and math performance and further impacts on career choices (Ashcraft, 2002; Frodsham, 2015; Ma, 1999; Malachias, 2018; Peixoto et al., 2016; Ramirez et al., 2018; Steele & Aronson, 1995; Wang, 2019). All too often, the long-term effects manifest as avoidance of studies needing math skills such as the science, technology, engineering, and math (STEM) career pathways.

Mathematics Anxiety Sources

In discussing math anxiety, a researcher must consider the source or catalyst for the anxiety. Most anxieties are born out of a negative experience, much as positive self-efficacy is born out of positive achievement and experiences (Bandura, 1997; Choe et al., 2019; Ramirez et al. 2018). Others build math anxiety around the actual mechanics involved in the mathematical activity–a timed test, working word problems, geometry, or multi-step mathematical operations (Gough, 1954; May, 2009; Tobias, 1993).

Researchers might endeavor to start with the source of the math anxiety and then attempt alleviation of the anxiety through an intervention. Some of these interventions might focus on test preparation or music or other "calming" influences to ameliorate the anxious state, while others propose discussion interventions, whereby math-anxious individuals discuss their emotions surrounding math in a supportive environment (Hembree, 1990; Ramirez et al., 2018; Tobias, 1993).

Some studies look at racial group correlations to math anxiety. For example, Johnson (2013) studied racial differences in attitudes towards math, specifically factoring the differences of math attitudes based on the teacher's treatment of students. Student attitudes of math were constructed on foundational teacher treatment of all races as capable, instructing math with compassion and support; therefore, any resulting math anxiety had developed through teacher communication of their own negative attitudes towards math (Johnson, 2013). The phenomena of the origins of math anxiety in Black students were also highlighted in Beilock et al. (2009). Beilock et al. (2009) questioned if high-math-anxious teachers contributed or transferred their math anxiety onto their students, also projecting their biases of African American students as deficient in mathematical reasoning and performance. Beilock et al. (2009) and Johnson focused on two disparate perspectives of teacher influence. In Johnson, teachers transferred their own math attitudes to their students separate from teacher treatment of students as capable. In Beilock et al. (2009), teachers fostered math anxiety and negative math attitudes through negative views of student capabilities based on race.

Generalized anxiety, of which math anxiety is related, also impacts a student's levels of math anxiety through concerns about performance on a math test, manifested as specific test anxiety. Test anxiety is defined to occur only when a student is taking a test, whereas math anxiety can occur outside of a high-stakes test environment and occur in any situation where a person engages or considers manipulation of numbers (Choe et al., 2019; Devine et al., 2012; Hembree, 1990). While closely related, test anxiety and math anxiety have proven negative effects on math performance (Ashcraft & Kirk, 2001; Ashcraft & Moore, 2009; Boaler, 2016; Hembree, 1990; Siebers, 2015; Siegler et al., 2012; Tobias, 1993). Poor student math performance as measured on math assessments has been shown to impact student motivation to study math at higher educational levels, leading to the logical reduction in motivation to pursue science, technology, engineering, math, and generally more advanced career pathways (Dowker et al., 2016; Hembree, 1990; Murnane et al., 1995).

Math Achievement, High School Rates and Broader Impacts

In the U.S., high school graduation is the first important academic milestone into adulthood. Since the 1940s, high school graduation rates have increased globally to the current high of 80-90% of students under 25 graduating from high school, including those adults earning an alternative credential (OECD, 2019). Alternative credentials include HSE programs such as the GED and the HiSET (Educational Testing Service, 2020; GED Testing Service, 2020).

Simply quoting graduation rates requires some context of the data sets used to communicate educational credentials earned. For instance, the U.S. Census Bureau statistics, U.S. Department of Education, and U.S. Bureau of Labor Statistics all attempt to collect and disseminate high school graduation statistics each measuring high school graduation credentials differently. The U.S. Census Bureau uses the American

Community Survey data on educational attainment (U.S. Census Bureau, 2020). The U.S. Department of Education utilizes the adjusted cohort graduation rate to measure high school graduation rates, which only measures those students who entered high school in the ninth grade and graduated high school “on time” with their cohort. These data do not include students who took longer than 4 years to graduate from high school or who later earned an HSE before their 25th birthday (U.S. Department of Education, NCES, 2020). The U.S. Bureau of Labor Statistics utilizes a different data set called the Current Population Survey (U.S. Bureau of Labor Statistics, 2021a). This survey is conducted monthly by the U. S. Census Bureau and collects information on the labor source, employment data, and household earnings, as well as workforce demographics (U.S. Bureau of Labor Statistics, 2021a).

Interestingly, with the creation of the GED after World War II, there has been a disproportionate and growing opinion of the GED as less than the traditional high school diploma. The initial purpose of the GED was to provide returning soldiers the opportunity lost while fighting the war overseas to complete their high school education as adults. Many of the soldiers returned as adults with families and no longer of the same generation as typical high school students. Over the years, a growing opinion has developed that those learners who earn a GED have less adequate skills than students who were able to persist and finish high school (Rose, 2013); however, Department of Labor and Department of Education studies show that students who eventually earn a high school diploma or HSE earn approximately 26% better wages over those employees in the workforce without a high school diploma or HSE (U.S. Bureau of Labor Statistics, 2021a; U.S. Department of Education, NCES, 2019). These data support the overall opinion that earning a high school diploma is a benefit for the individual and also creates improvements in the overall community in which that person lives (Rose, 2013).

Mathematics Anxiety in HSE Students and Math Performance, Math Avoidance

When deciding academic pathways, students who are experiencing math anxiety often make choices to avoid exposure to math coursework or careers strongly associated with math activities such as physics and accounting (Choe et al., 2019). This results in limited academic choice are often manifested in female college students engaging in math avoidance. According to Beilock et al. (2009), Ernest (1976), and Tobias (1993), female college students stay away from STEM career subject areas in many cases because of math anxiety, stereotype threat, and/or gender bias, preferring to study those academic areas that are more socially acceptable and traditionally aligned as "feminine" careers. Hembree (1990) furthered their hypothesis by studying student avoidance and its relationship to math performance. Similar to socio-cognitive theory, Hembree posited negative experiences in math foster a negative attitude towards math; the negative attitude towards math, in turn, manifests as math avoidance. This math avoidance further compromises a student's ability and performance through lack of exposure and skill development, reinforcing the student's personal theory that math is not a positive experience and should be avoided (Hembree, 1990). Math avoidance has been suggested to start at any time in the student's educational history; some studies have focused on the elementary grades hypothesizing the avoidance begins early and continues to build continued avoidance of math in the upper, secondary grades (Helming, 2013).

Math avoidance continuation in the college student has been studied in adult learner research focusing on student choice of major courses in college. Student math avoidance can have negative repercussions when a student is required to take a developmental math course to continue in their undergraduate major (Malachias, 2018). Malachias (2018) discussed the persistence, mindset, or attitudes students had in developmental math courses, along with their levels of math self-efficacy and/or math anxiety. Still further, math anxiety and math avoidance can manifest themselves in the students' choice of employment after college graduation (Hembree, 1990).

In other math avoidance research, Meece et al. (1990) studied math anxiety and how it influenced adolescent course enrollment and found math anxiety related negatively to students' future math-related college course decisions. The ramifications of math avoidance are multifaceted. These limitations naturally eliminate any science-, technology-, or math-based career choices, excluding the math-anxious individuals from job opportunities in an ever-increasing technological job market (Meece et al., 1990). Boaler (2016) suggested women who avoid STEM fields reduce their "life chances" (p. 7); the resulting avoidance of STEM, attributed in Boaler to fixed mindset, further negatively impacts the STEM disciplines through lack of diverse thinking and perspectives provided by the inclusion of women. Boaler further connected STEM avoidance with math anxiety at higher rates in females. Boaler also connected gender biases, math anxiety, stereotype threat, and math avoidance to the work of Steele (2010). Steele's research emphasis was less about avoiding STEM careers and more about how the threat of a stereotype, such as discussed in Boaler for female and minority students, can cause a student to avoid math situations where they might be viewed as confirming a negative stereotype. Avoiding problematic or biased math activity is not far removed from STEM career path avoidance as the math activities provide the experiences needed for a STEM career. Reinking and Martin (2018) specifically addressed STEM career avoidance and the underlying factors contributing to that avoidance. Those factors contributing to STEM avoidance were gender socialization and gender stereotypes formed through parental, teacher, or peer influences. Specifically, parents, teachers, courses, social media, peer group stereotypes, and peer pressure all promote the foundational stereotypes labeling STEM fields as unattractive to females.

Related to STEM avoidance, Choe et al. (2019) conducted a large-scale study on math anxiety and avoidance of math in effort-based decision-making. The researchers hypothesized that math-anxious adults perceive math as more effortful and less rewarding, which in turn causes the math-anxious adults to avoid more difficult math. Choe et al.'s study of math avoidance provided much-needed data supporting math anxiety as a factor of math avoidance above and beyond math performance levels through their innovative methodology of choice and reward.

Math Self-Efficacy in HSE Students and Math Performance, Math Avoidance

Huang et al. (2018) studied the interplay between math anxiety and math self-efficacy and the resulting impact of both conditions on math and science (STEM) career interest. Huang et al. focused on a crucial middle school period of development for students when discussions on career pathways and college preparatory coursework are educationally practical. In Huang et al., the researchers draw a bi-directional connection between math anxiety and math self-efficacy, noting the negative relationship between the two affective conditions of elevated anxiety and lowered self-efficacy, which Bandura (1997) posed earlier. Huang et al. suggested both constructs are contributing factors to career choice. Their study aimed to determine the mechanisms and how the two constructs ultimately impact career choice through math avoidance. Similar to Boaler (2016) and Dweck (2016), the researchers proposed a causal link between self-efficacy and the mindset of students on their career interest, suggesting that middle school students with a growth mindset have greater math self-efficacy and greater STEM career interest and, as a result, exhibit less math avoidance. This work is specific to middle school students, and I wonder if the phenomena transfer to adult student attitudes and mindsets, specifically the attitudes and mindsets of HSE students.

In several studies focusing on community college developmental math students, researchers found adult students enrolled in community college developmental math courses consistently displayed low math self-efficacy which had developed through math anxiety or negative math attitudes in early math experiences (Guy et al., 2015; Kiser, 2016; Malachias, 2018; Raju, 2018). Kiser (2016) connected math self-efficacy and mindset with college entry developmental math performance. Specifically, the students interviewed in Kiser's study professed to previously negative math experiences, which negatively impacted their math self-efficacy, including existing math anxiety experienced while enrolled in a developmental math course. The student math self-efficacy was directly related to previous student math performance experiences (Bandura, 1997; Kiser, 2016).

Additionally, Paul Nolting (as cited in Boylan, 2011) related math anxiety in developmental math students to avoidance of math coursework, not just in avoidance of STEM career pathways. Malachias (2018) further explored the math self-efficacy of developmental math students, and her study connected adult student historical influences from family, community, education, and culture to the students' math self-efficacy and persistence.

Other Elements: Math Anxiety, Math Self-Efficacy Related to Gender

According to Murnane (2013), U.S. high school graduation rates increased substantially between 2000 and 2010. While overall U.S. graduation rates increased, a gender gap persisted. Females were the majority of high school graduates in 2009, with 79.5% females compared to 73% of males graduating from high school in a 4-year cohort (Murnane, 2013). During the Obama administration, U.S. high school graduation rates increased to an all-time high of 83.2%, an increase attributed to many factors such as different reporting structures from state to state, increased early childhood programs, and more robust educational standards and accountability (Sanchez & Turner, 2017). This increase did not equalize gender gaps however, as overall gaps remained with males graduating from high school at lower rates than female students (McFarland et al., 2020). When including both students who left school before attaining a high school diploma and students who later enrolled in an HSE program and earned an HSE, the numbers are more positive: In the graduating class of 2019, 92.3% of males and 94.3% of females graduated from high school or an HSE program (McFarland et al., 2020). There remains a 2% gap between genders and roughly a 5% non-completion rate for 18- to 24-year-olds (McFarland et al., 2020).

Historically, male graduation rates fell from 80% in the 1970s to a low of 74% in 2000, with a gain in 2005, returning to 80% in 2010. Female graduation rates also wavered around the 80% mark from 1970 to 2000, with a significant gain of 85% in 2005 up to 86.9% in 2010. A question emerged as to why males were consistently graduating at a much lower rate than females, with gaps persisting (Murnane, 2013).

One might ponder higher female graduation rates compared to an inverse male-female rate of math achievement, where males have consistently performed at a higher level than females (Erturan & Jansen, 2015). Several meta-analyses have shown gender gaps in achievement often disappear when factors of math anxiety or race are controlled (Cheema & Galluzzo, 2013; Erturan & Jansen, 2015).

In the book *Overcoming Math Anxiety,* Tobias (1993) devoted an entire chapter to how gender bias affects students in math. In 2016, I read *Whistling Vivaldi* (Steele, 2010) and noted the gender bias and stereotype threat in his research mirrored my experiences as a college freshman math major. Steele and Aronson's (1995) study focused on the psychological influences of anxiety, stereotype threat, and bias in student achievement. Other studies, such as those by Song et al. (2016), further aligned gender stereotype threat to a negative influence on female math achievement, while two other studies found similar results in K-12 students (Baloglu & Koçak, 2006; Merritt, 2011).

Depending on the studies used and the variables included in the analysis, a researcher might find that the gender gap between math anxiety and math achievement disappears or at least becomes statistically insignificant (Else-Quest et al., 2010). Other studies even show a null correlation between math anxiety and gender, essentially drawing conclusions that math anxiety affects students more generally rather than specific to gender (Marks, 2008). Data analysis showed the differences between female and male students were smaller than reported, not influenced by location or occupational expectations, and reflected successful policy changes to promote the educational outcomes of females (Marks, 2008).

Pajares (1996) pointed out reverse correlations between a student's math efficacy and their gender. In his study, he noticed that math anxiety influenced the math self-efficacy of females more than males (Pajares, 1996). In her book *Mathematical Mindsets*, Boaler (2016) refuted the concept of a mathematical mind and how certain genders were presumed to have an enhanced natural ability for mathematical thinking over the other gender. Steele (2010) also discussed the impact of math anxiety derived from stereotype threat, manifested in widespread gender bias of natural math abilities or predisposition of mathematical self-efficacy. Steele and Aronson (1995) proposed that the gender of the student affected the mathematical performance and mathematical self-efficacy of the student, based largely on societal or cultural gender stereotypes permeating the student's consideration of their own skills, with no basis on the actual abilities of the student. Since mathematical self-efficacy is largely a social-cognitive construct, the social environments, experiences, and memories play a major role in its longevity and strength.

Huang et al. (2018) further supported this theory of math self-efficacy differing from males to females, with females in late adolescence and early adulthood being more likely to have a lower math self-efficacy, further impacting college major and future career choice. Additionally, Huang et al. noted female students tended to have a correspondingly higher math anxiety in addition to lower math self-efficacy. Female student math anxiety can be seen in labor figures, suggesting females are less likely to engage in career fields of STEM due to the development of lowered math self-efficacy (Huang et al., 2018; U.S. Bureau of Labor Statistics, 2021a).

Other Elements: Math Anxiety, Math Self-Efficacy Related to Race

When public schools were first desegregated in the U.S. during the 1960s, there was a clear awareness that educational attainment was not equal for all students; in particular, high school graduation rates among Black students versus White students were disparate (Snyder, 1993).

High school graduation rates have risen steadily over time from the 1940s when White graduation rates increased from 28.6% in 1940 to 77.9% in 1991 (Snyder, 1993). For African American, or Black, students, the high school graduation rate increase was particularly dramatic; from 8.9% in 1940 to 71.6% in 1991 (Snyder, 1993). The largest jump in graduation percentages occurred during the civil rights era when graduation rates in the 15% range jumped in a decade to nearly 30%, effectively doubling. By the 1990s, the racial gap persisted, with White students graduating at a rate 3% greater than their Black classmates until 2012. The graduation rate gap narrowed from a 10% gap in 1972 to approximately 3% in 2012, and while improved, graduation data indicate that a gap persists (Murnane, 2013). This achievement gap meant communities still experienced a gap in quality of life due to the persistent gap in high school graduation and the HSE rates of their community.

When analyzing if math anxiety disproportionately affects one race or another, math anxiety studies that include race as a variable typically compare only two racial groups: Black/African American and White/Caucasian students; however, studies using racial variables may include up to four racial and ethnic groups depending on the focus of the study. Research on differences between Black/African American and White/Caucasian students is valuable to concerns of inequity between educational access and math achievement. The five categories of race/ethnicity used in this study include White/Caucasian, Black/African American, AAPI, Hispanic/Latinx, and Other/Mixed Race. These racial/ethnic categories align with common public education report racial/ethnic groupings (NCCCS, 2019c; U.S. Census Bureau, 2020).

Research on math anxiety and racial differences suggests racial "stereotype threat" is considered a cause of high math anxiety and low math performance under pressure (Beilock et al., 2007; Steele & Aronson, 1995; Stricker & Ward, 2004). Stereotype threat was considered an effect Black/African American students experienced when they were assessed in an activity that invoked a "stereotype," such as a math or verbal skills exam. However, racial stereotype threat is not the only stereotype threat experienced. Older students experienced a type of age-related stereotype threat, while females experienced a gender stereotype threat (Jameson & Fusco, 2014; Steele & Aronson, 1995). When a stereotype exists for a group and pertains to math skills, group members may be subject to "threat" and find their performance compromised. When a student has the capability to perform the math being asked under stereotype threat conditions, they performed markedly lower than they would otherwise, resulting in their performance being compromised by math anxiety (Maloney et al., 2013).

Maloney et al. (2013) referred to multiple studies addressing stereotype threat relationships between gender, racial stereotype, and math performance. The studies referenced by Maloney et al. noted African American students performed worse when they understood the math test was intended to measure intelligence as opposed to telling test takers the test was only meant to measure problem-solving capabilities. In Johnson's (2013) study of African American students in Texas, the researcher suggested the students' math anxiety was impacted not just by their math experiences but also by the attitudes afforded them by their teachers.

Racial stereotypes persist in the U.S. due to outdated ideas of races having different intellectual capabilities (Steele & Aronson, 1995). For instance, African Americans were stereotyped as having fewer intellectual capabilities than White people, and White people were similarly stereotyped as having less physical strength and agility than African Americans (Steele & Aronson, 1995). These stereotypes persist for any grouping of genders, races, ages, or cultures who are aware of low societal expectations for their group and are explored further in this study (Herts & Beilock, 2017).

Pajares (2002b) mentioned race as a component of math self-efficacy when compared to the White students of the Pajares and Miller (1995) study. However, it was summarized in Pajares (2002b) that minority students, not just African American students, demonstrated positive self-concepts in multiple subject areas, despite differences in their self-efficacy levels in the respective subject matter. In the meta-analysis of Ma (1999), the researchers determined there were no racial differences with regard to performance and the student's level of math anxiety (Dowker et al., 2016; Ma, 1999). Similarly, Slavin and Karweit (1984) also indicated that when allowing for mathematical self-efficacy, there was no statistical difference noted between races.

Stinson (2008) utilized a more "backwards engineering" approach to understanding math self-efficacy and its relationship to race, specifically African Americans. In this study, the researcher examined the beliefs of four African American college graduates, their experiences in math classrooms, and their math self-efficacy. The four participants felt their race provided negative effects on their mathematical self-efficacy; however, these students persisted despite those effects and generally developed an opinion that math is a culture-less discipline (Stinson, 2008). The Stinson study participants all held high regard for the importance of math beyond school into daily life and career, providing them with greater motivation towards math. These study participants also held strong beliefs about their own math identity (Stinson, 2008). Roberts (2018) observed the impacts to math self-efficacy focused primarily on gender stereotypes, not race, rarely aligned with math self-efficacy but aligned with math anxiety and performance.

Other Elements: Math Anxiety, Math Self-Efficacy Related to Age

For the adult learner in an HSE program, Jameson and Fusco (2014) observed the more time elapsed since the student's last math course, the higher the math anxiety and the lower their self-efficacy. In particular, if greater than 10 years passed since the last math class, the student had significantly lower math self-efficacy (Jameson & Fusco, 2014). Nolting (as cited in Boylan, 2011) made similar assertions regarding time elapsed since a math class.

In a study of developmental math students, Malachias (2018) included the discussion of age in math attitudes of study participants. In Malachias's study, age was considered to have a positive "maturity" (p. 189) effect on the math anxiety of the students. In a similar study of developmental math students at a community college, Fannin-Carroll (2014) found there was no difference in the levels of math anxiety based on the age of the students. These studies provided some contrast to other studies of postsecondary students at community colleges where academic classrooms have a broader range of age groups. Studies specifically identifying age demographics usually focused on the variables of age groups or grades of the study participants, such as elementary, secondary grades, or groups of participants over the age of 18. Few studies focused on specific groups over the age of 18. Nolting's (as cited in Boylan, 2011) comments stated math skills were like a foreign language, and the elapsed time since a student had taken a math course had significant consequences on their math performance in later assessments, such as college-level placement tests. These implications could be further expanded on adult student populations to deduce that the older the returning adult student or the more time elapsed from the last math course, the more consequential it would be on their current math performance. Nolting (as cited in Boylan, 2011) further referenced math anxiety levels potentially amplified when students returned to school as adults, resulting in decreased math assessment performance.

In a similar study of adult learners, Betz (1978) found higher levels of math anxiety in older female students also conditional on the amount of time since high school math coursework. The older female students found themselves more anxious about math than younger female students (Bernstein et al. 1995; Betz, 1978). In general, the longer the time since their last math course, the lower their math performance was on a standardized test (Nolting, as cited in Boylan, 2011; Jameson & Fusco, 2104).

Literature Deficiencies

While many studies and much research focused on math anxiety and subsequent impacts on math achievement or performance, there did not appear to be any studies focused on the direct effect math anxiety has on attaining an HSC or a high school diploma. In Watts (2011), on which this study is based, the researcher discussed the effects of math anxiety levels and math self-efficacy levels on the math performance of ABE or HSE students. The study did not necessarily draw a connection between the ABE student math performance and their ability to earn an HSC (Watts, 2011).

Larson et al. (2015) did indeed focus on graduation as their dependent variable;

however, their math and science self-efficacy levels study was focused on STEM university students and the persistence towards graduation with a bachelor's degree, not a high school diploma. Similarly, Roberts (2018) and Merritt (2011) focused on undergraduate college students, specifically those enrolled in developmental math coursework. These studies differ from Watts (2011), as their study samples had already achieved an HSC (Merritt, 2011; Roberts, 2018). An interesting aspect of Roberts's and Merritt's studies was the inclusion of study participant age as a variable in their levels of math anxiety.

One study bridged the two populations of HSE students and postsecondary level adult students. Humphreys (2018) studied the math performance and needs of adult education students who at one time had been HSE students but had already achieved their HSE. Humphreys's qualitative study focused on a group of adult students who were enrolled in adult education courses and conducted interviews of the students to collect and analyze support needed for student success in further math coursework. Ultimately, the results of the study emphasized social and educational supports of college-level success, including student math self-efficacy levels, as a relationship to the participant's math performance (Humphreys, 2018).

Similarly, multiple studies discussed how math anxiety affected elementary, middle, and high school students' math performance on exams, including a thorough meta-analysis of studies among elementary and secondary school students (Ma, 1999). In the meta-analysis, Ma (1999) referenced the studies of Meece et al. (1990) for elementary school children as supportive data on the negative relationship of math anxiety to math performance as well as studies of 25 other researchers. Ma suggested the predictive nature of math anxiety to predict a student's math performance, referring to Sherman and Fennema (1977). The 26 studies of the Ma meta-analysis were all conducted before 1999 and provide further evidence of a lack of data for adult HSE students and their math performance towards an HSC.

One can project the degradation in performance from math anxiety and math self-efficacy affects future ability to earn an HSC based on the necessity of math skills to meet the requirements of an HSC. As of 2018, the dropout rate of U.S. public high school students had decreased from 9.7% to 5.3% (U.S. Department of Education, 2020). While this dropout rate improved from 2006, other countries in the OECD have since surpassed us in high school graduation gains. For instance, in 2000, the U.S. graduation rate of 87% was well above the OECD average of 66% and ranked highest in the 29 countries in the OECD. Since 2000, five countries (Lithuania, Czech Republic, Slovakia, Poland, and Canada) have now surpassed the U.S. with high school graduation rate gains of greater than 8% exceeding the U.S. in high school graduation (U.S. Department of Education, 2020).

High school diploma and HSE credentials were illustrated through the demographic data collected on the population, along with math test performance aligned to race or gender (OECD, 2019; Scheller & Malley, 2014). For instance, in Murnane (2013) and Sanchez and Turner (2017), the discussions of high school graduation rates highlighted early childhood programs to high school choice as factors influencing graduation rates of high school students but did not focus specifically on math anxiety or math self-efficacy as possible impacts. While early studies focused on predicting future achievement in math courses of study, the studies did not specifically address HSC attainment as an end goal (Nicoloff, 2018; Stevenson & Newman, 1986).

Additionally, math anxiety and math self-efficacy levels of community college populations, adult education students, or GED students can be correlated to demographic data such as gender and race; however, the relationship between math anxiety and math self-efficacy of gender or race is limited to student performance in a respective environment, the environment not necessarily related to HSC attainment (Guy et al., 2015; Kiser, 2016; Malachias, 2018; Raju, 2018; Roberts, 2018). In the context of NCCCS, Hispanic/Latinx populations make up a third of the adult education programs in the state compared to 29% Black or White students (NCCCS, 2019c). Much of the literature reviewed in this study addressing race or ethnicity differences in math anxiety or math self-efficacy levels focused on differences between White and Black populations. With a deficiency of research drawing attention to Hispanic/Latinx adult education students, a major population in North Carolina is excluded from the studies of HSE math students. In NCCCS, demographic data are collected on students enrolled in CCR programs generally; however, race/ethnicity demographics are not published for populations performing at the secondary education level and enrolled in HSE programs.

High school graduation and GED attainment rates, in addition to math performance data on standardized test performance, include demographic data as part of their analysis (OECD, 2019; McFarland et al., 2020). One must look quite deeply into current studies to find correlations between math self-efficacy and high school graduation rates or HSC attainment. While some studies can infer mathematical performance or achievement as an indication or predictor of educational credential attainment, these studies do not specifically align math self-efficacy to data on HSC rates (Duncan et al., 2007; Murnane, 2013; Siegler et al., 2012). It is this gap in literature that prompted my research study focus.

Math Anxiety and Math Performance in Nonacademic Environments

After a student graduates from high school or earns an HSE, they often find they continue to use reading skills in everyday life but rarely use the math skills learned after high school graduation (Nolting, as cited in Boylan, 2011). The amount of time elapsed since a student has taken a math course creates significant disadvantages for those who endeavor to take college-level math courses as adults (Nolting, as cited in Boylan, 2011). There are no research studies of adult math anxiety outside of the academic environment. Studies of math anxiety and performance are usually assessed in the academic environment and not in social or familiar settings (Ashcraft & Moore, 2009).

Tobias (1993) connected the math anxiety students experienced with their further avoidance of math-related occupations, such as a person who chooses business over engineering. Avoidance of math is common in community colleges where students develop interests in careers and may avoid math-heavy curriculum in favor of studies less math reliant such as history, English, business, or healthcare (Ashcraft & Moore, 2009; Choe et al., 2019; Fannin-Carroll, 2014; Maloney et al., 2013). Math-anxious students are further limited by their avoidance in career choice. The math-anxious adult may also develop the emotional response to math anxiety when encountered in daily life situations, such as figuring the tip on a dinner bill, calculating discounts on purchases, or determining household budgets (Tobias, 1993).

Theoretical and Practical Value

Studies have shown there are numerous variables that can impact a student's performance and their subsequent math achievement; additionally, studies ultimately relate the performance effect to further student academic achievement. Often, the nebulous “achievement” is discussed in terms of a student’s specific performance on math exams and assessments; however, when a student wants to attain a goal, such as a high school diploma or a GED or HiSET equivalency credential, it might be worthwhile for the providers of those credentials to understand how math anxiety affects the attainment of a credential. Thus far, studies have not specifically addressed the impacts of math anxiety on graduation rates or GED completion rates. The majority of students who return to school for an HSE are math anxious (Watts, 2011).

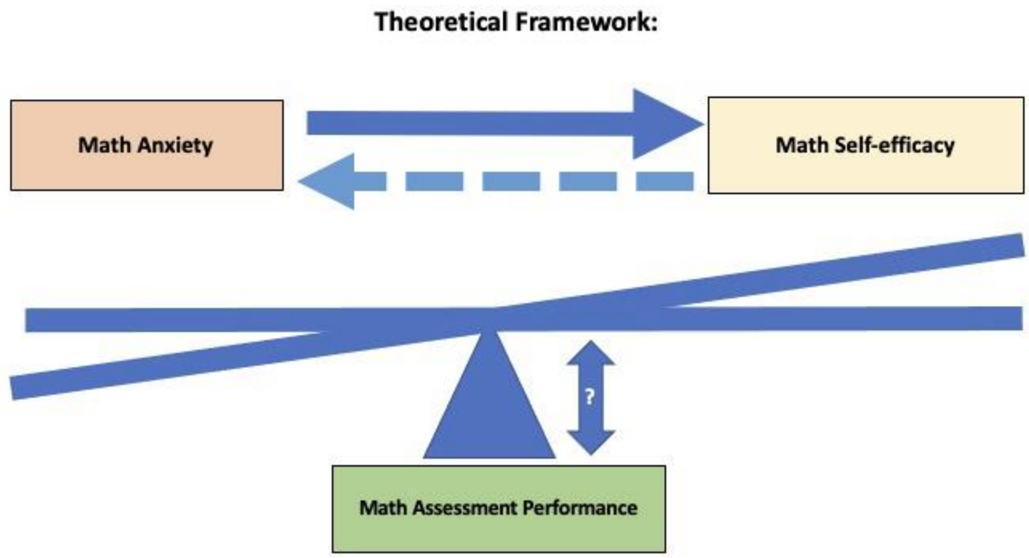
The theoretical basis of math anxiety initially identified by Gough (1954) as a disturbing phenomenon, later formally documented by Betz (1978), Richardson and Suinn (1972), and Tobias (1993), established math anxiety as an affective construct worthy of study for multiple school population groups. The negative correlation between math anxiety and math performance is reasonably established in most student populations (Ashcraft, 2002; Hembree, 1990; Ma, 1999; Tobias, 1993). Most recently, the work of Dowker et al. (2016), Luttenberger et al. (2018), and Ramirez et al. (2018) supported the ongoing need to continue to study the relationship, including math self-efficacy, as having a further effect on the ability to achieve an HSC. Dowker et al. (2016) summarized the multiple facets of math anxiety and performance, even suggesting other factors such as genetics and demographic characteristics, as well as providing a discussion of treatments.

Summary

After reviewing the literature, my theoretical framework is focused on math self-efficacy related to math anxiety and how both constructs can affect, either in concert or separately, math performance of HSE students (Bandura, 1997). Math self-efficacy, as part of social learning theory, allows for four sources of influences on a student's math self-efficacy: mastery experiences, vicarious experiences, social persuasion, and emotional states, such as anxiety (Bandura, 1977, 1997). In the case of physiological responses associated with math anxiety (increased heart rate, rapid breathing, or muscle tension), a student learns to associate the negative response to math behavior and math abilities (Bandura, 1971; Beilock & Willingham, 2014; Faust, 1992). A student's performance on a math assessment, combined with their anxious emotional state influences a student's math self-efficacy through this interplay of responses (Bandura, 1971). I theorized one of the constructs, math self-efficacy or math anxiety, would have a greater effect on math performance and, by extension, affect high school graduation to a greater degree. A visual representation of my theoretical framework guiding this study is included in Figure 2.

Figure 2

Math Anxiety, Math Self-Efficacy Theoretical Relationship Framework



My Math Anxiety, Math Self-Efficacy Theoretical Relationship Framework illustrated in Figure 2 guided my consideration of the literature and the relationships of the two theoretical constructs (math anxiety and math self-efficacy) and their influence on math performance. I hypothesized as a theoretical framework the relationship between math anxiety and math self-efficacy to be bilateral and reciprocal, with math anxiety negatively affecting levels of math self-efficacy more than math self-efficacy negatively affecting math anxiety. Considering self-efficacy theory and its sources including the emotional state of the student, such as anxiety, it stands to reason self-efficacy is influenced by math anxiety (Bandura, 1997). Further to the relationship of those constructs, before conducting this study, I theorized math anxiety, in concert with and separately from math self-efficacy, negatively affects math performance to a greater degree. Regardless, negatively affected math performance has follow-on repercussions of affecting a student's ability to earn an HSC.

The purpose of this study was to explore the relationships between levels of math anxiety and math self-efficacy and their impact on math performance, pursuant to the ability to earn an HSC.

Chapter 3: Methodology

Introduction and Overview of Research Design

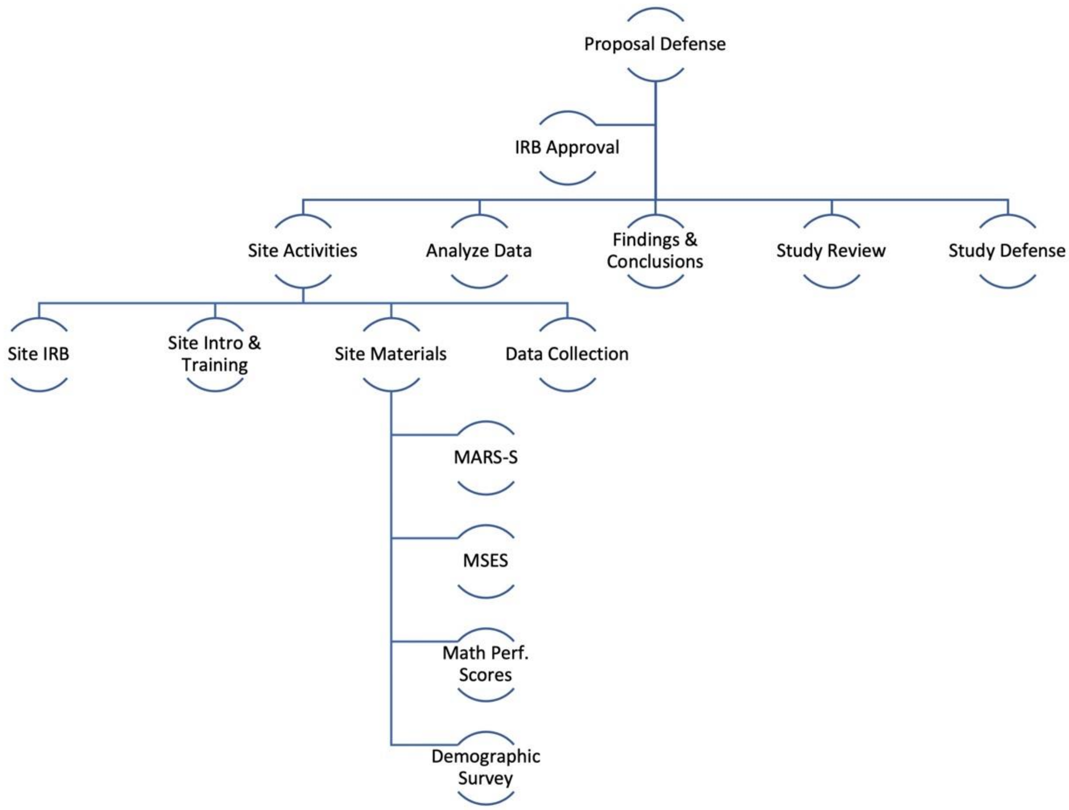
The purpose of this study was to determine the relationship between levels of math anxiety and math self-efficacy on the math performance of HSE students. This study mirrored Watts's (2011) study of the same constructs and population.

In Watts's (2011) study, the population sample was similarly ABE students enrolled in an HSE course; however, the study collected data from a sample of 107 participants. Participants were measured using the MSES and MARS 30-item, provided their gender and age, and math performance was assessed using scores from both CASAS and TABE math assessments (CASAS, 2021; DRC, 2019a; Nielsen & Moore, 2003; Suinn & Winston, 2003). Study participants were not asked to specify racial identity, excluding race as an independent variable. The study utilized a similarly quantitative approach to examine the relationships between levels of math anxiety and math self-efficacy on the math performance of the study sample and determined math self-efficacy had a greater effect on student math performance in the ABE population (Watts, 2011).

This study yielded a smaller sample but mirrored the demographic of HSE students, one of the quantitative instruments used, the geographic region, and the similar HSE programs. The anticipated value of this study is correlating math anxiety or math self-efficacy to a student's ability to be successful in mathematical performance needed to earn a GED/ HiSET/HSE, and if there have been improvements from 2011 to 2021. An overview of the study design is included in Figure 3.

Figure 3

Math Anxiety, Math Self-Efficacy, Math Performance of HSE Student Study Design



The study design illustrated in Figure 3 summarizes the process the study followed, starting with proposal defense in May 2021 and Gardner-Webb University's IRB approval in late June 2021 (Appendix D). The steps and details of each step in the study design process, including specifics of quantitative instruments and study sites, are further described in the remainder of this chapter.

The instruments chosen to measure participants' math anxiety and math self-efficacy levels provided a quantitative description of attitudes and opinions of the students regarding their math anxiety or math self-efficacy (Creswell & Creswell, 2018). Testing for a relationship using a Pearson correlation model analysis provided a measure of the correlation of math anxiety and math self-efficacy on math performance (Creswell

& Creswell, 2018).

This chapter describes the research methodology used to address the study research questions and describes the sample population and how the study sample was selected from the same geographic region as the original study (Watts, 2011). This chapter describes the instruments used to collect quantitative data, the methods of storing and securing the quantitative data, and the statistical methods used for data analysis. Finally, ethical issues pertinent to the study and expected results from this study are addressed.

Research Questions and Hypotheses

The research study was conducted to answer the following research questions:

1. What is the relationship between math anxiety, math self-efficacy, and math performance in HSE students?
2. Which factor had a greater impact on HSE student math performance: math anxiety or math self-efficacy?
3. How does math anxiety differ across gender, age, and race groups?
4. How does math self-efficacy differ across gender, age, and race groups?

To address the research questions, consistent with the initial study of math anxiety for HSE, a quantitative approach was chosen to measure the self-identified attitudes and opinions of the participants (Creswell & Creswell, 2018). HSE students provided quantitative data via two psychometrically valid instruments: the MARS 30-item and the MSES (Nielsen & Moore, 2003; Suinn & Winston, 2003). Students' levels of math anxiety and math self-efficacy were measured using these Likert-like scale instruments and were analyzed with the student's most current math assessment scores (provided by individual sites) as a valid measure of the student math performance data on a standardized math skills assessment. Both the MARS 30-item and MSES instruments, as well as the demographic survey, were available to students in a hardcopy (pencil and paper) format administered in the participant's classroom setting.

A quantitative study was most appropriate to answer my research questions about the relationships between a student's math self-efficacy or math anxiety and how those independent variables affect a student's math performance (Creswell & Creswell, 2018). Quantitative research in this study aligned with the research intent to describe and measure the degree or degree of relationship between two or more variables, such as math anxiety or math self-efficacy, or sets of scores (Creswell, 2012, as cited in Creswell & Creswell, 2018). The quantitative format of this study was equally appropriate due to the construct measurement instruments, the MARS 30-item and the MSES, which provided relationships between variables in quantitative data format (Creswell & Creswell, 2018).

To answer the four research questions, the following three testable null hypotheses were used to lead the statistical analysis of the data:

1. There is no relationship among math anxiety levels, math self-efficacy levels, and math performance in HSE students.
2. There is no relationship among math anxiety levels, math performance, age, race, or gender in HSE students.
3. There is no relationship among math self-efficacy levels, math performance, age, race, or gender in HSE students.

For this study, these three hypotheses were analyzed for statistical significance of

0.05 (α=0.05) using a stepwise procedure as part of a multiple regression analysis to answer Research Questions 1 and 2. An ANCOVA procedure was used to answer Research Questions 3 and 4, identifying age as a covariate.

Conceptual Framework

A conceptual framework illustrating the relationship of the study questions to the independent and dependent variables are included in Figure 1, illustrating the relationship between the independent variables of math anxiety and math self-efficacy and the variance on an HSE participant's math performance on a standardized math assessment. The relationship between the levels of math anxiety or math self-efficacy was analyzed using Pearson correlation analysis to determine which of the two variables had a greater effect on the dependent variable, the CASAS Goals or TABE 11/12 standardized math performance (CASAS, 2021; DRC, 2019a).

Population and Sample

The sample for this study includes students enrolled in HSE programs who are working towards earning their HSE, such as a GED or a HiSET (Educational Testing Service, 2020; GED Testing Service.com, 2020). Those students need passing scores on HSE exams in a number of subjects including language arts-reading, language arts-writing, language arts-language and grammar, science, social studies, and math. Students must earn passing scores in each of the subject areas before earning their HSE. A missing score in math prevents a student from earning their HSE, which has follow-on consequences both emotionally and financially (Hernandez, 2018; Murnane et al., 1995, 2000).

Students who enter HSE programs have not graduated from high school. They enter HSE programs at any age over 16 and in most cases do not pay tuition for these programs, which are usually administered at local community colleges. HSE programs are funded by NCCCS at the state level under the College and Career Readiness (CCR) program, with funding allocated for such adult education programs determined by student attendance and performance in that program (NCCCS, 2019b). Federal funding is also provided to the HSE programs through the Adult Education and Family Literacy Act, under Federal Title II Workforce and Innovation Opportunity Act of 1998 (U.S. Department of Education, 2016, 2020). The goal of these programs is to provide basic education to adult learners to improve their literacy skills and increase workforce opportunities. An HSE enables students to enter trade certificate programs, enroll in postsecondary academic programs, or be eligible for employment requiring a minimum of a high school diploma or equivalency.

Adult students enter HSE programs through two routes: either as an ABE student who progresses into the HSE program or directly into the HSE program with a demonstrated performance at the ASE level on a TABE or CASAS math assessment (CASAS, 2021; DRC, 2019a). HSE student math and reading skills are assessed as part of the community college adult education enrollment and placement protocols, and the choice of instrument may differ from school to school. Performance level nomenclature differs from site to site; however, ASE is understood as performing at NRS Levels 5 and 6, equivalent to Grades 9 through 12 (NCCCS, 2019c; NRS, 2019).

The population sample for this study is considered a single-stage convenience sample (Creswell & Creswell, 2018). The study sample was selected through a process aligned to the two-site study conducted by Watts (2011). I chose to expand the study sample to include a total of five sites in the western region of western North Carolina, which included the two sites from Watts. The study sample was recruited through purposive-convenience sampling, where the sample is not random or purposely stratified to represent the larger adult HSE population (Creswell & Creswell, 2018). The method of selecting the voluntary sample of HSE students included my approaching the HSE program directors at all five sites and receiving permission directly from the directors at three of the sites; meanwhile, I applied for IRB approval at the remaining two sites. I gained approval from Sites C and E (Appendices E and F respectively), which allowed me to conduct research with their adult HSE students. After permission was gained by all five participating sites, I discussed the study with the directors of the respective HSE programs and communicated the following: purpose and scope of the study; role of instructors and directors in the study; specific needs of site participants; time; materials necessary to conduct the study, materials I provided; and resources I required (test scores). I also offered to provide any results to their programs, if requested, specific to their participants. All measurement materials including copies of instruments were provided to each site in paper copy, along with video links to explain the study to instructors and participants.

Population and Sample Assessment

Adult CCR students' reading and math scores determine their placement in classes at either the ABE level or the ASE level. ABE and ASE programs are administered by the U.S. Department of Education Office of Career, Technical, and Adult Education (OCTAE), which provides funding and accountability through the Workforce Innovation and Opportunity Act Title II (U.S. Department of Education, 2016, 2020).

The Workforce Innovation and Opportunity Act Title II guidelines determine that all accountability for student progress is tracked by NRS (n.d.). As the accountability arm for the OCTAE, the NRS defines the score thresholds for ABE and ASE programs based on student CASAS or TABE performance (CASAS, 2021; DRC, 2019a; NRS, 2021). The NRS classifies students according to six levels of math performance from NRS Level 1, beginning ABE literacy, through to NRS Level 6, ASE (NRS, 2019). These levels are roughly equivalent to kindergarten, early elementary school, upper elementary school, low and high intermediate grades, and secondary school (high school).

The CASAS Goals and TABE 11/12 tests assess students on their reading comprehension and math skills (CASAS, 2020a; DRC, 2018). The tests are administered either in paper format or via computer format in a proctored setting on site of the community college. Sample score reports are included in Appendices G and H for CASAS Goals and TABE 11/12 respectively.

Study Settings

The settings for this study were HSE classrooms on five western North Carolina community college campuses, defined anonymously as Site A, Site B, Site C, Site D, and Site E. These five sites are all part of NCCCS and have adult education programs that operate under the same NCCCS CCR and Federal Title II Workforce and Innovation Opportunity Act funding and reporting systems (NCCCS, 2019b; U.S. Department of Education, 2016). The settings for data collection were the HSE classrooms of study sites. COVID-19 restrictions during 2020 and the first half of 2021 restricted the number of students allowed in a building at one time (Executive Order 117, 2020; Executive Order 120, 2020). Most community college programs offered distance learning programs to students in HSE programs including fully synchronous distance learning or all online learning through a learning management system. Many sites resumed in-person instruction at varying levels (NCCCS, 2021). The settings did not include online forms of the instruments, as most in-person instruction was resumed; however, remote (online) instruction continued to be offered on NCCCS campuses due to COVID-19 considerations (NCCCS, 2021).

Individual HSE programs vary depending on the regional characteristics of the adult education population. HSE programs provide classes during the daytime, afternoons, and evenings; in person; fully online; as “independent study labs”; or as a blended (online and in-person instruction) format. The sites and students of this study sample represent all the above HSE program formats except for the fully online participants due to the paper-based instruments. The individual samples varied from class to class but could have included as few as two students or as many as 20 students per class. HSE programs typically have fewer than 20 students in attendance on any given day. Individual site enrollment details are provided in each site’s description.

Site A is a community college in western North Carolina with a total enrollment of 2,851, of which 378 are CCR students. Of those CCR students, 28 were enrolled in the HSE program and approximately 24 students were over 18 and eligible for this study. Table 1 highlights the demographics of both the CCR students who were included in this study and the overall demographics of Site A.

Table 1

Enrollment and Demographic Data of Site A

	Male	Female	Black	Hispanic	White only	Other
Total enrollment	58%	42%	3%	2%	93%	2%
Adult ed. enrollment	66%	34%	28%	22%	46%	4%

Note. 2017-2018 Student data procured from 2019-2020 NCCCS state published metrics, staff data procured from site team.

Site A is considered a small-sized community college in NCCCS. The adult education program at Site A had a population of 378 of the total 2,856 students at the school in 2019. The adult education students were less equally balanced in their male-female ratio compared with the overall school gender population. Site A has a predominantly White population, but the adult education programs were more balanced with nearly equal amounts of Black and Hispanic students.

Site B is also a community college in the western part of North Carolina. The total student enrollment at Site B is 4,258 students. Table 2 highlights the demographics of both the adult education students, some of whom are included in this study, and the entire community college population demographics of Site B.

Table 2

Enrollment and Demographic Data of Site B

	Male	Female	Black	Hispanic	White only	Other
Total enrollment	56%	44%	5%	3%	82%	10%
Adult ed. enrollment	67%	33%	34%	26%	32%	8%

Note. 2017-2018 Student data procured from 2019-2020 NCCCS state published metrics, staff data procured from site team.

Site B is considered a medium-sized community college in NCCCS. The adult education program at Site B had 747 students from the total site population of 4,258 students in 2019. Of those adult education students, approximately 75 were performing at HSE levels. Adult education students are less equally balanced in their male-female ratio with 30% more male students than female students. In terms of racial makeup, Site B has a predominantly White population, but the adult education programs, of which HSE participants are included, were more balanced with nearly equal amounts of Black, Hispanic, and White students.

Site C is a community college also located in the western half of North Carolina. Site C is in a larger metropolitan area serving more than one North Carolina county. The proximity to a larger metropolitan area, along with multiple satellite locations for coursework, explains the high enrollment for the college as a whole. Demographic data for Site C are articulated in Table 3.

Table 3

Enrollment and Demographic Data of Site C

	Male	Female	Black	Hispanic	White only	Other
Total enrollment	46%	53%	6%	3%	83%	8%
Adult ed. enrollment	42%	58%	14%	32%	48%	5%

Note. 2017-2018 Student data procured from 2019-2020 NC Community College System state published metrics, staff data procured from site team.

The adult education program at Site C had 1,039 students from the total site population of 13,832 students in 2019, and this site is by far the largest of the sites in this study. Of the total adult education students at Site C, approximately 80 students were performing at the secondary education functioning level. The adult education students are almost as equally balanced in their male-female ratio as the overall site student gender population. In terms of racial makeup, Site C has a predominantly White population, but the adult education programs are not as imbalanced with more White students, 15% fewer Hispanic students, and 18% fewer Black students.

Site D is a community college located in the foothills region of western North Carolina, with a medium-large enrollment. Site D enjoys a location within 20 miles of a larger metropolitan center and a more rural and agricultural community. Similar to Site C, Site D also serves two counties in the region with two campus locations. Demographic data for Site D are illustrated in Table 4.

Table 4

Enrollment and Demographic Data of Site D

	Male	Female	Black	Hispanic	White only	Other
Total enrollment	54%	46%	5%	8%	80%	7%
Adult ed. enrollment	52%	48%	22%	34%	39%	5%

Note. 2017-2018 Student data procured from 2019-2020 NCCCS state published metrics, staff data procured from site team.

The adult education program at Site D had 719 students from the total site population of 6,544 students in 2019. Of the total adult education student population at Site D, approximately 70 students were performing at the adult secondary level. The adult education students are equally balanced in their male-female ratio in both total student and adult education population. In terms of racial/ethnic makeup, Site D has a more equally balanced racial composition of Black, Hispanic, and White students. While Site D was invited to participate and agreed to conduct the study, they did not provide any participant responses for data collection and analysis.

The fifth site in this study, Site E is a community college located in a large metropolitan area of south-central North Carolina with a large enrollment. Site E serves one county in the region across seven campus locations. The participants in this study included only those students enrolled in programs at the central campus of Site E, summarized in Table 5.

Table 5

Enrollment and Demographic Data of Site E

	Male	Female	Black	Hispanic	White only	Other
Total enrollment	41%	59%	30%	12%	45%	13%
CCR enrollment	38%	62%	31%	45%	14%	10%

Note. 2017-2018 Student data procured from 2019-2020 NCCCS state published metrics, staff data procured from site team.

Site E's adult education program had 3,303 students from the total site enrollment of 18,824 students in 2019. Of the total adult education student population, approximately 469 students were performing at the adult secondary level. The adult education students are nearly as equally balanced in their male-female ratio as the overall site student population. Site E's overall racial-ethnic makeup has a larger percentage of White students, followed by 30% Black/African American students and slightly fewer Hispanic/Latinx students. Site E has the most Hispanic adult education students of the five sites, which is mirrored in the study participant response rate.

Site-Specific Instruments

The HSE student population in this study is assessed upon entry into the HSE program by either their performance on a CASAS Goals or TABE 11/12 math assessment, from which the math scores provide the math performance evaluation data of this study. Samples of a CASAS Goals performance report are included in Appendix G, and an example TABE 11/12 score report is included in Appendix H. The choice of using a CASAS Goals or TABE 11/12 assessment for incoming HSE students is the decision of the school administering the assessments. Each site in the study providing HSE programs uses either the CASAS Goals or the TABE 11/12 test to assess incoming students and determine their placement level in the site's adult education program. The CASAS Goals and TABE 11/12 math assessments both provide scored assessments of the students' ability in the math content standard areas defined by the NCCCS ABE or NCCCS ASE content standards (NCCCS, 2014). For this study, only the most recent scores from the TABE 11/12or CASAS Goals math test were collected from participants.

The CASAS Goals math assessment measures student mathematical reasoning and performance of mathematical problems covering number sense and operations, geometry, algebraic thinking, measurement, data analysis, statistics, and probability (CASAS, 2020a). Students can take the 1-hour assessment in a computer-based or paper-based format, depending on their preference and site capabilities. The raw scores from the CASAS Goals math assessment are converted to a scale score, which determines the student's placement in the adult education program. According to Karontonis and Serici (2006, as cited in Jacobsen, 2020), cut scores were determined for each NRS level via the Bookmark method. Classification accuracy of 82% and classification consistency of

72.5% were determined using Rudner's (2001, as cited in Jacobsen, 2020) item response theory method by the instrument developers. Internal consistency using Cronbach's alpha ranged from 0.80 to 0.87 across the four CASAS Goals math test forms (J. Jacobsen, personal communication, May 6, 2021). Item reliability using WINSTEPS ranged between 0.98 and 0.99, and "unknowable true reliability lies somewhere between the real and the model reliability" (J. Jacobsen, personal communication, May 6, 2021; Linacre, 2016, as cited in Jacobsen, 2020).

The CASAS Goals math assessment groups ability levels in increasing alphabetical order from ability Level A as the lowest test difficulty level, followed by B, C, and D. Ability Level D test forms are the highest difficulty in the CASAS Goals math test (CASAS, 2021). For a student to qualify for placement in an HSE program, they must earn scores in the ASE range with scale scores of 236 and above on the Level C or Level D test forms (CASAS, 2021). Students who score at least a 236 scale score on the math portion of the CASAS Goals math assessment are considered capable of performing high school, ASE-level math. Adult education students enrolled in HSE programs at each site were eligible to participate in this study.

The TABE 11/12 assessment similarly measures student academic skills in several subject areas including reading, math computation, applied math, language, vocabulary, and spelling. The TABE 11/12 test measures a student's ability in the four operations (addition, subtraction, multiplication, and division), in addition to fractions, percent, and exponents. The applied math test measures a student's ability in a "real world" or applied setting such as household funding, recipes, repair tasks, etc. The TABE 11/12 is administered in five different ability level groupings or forms which are in decreasing alphabetical order. The lowest difficulty level of the TABE 11/12 test is denoted as L (literacy); the next highest ability level is E (easy), followed by M (medium), D (difficult), and A (advanced) as the highest ability level (DRC, 2019a). Students are considered to be performing math at the high school level or ASE level when they score a 657–800 on the A level test (DRC, 2019a). Those students scoring 657 or more on an A level TABE 11/12 test were enrolled in HSE programs at their respective sites and were eligible for participation in this study. Limitations of the TABE impacting data analysis are discussed in Chapter 5.

The TABE 11/12 math test includes 35 math application items, including estimation and computations of time, distance, weight, etc. The TABE 11/12 math tests were developed through a comprehensive review of the OCTAE CCR content standards to determine common educational goals for the skills assessed and knowledge and skills emphasized, as applied to the adult population (DRC, 2017; U.S. Department of Education, 2020). Content validation was conducted to ensure reduced construct irrelevant variance and minimized construct underrepresentation (DRC, 2017). Differential item functioning analyses, as part of rigorous item analyses, ensured measures of irrelevant items were avoided. The reliability coefficient using Cronbach's alpha ranged from 0.75 to 0.94 for TABE 11/12 mathematics of either online or paper-and-pencil, considered psychometrically acceptable for assessments of a 35-item length (Cronbach, 1951). Online TABE 11/12 math assessments are administered by the DRC Insight (DRC, 2018).

Research Instruments

The MARS 30-item (Suinn & Winston, 2003) provides a shorter and equally reliable alternative to the original 98-item MARS by Richardson and Suinn (1972) and is included as utilized for this study in Appendix A. The MARS 30-item contains 30 items that ask participants to rate their level of discomfort or anxiety using a 5-level Likert scale. The MARS 30-item was developed to provide a shorter MARS when utilizing the 98-item MARS is inappropriate, such as when a shorter instrument is needed or when testing time is limited (Suinn & Winston, 2003). The MARS 30-item used a Cronbach alpha of 0.96, which indicates a high level of internal consistency (Cronbach, 1951). Additionally, the test-retest reliability for the MARS 30-item was 0.90 ($p < 0.001$; Suinn & Winston, 2003). The MARS 30-item contains 30 items that include questions about levels of anxiety when performing math tasks in typical nonacademic contexts, observing others performing tasks, thinking about possible math tasks, or anticipating being assessed at math (Suinn & Winston, 2003). The validity at 1-week intervals using Pearson correlation was $r = 0.92$ and $r = 0.94$ ($p<0.001$; Suinn & Winston, 2003). Validation of MARS 30-item scores indicated an inverse correlation to math grades with $r = -0.41$ ($p < 0.001$; Suinn & Winston, 2003).

The MARS 30-item is scored using a fully anchored 5-point Likert scale, with a possible score range of 30-150 for the 30-item instrument. Scoring for the 30-item instrument provided by the researcher suggests scores falling above the 75% level, along a normative percentile curve, would be categorized as eligible for intervention. A participant with a raw score of 78 or greater falls along the > 75% curve. For this study, participant math anxiety levels greater than 75% are interpreted as math-anxious, while participants scoring less than 75%, with a score of less than 78, are interpreted as not math-anxious (Ashcraft & Kirk, 2001).

The MSES used in this study is a quantitative survey instrument measuring nine content areas of math to be completed by participants self-evaluating their abilities in two hypothetical contexts: math classroom and math test (Appendix B). The MSES generates quantitative math self-efficacy data with an individual classroom or test context score range of 9 to 45 using a 5-point Likert scale of 1 (not at all confident) to 5 (very confident; Nielsen & Moore, 2003). Total math self-efficacy scores are obtained by totaling the response numbers from both classroom and test contexts and deriving a sample mean score range of 18-90, averaged along a normal curve with four quartile ranges of 0-25, 26-50, 51-75, and 76-100 percentiles. The two contexts of the 9-item MSES demonstrated strong internal consistency reliability through Cronbach's alpha = 0.93. Internal reliability in each MSES context of MSES class and MSES test had Cronbach alphas of 0.86 and 0.90 respectively.

Demographic survey data collected include age, gender, race, years since participant last attended a secondary or elementary formal school, and years since participant had taken a math class. Responses to the demographic gender item included three responses of male, female, and nonbinary. Participant response options to the survey item of age included the month and year of birth, which was calculated based on the date of data analysis. Response options for race/ethnicity included White/Caucasian, Black/African American, Hispanic/Latinx, AAPI, and Other/Mixed Race. The categories for race/ethnicity closely align with the categories used in the NCCCS demographic data for adult education students. Participant responses to years since attending secondary or elementary formal school and years since having taken a math class were provided in continuous numerical values. Participants were encouraged but not required to answer all the demographic items on the survey to aid data analysis. It is possible concerns about anonymity may have existed; therefore, participants were reminded no identifying data were collected as part of this study.

Data Collection Procedures

To prepare for conducting the study, I earned a CITI certification to comply with standards related to Human Research and the Responsible Conduct of Research for Doctoral Learners (CITI Program, 2021). As part of my Application to Utilize Human Subjects to the IRB at Gardner-Webb University, my CITI certification and application materials were submitted and exempt approval was granted. Approval was also sought from each of the five study sites to approach HSE students for participation in research. I contacted the directors of CCR or HSE programs through email or phone and was granted permission outright by the director at three sites and was directed to apply to the site IRB for permission to conduct research with adult HSE students at two sites. A copy of the invitation to participate is included in Appendix I. After gaining approval to conduct research from all sites, I met with all CCR program directors in person, except for two sites, and explained the purpose and scope of the study, the materials, data collection activities, and timeline for the study. Approval certificates are included in Appendices E and F for Sites C and E respectively. To assist with disseminating study information to the instructors, I created two videos explaining the study materials to instructors and another video explaining in more simple terms the study to students. Per Gardner-Webb University policy, the participants were not compensated; however, study participants accrued attendance hours for the time taken during class to complete the study instruments and surveys. Each HSE class instructor or program coordinator provided the quantity of instrument packet copies sufficient to HSE student enrollment at the site. I provided informed consent forms (Appendix J) to be signed by study participants before instructors were to distribute the coded data collection instrument packages.

Hard copies of the survey instruments (demographic survey, MARS 30-item, and MSES) were provided in coded, sealable manilla envelopes for participants to complete in class, place in the envelopes, seal, and return to the class instructor. I provided classroom instructors with a checklist on each coded survey instrument package to summarize materials completed and enter test scores. Each site was given a number of instruments based on the suggested number of participants, coded with the letter of their site (i.e., A for Site A), and a number ranging from 1-96 to denote the number of participants. After 2 weeks, I reminded instructors to request participants to complete the surveys and instruments for collection the following week and arranged a mutually convenient time to collect completed survey instrument packets. It was the responsibility of the instructor to collect CASAS Goals or TABE math assessment scores for each participant who completed a survey package to be included on the package code sheet provided to instructors. I did not need to utilize a research assistant at any site to collect completed instrument responses or CASAS Goals or TABE math assessment data; the class instructor acted as a research assistant. In Watts (2011) and Helming (2013), site-based research assistants provided support in administering the instruments and data collection.

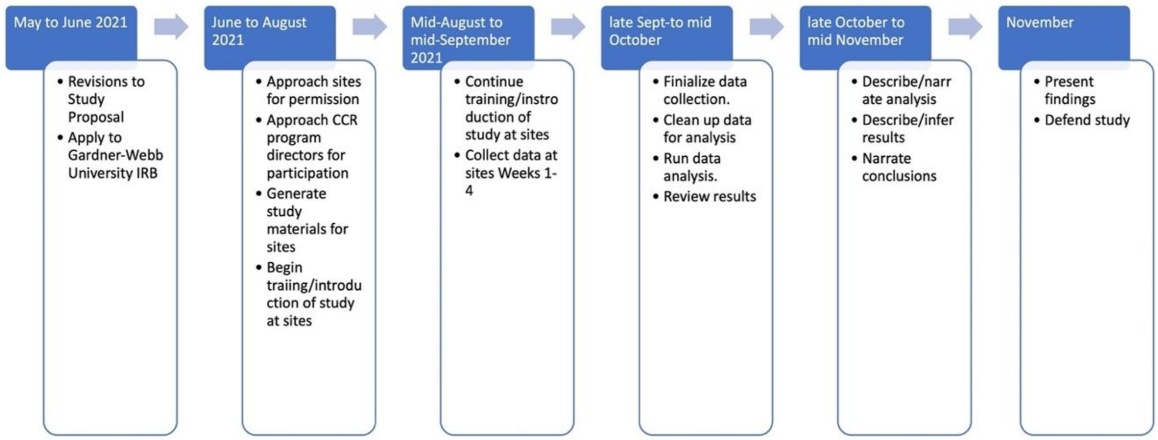
For CASAS Goals and TABE math assessment scores, the test form and the level (test Levels A/B, C, or D and test Levels E, M, D, or A respectively) were not recorded; only the scale score used for placement or promotion was recorded. Participants were encouraged to document their participant code so they could receive their MARS 30-item and MSES scores anonymously after analysis. MARS 30-item and MSES scores were provided to instructors via the participant code if requested. No identifying data other than the site participant were attached to the MARS 30-item, the MSES, the demographic survey, or the CASAS Goals or TABE math assessment scores. Participants were encouraged to be honest on the survey instruments due to the anonymous process of data collection. They were assured no identifying data were collected on any of the instruments, and TABE or CASAS Goals math assessment results included only student score and codified identifier.

It was anticipated, with two independent predictor variables of math anxiety and math self-efficacy levels, in order to have a medium effect size of 0.15 ($f^2 = 0.15$), with an α error probability = 0.05, and a confidence level (1-β error probably) = 0.95, a total sample size of at least 184 would be needed to provide valid results from a total population of 722 (Raosoft, 2021). This sample size was not achieved, as discussed in additional limitations in Chapter 5. The analysis used to determine the sample size for this study and population sample is included in Appendix K.

A proposed study timeline including the steps described above and an estimated time frame for each step is included in Figure 4 and guided the collection of data at each of the sites.

Figure 4

Math Anxiety, Math Self-Efficacy, Math Performance Quantitative Study Timeline



The proposed study timeline illustrated in Figure 4 assumed Gardner-Webb University IRB approval turnaround time of approximately 1 month, which occurred along a shorter time frame of 2 weeks. Additionally, the proposed study timeline assumed the traditional CCR program academic year intake increases for the fall semester, starting in mid- to late-August, and took advantage of program enrollment increases in mid-August. During late July, August, and September, the researcher provided the necessary introductions at each site to ensure instructors were comfortable with the study protocols and data collection activities. Ongoing support for each of the five sites was provided through phone or email. Data collection was conducted bi-weekly for 4 weeks to allow for any delays from incoming program participants. Data analysis was conducted after all data from the five sites were collected and entered into an Excel spreadsheet for direct importation into SPSS (IBM, 2021).

Alignment Table to Research Questions

To help provide clarity of how the different measurement instruments used in this study align to the research questions, I have provided a table for each research question in

Tables 6, 7, and 8. Table 6 aligns Research Questions 1 and 2, the traits to be measured as part of the research question, and the research instrument to be used to gather data relevant to the trait and research question. For space within the tables, CASAS Goals and TABE 11/12 have been abbreviated to CASAS and TABE, respectively.

Table 6

Alignment Table of Research Questions 1 & 2, Instruments, and Analysis Methods

RQ 1: What is the relationship between math anxiety, math self-efficacy, and math performance in HSE students?

RQ 2: Which factor had a greater impact on HSE student math performance: math anxiety or math self-efficacy?

Trait	Instrument	Data collected	Data analysis process
Mathematics anxiety level	MARS 30-item (Suinn & Winston, 2003)	Student responses to MARS 30-item	Quantitative data on math anxiety levels (30-item 5-point Likert scale, 30-150, along normative percentile curve)
Math self-efficacy level	MSES (Nielsen & Moore, 2003)	Student Responses to MSES	18 item (two context 9-item, 5-point Likert scale, 18-90, along normative percentile curve)
Math performance	CASAS or TABE math assessment scaled scores. Aligned to NRS Levels 5-6. NRS Lvl 5 is low, NRS Lvl 6 high.	CASAS or TABE Math assessment data	CASAS scale scores: low 225-235, high ≥236. TABE scale scores: low 596-656, high 657-800.

According to the alignment of research questions to instruments and data analysis methods in Table 6, there are two relationships and degrees of significance of relationships explored through Pearson correlation analysis to answer Research Questions 1 and 2 (Urdan, 2017). It was anticipated either math anxiety or math self-efficacy had a greater relationship (correlation) to the math performance of HSE students. Identifying this relationship answered Research Question 2, “Which factor had a greater impact on the math performance of HSE students: math anxiety or math self-efficacy?” Because the same analysis answered Research Questions 1 and 2, a separate alignment table is not provided. To address Research Question 3, which seeks to find the differences in math anxiety levels across gender, age, or race groups, I provide Table 7.

Table 7

Alignment Table of Research Question 3, Instruments, and Analysis Methods

RQ 3: How does math anxiety differ across gender, age, and race groups?			
Trait	Instrument	Data collected	Data analysis process
Age, math anxiety levels Gender, math anxiety levels Race, math anxiety levels	MARS 30-item (Suinn & Winston, 2003) Demographic survey	Student responses to MARS 30-item Age, gender, race data from Student Demographic Survey	ANCOVA: Math anxiety levels + age covariate Math anxiety levels + gender Math anxiety levels + race
Math performance	CASAS or TABE math assessment scaled scores. Aligned to NRS Levels 5-6. NRS Lvl 5 is low, NRS Lvl 6 high.	CASAS or TABE math assessment data	CASAS scale scores: low 225-235, high ≥236. TABE scale scores: low 596-656, high 657-800.

Table 7 aligns the data collected using the specified instruments to answer the question, “How does math anxiety differ across gender, age, and race groups?” The gender, age, and race data were collected using a demographic survey. The math anxiety level data were collected using the MARS 30-item instrument and were analyzed for their effect on student math performance as measured by the TABE 11/12 or CASAS Goals math assessment (CASAS, 2021; DRC, 2018; Suinn & Winston, 2003).

Table 8 aligns Research Question 4, “How does math self-efficacy differ across gender, age, and race groups,” with the data collection instrument, data, and analysis of this study.

Table 8

Alignment Table of Research Question 4, Instruments, and Analysis Methods

RQ 4: How does math self-efficacy differ across gender, age, and race groups?			
Trait	Instrument	Data collected	Data analysis process
Age, math self-efficacy levels Gender, math self-efficacy levels Race, math self-efficacy levels	MSES (Nielsen & Moore, 2003) Demographic survey	Student Responses to MSES Age, gender, race data from Student Demographic Survey	ANCOVA: Math self-efficacy levels + age covariate Math self-efficacy levels + gender Math self-efficacy levels + race
Math performance	CASAS or TABE math assessment scaled scores. Aligned to NRS Levels 5-6. NRS Lvl 5 is low, NRS Lvl 6 high.	CASAS or TABE Math assessment data	CASAS scale scores: low 225-235, high ≥236. TABE scale scores: low 596-656, high 657-800.

In Table 8, the MSES was used to collect data on student self-efficacy in both classroom and test contexts (Nielsen & Moore, 2003). The student demographic survey collected data on student gender, age, and race. I performed an ANCOVA to determine if there are differences in student math self-efficacy among groups of different genders and races/ethnicities using age as a covariate (CASAS, 2021; DRC, 2018.) The rationale for using age as a covariate was the broad range of ages in study participants, as nontraditional students in the smaller sample size (N=55), which ranged from 18 to 69 years of age (U.S. Department of Education, NCES, 2020).

The purpose of conducting an ANCOVA was to provide between-group differences in math anxiety or math self-efficacy levels (Urdan, 2017). The ANCOVA compared the independent variables of student gender, race/ethnicity, and the covariate of age on the dependent variables of math anxiety levels via the MARS 30-item and math self-efficacy levels via the MSES instruments. If there were differences in math anxiety or math self-efficacy levels between the demographic groups, conducting an ANCOVA would have determined which group exhibits more math anxiety or less math self-efficacy in the Beta analysis, as indicated by statistical significance. Understanding which demographic has greater levels will guide future studies examining either math self-efficacy or math anxiety for different groups of students.

Data Analysis, Statistical Methods

I performed two analyses: (a) a Pearson correlation to measure the relationship of math anxiety levels and math self-efficacy levels to CASAS Goals or TABE math performance; and (b) an ANCOVA using independent variables of age, gender, and race on math self-efficacy levels and math anxiety levels respectively. The independent variable of age was a continuous variable provided by participants in the form of month/year. While age groupings may align with the NCCCS adult education student demographic categories, this study collected sample data that did not present naturally occurring age groups (NCCCS, 2019a). The independent variable of gender included three possible values: male, female, and nonbinary. The independent variable of race/ethnicity included five possible values of White/Caucasian, Black/African American, Hispanic/Latinx, AAPI, and Other/Mixed Race. The independent variable of "other" can include participants who identify as Native American, Alaskan Native, or any combination of more than one race. Independent variable data were provided voluntarily through participant responses to the demographic survey and were dependent on participant self-identification to the values presented.

Data for independent variables of the MARS 30-item score and MSES score were provided by participant responses to each of the measurement instruments. The MARS

30-item data generated quantitative math anxiety measurement data with a range of 30-150 on the 30-item 5-point Likert scale instrument (Suinn & Winston, 2003). Ashcraft and Kirk (2001) organized score ranges as follows: high ≥ +1 SD of $\underline{X}$, medium ±0.5 SD of $\underline{X}$, and low ≤-1 SD of $\underline{X}$, with $\underline{X}$ denoting sample mean. However, the publisher of the MARS 30-item suggests scoring Parts I and II as a combined score along a normative curve, with interventions for students scoring at the 75th percentile and above, effectively a raw score ≥ 78 (Suinn & Winston, 2003).

The independent variable of math self-efficacy was measured through the use of the MSES (Nielsen & Moore, 2003). The MSES is an 18-item survey designed to measure perceived math competence at the lower ASE level of math curriculum in two hypothetical contexts: a math classroom and a math test (Nielsen & Moore, 2003). Participant self-efficacy was measured across nine content areas using a 5-point Likert scale; the survey can be administered alone or as originally intended, as two separate instruments to measure participant math self-efficacy in either of the two contexts of math classroom context and math test. Each individual context MSES generates quantitative math self-efficacy data with a score range of 9 to 45 using a 5-point Likert scale of 1 = not at all confident to 5 = very confident, hence a combined range of 18-180 provides total math self-efficacy scores (Nielsen & Moore, 2003). A combined MSES score for both math classroom and math test contexts can be scored using a normative percentile curve along four quartiles 0-25, 26-50 51-75, 76-100, with a median score of 54 across both contexts (Nielsen & Moore, 2003). A confidence lower than 54 would indicate sufficiently low math self-efficacy as to warrant intervention to ameliorate low levels of confidence in ability (Nielsen & Moore, 2003).

The dependent variable data of CASAS Goals or TABE 11/12 performance scores were provided by a site-administered math assessment portion of the CASAS Goals or TABE math assessment. These two math assessments were administered to all participants in their respective HSE programs as part of the intake, placement, and promotion process. The CASAS Goals and TABE 11/12 math assessment scores provide HSE programs with quantitative math performance data organized into ranges of low, medium, and high levels of math skill sets. CASAS Goals math assessment scale scores are organized in two levels of NRS Level 5, high-intermediate 226-235, and NRS Level 6, ASE $\geq$ 236 (CASAS, 2021; NRS, 2019). The TABE 11/12 scale math assessment scores are organized based on the TABE 11/12 scale scores for NRS Levels 5 and 6, ASE grade-level equivalents of 9 (low), 10, (low-intermediate), 11 (high-intermediate), and 12 (high; DRC, 2019a). For this study, all math assessment scale scores were used in their continuous data form for data analysis.

Validity and Reliability of Site-Specific and Research Instruments

To ensure validity and reliability in the data collection, instruments used have proven validity and reliability through independent analyses. According to CASAS (2021), the CASAS Goals tests have undergone rigorous statistical validity and reliability measures to ensure their rigor in accurate student assessment as reviewed earlier. CASAS Goals also ensures an item response theory in their item bank construction and tests (CASAS, 2020b). Similarly, as reviewed earlier, the DRC assures reliability and validity of the TABE 11/12 tests using multiple item reviews for each test question, which were also field tested and analyzed to confirm the questions' measurement properties (DRC, 2019b).

The MARS 30-item used a Cronbach alpha of 0.96, which indicates a high level of internal consistency. Additionally, the test-retest reliability for the MARS 30-item was 0.90 ($p < 0.001$; Suinn & Winston, 2003).

Nielsen and Moore (2003) conducted an analysis on the MSES on a sample of 302 Australian high school students. This demographic of high school student academic level would be similar to the student academic levels found in most HSE programs; therefore, a discussion of the results is relevant to the study population. In their study, Nielsen and Moore determined internal reliability for the two domains of math class self-efficacy and math test self-efficacy achieving Cronbach alphas of 0.86 and 0.90 respectively. The MSES indicated strong statistical significance of score convergent validity in both classroom and test contexts (Nielsen & Moore, 2003).

The researcher-developed demographic survey asked study participants their age (a continuous variable), gender (male, female, nonbinary), race/ethnicity (White/ Caucasian, Black/African American, Hispanic/Latinx, AAPI, and Other/Mixed Race), years since last enrolled in either public or private school, and years since last school math class.

Ethical Issues

To promote ethical behavior, no potential study participants were coerced into participating in the study by either the researcher or the classroom instructor. The classroom instructor did not benefit from assisting in the data collection process but may benefit from the results, which may aid to inform their instructional practices. As this is not an experimental design, there was not a control or experimental group with potential benefits to only one group. Incentives for participation, such as a gift card, were not used, as gift cards may be construed as undue influence or pressure on the student to participate (Creswell & Creswell, 2018).

To ensure the privacy of the participants, no identifying data were collected from the students and any identifiers attached to the CASAS Goals or TABE 11/12 assessment scores were eliminated. Each site remained anonymous as well, only identified as a code of A-E with individual participants provided a number after the code to assist in future retrieval of data. No master list of student names was provided. Site codes and raw data are kept in a secure file cabinet in the researcher's private office and will be for 5 years, after which all data will be destroyed.

Concern for participants' emotional well-being was taken into consideration when administering the instruments. It is possible the exercise of completing the MARS 30-item or MSES generated anxiety or produced negative emotions in the participants simply through the process of participating in the study. It was suggested any participant who felt feelings of anxiety or negative emotions during participation was able to stop immediately, without any penalty or consequence. Additionally, participants may have experienced survey fatigue. To counter-balance possible survey fatigue, classroom instructors were advised to randomize survey order and to allow participants breaks between surveys, if desired. If preferable, participants were encouraged to complete one survey in class 1 day and complete the remaining survey(s) in class the following day. I am not aware if this was implemented as I was not present at each of the sites for survey administration.

Classroom instructors or program coordinators who retrieved CASAS Goals or TABE math score data are typically able to access student math performance scores to inform classroom instruction of student ability level, and no special permissions were necessary to enable the collection of math assessment scores. All raw data collected from the participants will be destroyed after 5 years.

Expected Results

Based on a similar study conducted 10 years ago by Watts (2011), it was expected student math performance scores were greater when the variable of math self-efficacy is higher and math anxiety level is lower; similarly, data analysis is expected to reveal a stronger correlation of one of the two constructs on math performance. It was unclear if gender differences in adult student math self-efficacy persisted as some studies conducted on younger, elementary, or secondary school-aged children suggested (Kranzler & Pajares, 1997; Meece et al., 1990; Noddings, 1996; Pajares, 2002b). There were data to suggest all age groups, genders, and races experiencing math anxiety had experienced low levels of math self-efficacy.

Across all demographic groups, it was expected math anxiety intervention levels (< 75 percentile) had a negative effect on math performance scores. Similarly, lower math self-efficacy levels (< 54) yielded a negative effect on math performance, while higher (> 54) levels of math self-efficacy were expected to have a positive effect on math performance (Haciomeroglu, 2017; Huang et al., 2018; Meece et al., 1990). What was hoped to be discovered were statistically significant differences < 0.05 (α=0.05) in math anxiety or math self-efficacy levels among different ages, genders, or races/ethnicities. Any significant differences discovered would have warranted further discussion on different approaches by educators.

Summary

While the reviewed literature indicates variations in relationships between math anxiety levels and math self-efficacy levels to math performance, understanding the relationship specific to adult HSE students will enlighten CCR programs of identified factors negatively influencing math performance, projecting math performance for HSC attainment. The goal in education is to help students learn, and having quantitative data to guide programs on how learning is affected benefits students and communities through increased student outcomes.

Chapter 4: Results

Research Purpose and Study Sample

The purpose of this study was to explore the relationship of math anxiety and math self-efficacy on the math performance of HSE students. Understanding the impact of math anxiety or math self-efficacy on the math performance of HSE students can be projected to affect the ability of the HSE students to meet the HSE or adult high school math graduation requirements. Further, communities across the U.S. are striving to increase high school graduation rates for local economic betterment (Murnane, 2013, Rose, 2013). Adult education and HSE program providers will benefit from the result of this study and will have specific data to inform their instruction of HSE math students.

Understanding the two constructs impacting student math performance, math anxiety and math self-efficacy, quantitative survey data were gathered from four community college sites in the western North Carolina region. As discussed in Chapter 3, these sites were chosen for their proximity to the researcher as a convenience sample and their HSE program enrollment population. The survey data were gathered directly from adult students while attending their HSE math classrooms during August and September of 2021. All the study participants completed paper-based survey instruments and signed informed consent forms, and math scores were provided directly to the researcher by research assistants at each site.

Each of the five sites invited to participate in the study provide HSE programs, which included AHS participants. The study focused on those adult students over the age of 18 who enrolled in an HSE program and were placed in the adult secondary-level math class based on their performance in a placement assessment. Each of the sites used either the CASAS Goals or the TABE 11/12 standardized adult education assessment as the method to determine student placement in their program. Students operating at the ABE level, which is operationally considered below ASE, were not the target participants in this study.

For this study, five sites were approached to participate, one of which declined participation and was replaced by a different, larger site. The design of the study was proposed in the spring of 2021. The general education community assumption was COVID-19, the disease resulting from infection of the novel coronavirus or SARS-CoV-2, would have abated to the extent full in-person classroom instruction would resume at all sites; however, SARS-CoV-2 infection rates in the fall of 2021 did not abate sufficiently to encourage a complete return to in-person instruction for students and instructors, and some variation of remote instruction continued, with only a partial return to in-person HSE classroom instruction (Jaschik, 2021; NCCCS, 2021). Student attendance at in-person math classes negatively impacted data collection at three of the sites due to the limitation of a paper-based instrument necessitating in-person study participants. Since Gardner-Webb University IRB approval for this study was contingent on a paper-based data collection format, study participation was further limited to those enrolled and attending in-person instruction (Gardner-Webb University, 2021).

Data Collection Procedure

To prepare for data collection, survey packet envelopes were assembled which included the following: an Invitation to Participate, an Informed Consent, a stamped copy of an Informed Consent, a copy of a data collection organizer sheet with space for test scores, the MARS 30-item instrument, and the MSES instrument. All envelope contents and the exterior of the envelope were coded with the letter of the site and a sequential number from *1* to *n*, depending on the perceived number of participants at the site to ensure participant anonymity. Sites were approached in late July after Gardner-Webb University IRB approval, with an additional site approached in late August. When a site agreed to participate or approved my conducting the study with the study sample population, I met with each of the program directors to discuss the purpose of the study and what the study would entail for data collection. After meeting with the individual sites, I provided enough coded survey packets for the size of their program, as provided to me by each of the program directors. Each site retained the survey packets for a minimum of 2 weeks and a maximum of a month to aid in completion by study participants. To aid in the dissemination of information for both the classroom instructors and the students, two videos were created explaining the forms and information needed. The video links were sent to sites that felt they would be beneficial for students or instructors/coordinators. Site directors explained the study to classroom instructors and/or coordinators. Video links provided in emails were provided, if requested, to the classroom instructors and coordinators by the site program director. Classroom instructors and coordinators at each site were responsible for administering the surveys to participants. Table 9 summarizes site survey distribution and participation.

Table 9

Site Survey Distribution and Participation

Site	Survey packets distributed	Complete survey packets returned
Site A	20	8
Site B	10	8
Site C	60	11
Site D	10	0
Site E	96	45
Total	196	73

Note. Incomplete survey packets did not include signed informed consent and were destroyed.

Among the five sites, a total of 196 survey packets were assembled and distributed. A total of 78 packets were returned to the researcher for analysis and inclusion in this study. Not all survey packets included all of the information requested, and the six missing informed consent or completed survey instruments were discarded as they did not provide permission or data for analysis. Seventy-two survey item packets form the participant sample for this study. A minor few of the 72 study participants did not answer every item on both instruments, either through discomfort or through carelessness; however, the IBM SPSS software accounted for any missing responses in its analysis of math self-efficacy, math anxiety, and math performance data provided (SPSS, 2021). If enough responses were missing from the data, the SPSS software removed the entire dataset at the stepwise phase of analysis, thereby eliminating any skewed or invalid data results (SPSS, 2021). Therefore, in regression and ANOVA analysis further in this chapter, total valid datasets are indicated as N = *n* and may vary according to complete data received. Similarly, the discussion of data analysis pertaining to math performance only includes the datasets from participants where a math performance score was provided to the researcher. Site D returned zero survey packets and was not included in further site discussions.

Demographic Data

Study participants were asked to complete a 5-question demographic questionnaire (Appendix C), which asked participants to self-identify age in birth month/birth year, gender, and race/ethnicity. Race/ethnicity identification was identified in the following five categories: White/Caucasian, Black/African American, Hispanic/ Latinx, AAPI, and Other/Mixed Race. The race/ethnicity distribution per site is included in Table 10.

Table 10

Study Sample Distribution by Race/Ethnicity

Site	White/ Caucasian	Black/African American	Hispanic/ Latinx	AAPI	Other/ Mixed Race
Site A	8	0	0	0	0
Site B	6	1	1	0	0
Site C	8	0	1	0	2
Site E	6	15	19	2	2
Total	28	16	21	2	4

Note. One participant at Site E declined to identify race/ethnicity.

Sites A, B, and C of this study comprised a largely White/Caucasian population at 79% representation for those three sites; the overall study sample becomes more diverse by the inclusion of Site E. Site E, which included more Hispanic/Latinx ethnic identification at 48% of Site E’s total participants, also included most of the Black/African American study sample population except one. Black/African American representation is missing entirely from the study sample of Sites A and C. Overall, the sites that participated in this study were majority White/Caucasian at 52%, with

Hispanic/Latinx at 29% represented, followed by Black/African American participants at 22% representation. The two smallest racial/ethnic identities of this study sample were AAPI at 2% and Mixed Race/Other at 4% representation. Participant gender was provided as either male, female, or nonbinary. Participant distribution is articulated in Table 11.

Table 11

Study Sample Distribution by Gender

Site	Male	Female	Nonbinary
Site A	4	4	0
Site B	4	4	0
Site C	7	4	0
Site E	32	12	1
Total	48	24	1

All study participants self-identified their gender on the demographic survey instrument as three possible categorical entries: male, female, and nonbinary. Gender distribution among Sites A and B was balanced. Sites C and E had a larger proportion of male study participants than females, with a ratio of 8:3, male to female. Site C had the only nonbinary identified participant of the study. To calculate age, participants were asked to provide their month and year of birth. The study sample distribution is included in Table 12 (Robinson & Leonard, 2019).

Table 12

Study Sample Distribution by Age Group

Site	18-25	25-34	35-44	45-54	55+
Site A	4	0	2	0	1
Site B	3	1	3	0	1
Site C	3	4	4	0	0
Site E	12	13	7	9	4
Total	22	18	16	9	6

Note. One participant declined to provide age.

Age groupings in Table 12 are provided as descriptive data for similar groupings used in HSE and ABE demographic metrics which are published annually by NCCCS. The age groupings in Table 12 are merely a reference point; analysis of the relationship of math anxiety, math self-efficacy levels, and math performance was performed on the continuous data of numerical age. The majority of participants in the study sample across all sites were in the age range of 18-25 years old. This age is considered the nontraditional student, although there were study participants who fell in the highest age range of 55 years old and older (U.S. Department of Education, NCES, 2020). Participants ranged in age from 18 to 69.

Research Questions

The quantitative survey data gathered from the 72 study participants were analyzed to answer the following research questions:

1. What is the relationship between math anxiety, math self-efficacy, and math performance in HSE students?
2. Which factor had a greater impact on HSE student math performance: math anxiety or math self-efficacy?
3. How does math anxiety differ across gender, age, and race groups?

4. How does math self-efficacy differ across gender, age, and race groups?

Data Analysis

Raw survey responses were converted into quantitative data as a numerical value and entered into an MS Excel spreadsheet for final importation into the SPSS software. MARS 30-item data were entered as scores per survey item with values from 1 to 5 along a 5-point Likert-like scale. MSES data were entered as numerical values per survey item with values from 1 to 5 along a 5-point Likert-like scale. In both survey instruments, total survey instrument response values of each participant were used as the quantitative data to be analyzed. Data analysis was then conducted using SPSS software using Pearson correlation analysis followed by a stepwise regression method of data removal to address the gaps in data to retain as much of the data as possible (IBM, 2021). Regression analysis for Research Questions 1 and 2 and an ANCOVA for Research Questions 3 and 4 were conducted from raw data entered into an Excel spreadsheet from demographic, MARS 30-item, and MSES survey instruments (Lund Research, 2013; SPSS, 2021).

Demographic Survey Instrument Data

Participants entered their responses to the 5-question demographic survey instrument in numerical and categorical selections (Appendix C). Demographic survey items included the birth month and year as numerical entries, gender and race/ethnicity as categorical selections, date of last math class, and date of last time in school as numerical month and year entries. The latter two demographic survey items were not relevant to the research questions of this study and largely provided invalid responses from the study participants. Data collected from these two survey items were not included in the data analysis.

Demographic Data Conversion to Quantitative Values. For quantitative analysis of demographic survey item responses, participant responses on the demographic survey instrument were converted to a numerical value. Gender responses were converted to 1 = male, 2 = female, 3 = nonbinary. Race/ethnicity selections were converted to 1 = White/Caucasian, 2 = Black/African American, 3 = Hispanic/Latinx, 4 = AAPI, and 5 = Other/Mixed Race. Age was provided as numerical month and year and calculated by converting month and date to a consolidated mm/yyyy data value and subtracting the date in mm/yyyy format from the current date of the data analysis in mm/yyyy format with the value of 09/2021(Robinson & Leonard, 2019). The date of the last math class was provided as numerical month and year; the date of the last time attending school was provided similarly as numerical month and year. Participants offered varying understandings of the dates to be provided. Some provided the current mm/yy for their math class, no dates, or a past date. Considering the varying responses and since neither the date of the last math class or the date of the last school attendance address the research questions, these data were excluded from data analysis.

MARS 30-Item Survey Instrument Data

Study participants provided responses on the MARS 30-item via selection along a 5-point Likert-like scale (Suinn & Winston, 2003). Responses to survey items included “not at all,” “a little,” “a fair amount,” “much,” and “very much.” Participants were asked hypothetical situational questions about their feelings of anxiety in the context of varying situations. Situations included classroom activities such as “being given a pop quiz in math class,” “taking an examination (quiz) in a math course,” and “being given a homework assignment of many difficult problems which is due the next math class.”

Real-world contextual situations posed included items such as "reading a cash register receipt after your purchase" and "totaling up a dinner bill that you think overcharged you." Other contextual items pose questions related to math performance on an exam such as "taking an examination (final) in a math course" or "thinking about an upcoming math test five minutes before."

MARS 30-Item Data Conversion to Quantitative Values. Participant responses were converted to a numerical format input into an MS Excel spreadsheet for data analysis. The responses, and their quantitative value, followed the format: 1= not at all, 2 = a little, 3 = a fair amount, 4 = much, and 5 = very much.

Participant responses yielded a total math anxiety score, which was scored according to the publisher's instructions as the sum of all survey items, the total of which was aligned to a publisher-provided percentile range. As an example, according to Suinn and Winston (2003), a participant with a raw MARS 30-item score of 78 would fall into the 75th percentile range and be considered to be highly math-anxious. Any cumulative MARS 30-item score above 120 would be considered well above the 75th percentile range and in the 99th percentile. Of the participants who provided complete MARS 30-item responses, 43 participants responded with a cumulative math anxiety score at or above the 75th percentile level and two scored in the 99th percentile. Of the study participant responses, the lowest score of 30 and the highest scores of 142 and 150 respectively provided a range in math anxiety participant scores of 120. Suinne and Winston recommended study participants who score higher than the 75% level are suitable for math anxiety interventions. Higher math anxiety scores are indicative of higher levels of math anxiety and may be attributed to a negative effect on math performance (Ashcraft &

Kirk, 2001; Ashcraft & Moore, 2009).

MSES Survey Instrument Data

Responses to the MSES (Nielsen & Moore, 2003) were collected on an instrument asking participants to self-evaluate their levels of self-efficacy and confidence of performing specific math activities in two contexts: the math classroom and the math test. Each context posed the same nine activity items along a 5-point Likert-like scale. Responses asked participants to evaluate their ability to solve math problems by type such as "work with fractions" or "solve an algebra problem." Participants self-evaluated their ability to conduct these mathematical functions in the two contexts (classroom or test) along a scale from "not at all confident" to "very confident."

MSES Data Conversion to Quantitative Values. Participant categorical responses on the MSES were numerically aligned to the level of confidence and converted to a quantitative value in the following format: 1 = not at all confident to 5 = very confident. The three undefined levels of confidence between the two extremes were entered as values of 2, 3, and 4, respective to their position along the Likert-like scale on the survey instrument. The publisher of the MSES instrument did not provide scoring guidelines for use in a small-scale study but did articulate descriptive statistics when determining the psychometric validity and reliability of the MSES (Nielsen & Moore, 2003).

A lower MSES overall score indicates a lower level of self-efficacy for the participant to successfully perform that skill set in consideration of both contexts proposed, math test or math classroom (Nielsen & Moore, 2003). The midpoint value of the Likert-like scale is 3, yielding a calculated mean of 3 on both 9-item contexts, a per context numerical median value score of 27, or 54 cumulative median confidence value for both contexts. Using the MSES 5-point Likert-like scale, the lowest possible combined score would yield an 18, and the highest score possible is a value of 90. A confidence lower than 54 would indicate sufficiently low math self-efficacy as to warrant intervention to ameliorate low levels of confidence in ability (Nielsen & Moore, 2003).

Of the 67 participants who completed the MSES in its entirety, 48, or 72%, scored lower than the theoretical median of 54 for the two contexts combined. For the classroom context, participants self-evaluated their confidence as a mean of 22.88, with a median value from responses of 23. For the testing context, study participants self-evaluated their confidence as a mean of 19.64 with a median confidence value of 18.

The SPSS multiple regression analysis of the valid datasets (N = 55), provided similar results to the total provided responses, as illustrated in Table 13.

Table 13

Descriptive Statistics of Valid Datasets

	Mean	Standard deviation	N
CASAS Goals math	220.27	9.837	55
Math self-efficacy total	41.44	18.642	55
Math anxiety total	78.95	28.124	55

Table 13 summarizes math performance scores from the CASAS Goals math assessment as reported for 56 of the participant survey packets, of which 55 were included in the data analysis. Since only eight of the returned survey packets included scores using the TABE 11/12 math assessment, the number of TABE 11/12 scores provided were too low to provide any statistical validity when analyzing the relationship of the eight scores to math anxiety and math self-efficacy and were eliminated from the dataset for analysis (SPSS, 2021).

The mean CASAS Goals math performance score from the study participants was 220.27, while the median math score was 221. A score of 220 is considered within the range of high intermediate, or NRS Level 4 (CASAS, 2021). This math score is considered, in prekindergarten to 12th-grade context, to be considered a skill level equivalent to Grades 6-8, or middle school level (NRS, 2019). While study sites were advised to invite participants who were performing at the ASE level in math, many programs have varying policies on their placement determinations. Therefore, it is likely some participants are placed in an HSE program who may not yet be performing at the ASE level in math. Individual HSE programs across NCCCS implement varying protocols for placing students in their programs, depending on their staffing, testing, and enrollment dynamics. It is possible among the five sites of this study that some programs may place HSE students based on reading scores or other measures.

Relationship of Math Anxiety, Math Self-Efficacy, and Math Performance

The first two research questions addressed the relationship of math anxiety, math self-efficacy, and math performance and the degree or strength of one or the other's correlation to the math performance scores.

1. What is the relationship between math anxiety, math self-efficacy, and math performance in HSE students?
2. Which factor had a greater impact on HSE student math performance: math anxiety or math self-efficacy?

By analyzing the relationship of scores from the MARS 30-item, the MSES, and math performance scores, a study of the relationship of two independent variables of math anxiety and math self-efficacy and their relationship to a dependent variable of math performance warranted the choice of regression analysis (Lund Research, 2013). Pearson correlation regression analysis of the relationship of the two independent variables of math anxiety and math self-efficacy addressed Research Question 1 while also addressing the question of which condition affects math performance to a greater degree, as posed in Research Question 2. Therefore, the data analysis addressing the first two research questions is discussed together in this section.

Data Analysis Procedures

To answer Research Question 1, a multiple regression analysis was run to determine the strengths of the relationship between the CASAS Goals math scores, math self-efficacy, and math anxiety levels. The descriptive statistics for these variables were provided in Table 13. Further multiple regression analysis was conducted using the stepwise method to show the iterative changes in the regression equation by adding the independent variables of math anxiety and math self-efficacy levels into the model one at a time. The results are displayed in Table 14.

Table 14

Multiple Regression Analysis of Math Anxiety, Math Self-Efficacy on Math Performance

		Unstandardized coefficients		Standardized coefficients		
	MSES Model	B	Std. Error	Beta	t	Sig.
1	Constant	213.329	3.118	526.902	68.418	.000
	Math self-efficacy total	0.168	.069	.318	2.438	.018
	Math anxiety total	-.005[b]	-.039	.969	-.005	.915

The multiple regression analysis omnibus detailed in Table 14 showed the regression model was significant, $F [1,54] = 5.944$, $p = .018$ ($p < .05$). The individual parameters were investigated to see the predictive strength. There was a positive relationship between math self-efficacy and math performance, illustrated in $t(54) = 2.438$, $p = .018$. Math anxiety was not a significant variable in the model, illustrated in $t(54) = -039$, $p = .969$. The final regression equation is as follows: $y = 213.33 + b_1 (.168) + b_2 (-.005) + error$; where y = CASAS Goals, b_1 = math self-efficacy (MSES), and b_2 = math anxiety (MARS 30-item). A model summary of these results is shown in Table 15.

Table 15

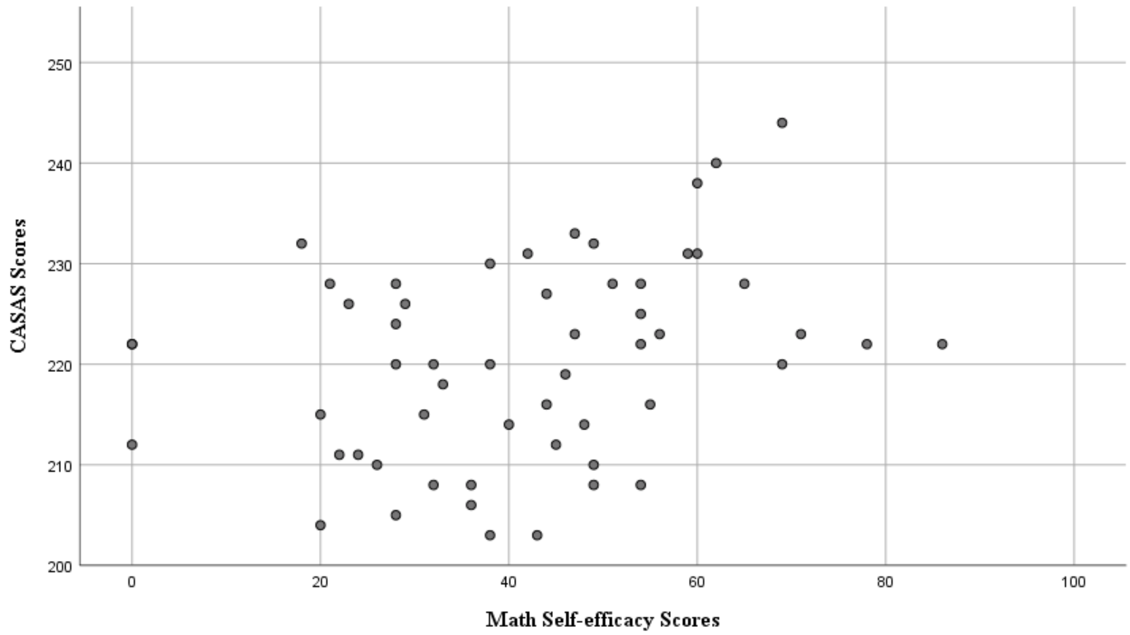
Model Summary of Relationship of Math Self-Efficacy on Math Performance

Model	R	R square	Adjusted R square	Std. error of the estimate	F change	Sig.
1	.318[a]	.101	.084	9.415	5.944	.018

With the MARS 30-item variable removed as part of Model 1, math self-efficacy indicated a significant relationship to math performance on the CASAS Goals math assessment, $F[1,54] = 5.944$, $p = .018$. A dot plot illustrates the specific correlation values between MSES and CASAS Goals math scores in Figure 5.

Figure 5

Dot Plot of Math Self-Efficacy by CASAS Goals Math Score Correlation



The dot plot of Figure 5 shows a moderate positive relationship between MSES values (a measure of the student's math self-efficacy) and the CASAS Goals math scores. While not a largely positive relationship, R = .018, it is a significant positive relationship between the two variables indicating that as math self-efficacy increases, math performance likewise increases.

Math Anxiety Across Demographic Groups

To answer Research Question 3, the associated levels between math anxiety levels from MARS 30-item scores and math performance derived from CASAS Goals math scores, among demographic groups of age, race/ethnicity, and gender, an ANCOVA was performed. The intention of using an ANCOVA was to understand the levels of math anxiety as experienced across genders and racial/ethnicities, using age as a covariate. The rationale for using age as a covariate is the broad range of age groups in the study participants, as nontraditional students in the smaller sample size (N = 55), ranging from 18 to 69 years of age (U.S. Department of Education, NCES, 2020). Table 16 details descriptive statistics of math anxiety levels among males and females of different races/ethnicities.

Table 16

MARS 30-Item Levels Among Genders of Differing Races/Ethnicities

Gender	Race/ethnicity	Mean	Std. deviation	N
Males	White/Caucasian	69.58	23.551	12
	Black/African American	39.75	30.137	4
	Hispanic/Latinx	63.33	22.474	6
	AAPI	130.00	.	1
	Total	65.39	28.913	23
Females	White/Caucasian	80.53	39.111	15
	Black/African American	83.75	33.024	12
	Hispanic/Latinx	87.31	32.211	16
	AAPI	91.00	.	1
	Mixed Race/Other	75.00	18.385	4
	Total	83.35	32.844	48

The statistics provided in Table 17 summarize math anxiety levels measured by the MARS 30-item instrument for males and females (Suinn & Winston, 2003). The one participant who identified as nonbinary, being the sole data point for the gender identification category, was not included in the descriptive statistics. For each gender group, the race/ethnicity grouping with the math anxiety levels for that gender and race/ethnicity combination is provided along with the number of participants in the group (N=). According to the publisher-provided scoring guide, a raw MARS 30-item score of 78 or higher is considered above the 75th percentile range deemed to be highly math-anxious. Scores below 78 are not considered math-anxious. The descriptive data do not suggest a correlation of math anxiety levels and different race/ethnicity groups of the two genders. The ANCOVA for gender and race/ethnicity and MARS 30-item values are included in Table 17.

Table 17

ANCOVA Math Anxiety Levels Correlation to Gender and Race/Ethnicity

Source	Type III sum of squares	df	Mean square	F	Sig.
Corrected Model	13569.575[a]	9	1507.731	1.519	.162
Age	802.334	1	802.334	.808	.372
Gender	666.219	1	666.219	.671	.416
Race/Ethnicity	5175.440	4	1293.860	1.304	.279
Gender *Race/Ethnicity	4084.380	3	1361.460	1.372	.260
Error	60538.087	61	992.428		
Total	500939.000	71			
Corrected Total	74107.662	70			

The math anxiety levels of the different race/ethnicity groups of different genders do not provide a significant correlation to one grouping or another F[3,71] = 1.372 p = .260, using p < .05 for statistical significance for two or more variables. Age as a covariate is removed as it is not statistically a significant variable in math anxiety among gender and race/ethnic groups, F[1,71] = .808, p = .372. When evaluating the relationship of math anxiety among race/ethnicities, there is not a significant correlation, F[4,71] = 1.304, p=.279); when evaluating gender groups' math anxiety, there is a similar lack of significant correlation F[1,71] = .671, p=.416. In summary, across the study sample population, gender and race/ethnicities experience the same level of math anxiety, and one group does not experience more math anxiety than the other.

Math Self-Efficacy Across Demographic Groups

To answer Research Question 4 of associated levels between math self-efficacy values among different ages, genders, and races/ethnicities, an ANCOVA was conducted. The descriptive statistics for the population sample of this study are included in Table 18.

Table 18

MSES Levels Among Genders of Differing Races/Ethnicities

Gender	Race/ethnicity	Mean	Std. deviation	N
Males	White/Caucasian	45.58	18.253	12
	Black/African American	56.75	28.324	4
	Hispanic/Latinx	49.20	7.855	5
	AAPI	45.00	.	1
	Total	48.41	17.872	22
Females	White/Caucasian	30.07	19.579	15
	Black/African American	39.00	17.725	12
	Hispanic/Latinx	31.81	19.894	16
	AAPI	40.00	.	1
	Mixed Race/Other	46.50	17.311	4
	Total	34.46	18.972	48

The descriptive statistics provided in Table 18 summarize math self-efficacy as measured by participant responses on the MSES (Nielsen & Moore, 2003). One study participant identified as nonbinary and, as the sole data point for the nonbinary gender identification category, was removed from the descriptive statistics. For the male or female gender groups, race/ethnicity groupings with math self-efficacy levels are provided along with the number of participants in the group (N=). A raw score of 54 is considered the median for math self-efficacy, and the publisher notes math self-efficacy scores above the median are considered self-confident, or not lacking math self-efficacy. The descriptive data in Table 19 do not provide a correlation of math self-efficacy levels and race/ethnicity of the two genders. The ANCOVA for gender, race/ethnicity, and the MSES response values are included in Table 19.

Table 19

ANCOVA Math Self-Efficacy Levels Correlation to Gender and Race/Ethnicity

Source	Type III sum of squares	df	Mean square	F	Sig.
Corrected Model	4641.615[a]	9	515.735	1.412	.204
Age	57.181	1	57.181	.157	.694
Gender	1074.574	1	1074.574	2.941	.091
Race/Ethnicity	1255.865	4	313.966	.859	.494
Gender *Race/Ethnicity	95.142	3	31.714	.087	.967
Error	21919.656	60	365.328		
Total	132175.000	70			
Corrected Total	26561.271	69			

The math self-efficacy levels of the different race/ethnicity groups of different genders do not provide a significant correlation to one grouping or another. Age for this calculation is still not a significant variable for math self-efficacy levels across gender and race/ethnicity, $F[1,70] = 0.157$, $p = .694$. When age is removed as a covariate and when math anxiety levels among genders and race/ethnicities are correlated, there does not appear to be a significant relationship across populations for math self-efficacy levels. In Table 19, gender values are not significantly correlated to math self-efficacy levels, $F[1,70] = 2.941$, $p = .091$; similarly race/ethnicity self-efficacy values are also not significantly correlated $F[4,70] = .859$, $p = .494$. Subsequently, variables of gender and race/ethnicity combined are not correlated to math self-efficacy levels in this study sample population $F[3,70] = .087$, $p = .967$. According to the analysis of the participant data provided in this study, the HSE sample population groups experienced the same level of math self-efficacy.

Summary of Results

The purpose of this study was to explore the relationship of math anxiety, math self-efficacy, and math performance of HSE students at five sites across western North

Carolina. As the data show, there was not a statistically significant relationship between math anxiety and math self-efficacy together on math performance scores or a significant relationship between math anxiety alone on math performance; however, for the study sample, the data showed a significant correlation of math self-efficacy to math performance. As a follow-up to a study conducted by Watts (2011) on a similar population sample, data collected for this study confirmed the results from the Watts study: Math self-efficacy has a statistically significant relationship to math performance for HSE students in both study samples. Additionally, for this study sample, there was not a significant correlation between age, gender, or race/ethnicity groups and math anxiety or math self-efficacy levels.

Chapter 5: Discussion

Summary of Findings

After review of research literature examining the relationship of math anxiety and math self-efficacy on the performance of students in multiple populations, including but not limited to elementary school students, high school students, and postsecondary school students globally, there is a dearth of literature addressing a population outside of traditional educational contexts: the HSE student. The purpose of this study was to address the implications of math anxiety, math self-efficacy, and their relationship to math performance for a population of students who have not graduated from high school but are considered adult, nontraditional students and are pursuing an HSC through alternative means, such as a GED, AHS, or HiSET program (U.S. Department of Education, NCES, 2020). This quantitative study aimed to address the gap in the literature and determine if a relationship existed between math anxiety and math self-efficacy impacting math performance in this nontraditional student population (U.S. Department of Education, NCES, 2020). Additionally, data were collected and analyzed to understand if one group among these HSE students was affected by elevated levels of math anxiety or reduced levels of math self-efficacy more than another group. This quantitative study aimed to address the four following research questions through the collection of math anxiety, math self-efficacy, and math performance data from four NCCCS sites offering HSE programs.

1. What is the relationship between math anxiety, math self-efficacy, and math performance in HSE students?
2. Which factor had a greater impact on HSE student math performance: math

anxiety or math self-efficacy?

3. How does math anxiety differ across gender, age, and race groups?
4. How does math self-efficacy differ across gender, age, and race groups?

Multiple sites were approached to participate in the study and ultimately quantitative survey data were collected from four sites; the adult HSE students agreeing to participate formed the study population sample. Quantitative data were gathered from the participants on their self-assessment of their levels of math anxiety through the MARS 30-item instrument (Suinn & Winston, 2003). Math self-efficacy level data were gathered from participants via the 18-item MSES instrument (Nielsen & Moore, 2003). Math performance score data were provided by the four participating sites derived from either the CASAS Goals math assessment or the TABE 11/12 assessment (CASAS, 2021; DRC, 2018). Demographic data were obtained from students on age, gender, and race/ethnicity.

Quantitative data were collected from the three survey instruments and analyzed through a Pearson correlation with stepwise data removal before ANOVA analysis to explore and explain the relationship, if any, of math anxiety and math self-efficacy on levels of study participant math performance. Further regression analysis was conducted to understand if one condition, math anxiety or math self-efficacy, had a greater or significant relationship to the math performance of the study participants. Additionally, quantitative data collected from the three survey instruments were analyzed through an ANCOVA to determine if a relationship between math anxiety existed among different ages, races/ethnicities, or genders. Similarly, a further ANCOVA was conducted to determine if math self-efficacy levels differ among different ages, races/ethnicities, or genders.

Discussions of the conclusions drawn from the data analyses are discussed in this section. In alignment with the research questions, the relationship of math anxiety, math self-efficacy, and math performance is discussed first, followed by the discussion of differences in math anxiety among different age, gender, and race/ethnicity groups. Finally, the relationship of math self-efficacy among different age, gender, and race/ethnicity groups is discussed. The conclusions of the data analyses provide insight and suggestions to improve math performance outcomes for HSE students.

Conclusions of Research Questions 1 and 2

The data provided by participants in this study to address the relationship of math anxiety and math self-efficacy on the math performance of HSE students yielded muted relationships of math anxiety in combination with math self-efficacy as significant to affect math performance. Mean math anxiety for the study population was scored at 78.96 from the valid datasets, with a median math anxiety score of 84.5. The mean math self-efficacy score for the study sample was 41.44 for the 55 (N = 55) valid datasets measuring math self-efficacy and its relationship to math performance. The correlation of math anxiety to math self-efficacy was negative at -.292 and not a significant correlation but understandably negative, as it is well understood that as math anxiety increases, math self-efficacy is expected to decrease. The correlation of math anxiety to math performance was -.098, indicating not just a negative relationship but also reaffirming theories proposing that as math anxiety increases, math performance decreases. In the results of this study, while a negative relationship exists, the data do not indicate a significant correlation of the independent variable of math anxiety on the dependent variable of math performance. The correlation of math self-efficacy and math performance was initially .318, indicating the positive relationship of increased math self-efficacy levels affect math performance and indicating a stronger correlation to math performance. When disaggregated from math anxiety, levels of math self-efficacy had a significant correlation to math performance at $p = .018$ ($p < .05$).

These results supported the findings of Haciomeroglu (2017), Huang et al. (2018), and Meece et al. (1990) whose studies did not find a direct relationship of both constructs on math performance. The lack of a combined relationship to math performance confounds the research of Ashcraft (2002), Malachias (2018), and Wang (2019) who found more significant relationships of the two constructs on the math performance of study participants, even though their study samples were not HSE students. The more recent study by Wang went further to confirm anxiety displayed during stressful math activities has spillover into other activities such as language arts assessments.

These results also supported the findings of Watts (2011), the inspiration for this study. Watts's study of a similar population of adults enrolled in ABE and HSE programs determined self-efficacy had a greater correlation on math performance than math anxiety. Beilock et al. (2009), Kiser (2016), Jamieson et al. (2016), and Malachias (2018) indicated the math anxiety experienced by students developed a decreased level of math self-efficacy, and the resulting low math self-efficacy correlated a negative impact on the math performance of the students in these studies. It is not possible to know at this point which construct, math anxiety or math self-efficacy, initially caused the other condition, a sort of chicken-and-egg dilemma requiring further study.

Conclusions of Research Question 3

To address the question if math anxiety levels differ among different ages, races/ethnicities, and genders, the ANCOVA was conducted, and findings indicate that among the genders, ages, or races/ethnicities, there is no difference in the degree or level of math anxiety. The results show that males averaged a math anxiety score of approximately 65.39, which falls below the publishers' suggested threshold of 78. Additionally, while slightly higher, females in the valid study sample averaged a math anxiety score of 83.35, which is higher but not considered statistically significant for the study sample (N = 71 total). While age was included in the data analysis, it was not a significant covariate in either race or gender correlations. This determination was made when considering the wide range of ages included in the relatively small sample size.

Among the various race/ethnicity groups, White/Caucasians averaged a math anxiety score of 75.67, which could be considered right at the math anxiety threshold for intervention. White males indicated lower levels of math anxiety at a mean of 69.58 compared to the White female participants with a mean score of 80.53. These more elevated levels of math anxiety for female study participants are supported by the research of Steele and Aronson (1995) and Erturan and Jansen (2015). Other studies, however, do not support a gender difference in math anxiety levels, such as Else-Quest et al. (2010) and Marks (2008), who determined from their study data that math anxiety affects generally not specifically based on their gender. Even with the elevated levels of math anxiety exhibited by the White females compared to the White males, their levels of math anxiety were not statistically significant for their race/ethnicity group.

Black/African Americans participating in this study had a mean math anxiety score of 72.75, indicating slightly lower than threshold math anxiety levels among the valid datasets. Black/African American females by contrast had a math anxiety score mean of 83.75, which again is supported by the research of Johnson (2013) and Maloney et al. (2013) and the seminal research of Steele and Aronson (1995) which introduced the construct of stereotype threat, all of which found elevated levels of math anxiety among Black/African American students as compared to their White/Caucasian colleagues.

The two AAPI students who provided valid datasets included in this study averaged a math anxiety score of 110.5, which indicates a very high level of math anxiety above the published math anxiety threshold of 78 (Suinn & Winston, 2003). It is possible the two study participants are too few to provide valid comparison data for this study. However, these elevated levels of math anxiety are supported by the limited research of Pajares (2002b) who found differences in multiple racial groups, not just between Black/African American and White/Caucasian students. However, the meta-analysis by Ma (1999) determined there was no racial difference in math anxiety levels.

Hispanic/Latinx students averaged a math anxiety score of 80.77, indicating a higher than threshold level of math anxiety among Hispanic/Latinx study participants. Female Hispanic/Latinx participants experienced more elevated levels of math anxiety with a mean score of 87.31 as compared to the male Hispanic/Latinx study participants who exhibited a lower than threshold math anxiety with a mean of 63.33. Studies specifically addressing Hispanic/Latinx math anxiety levels are sparse at best; however, one can extrapolate from the Pajares (2002b) study of minority students that the results are supported.

The few participants who identified as Other/Mixed Race averaged a math anxiety score of 75, below the threshold for consideration of interventions for math anxiety. There are no studies to date specifically focusing on mixed-race students, as the component makeup of a mixed-race student can vary so widely, making data analysis difficult. Among these five groups, the math anxiety scores did not have a statistically significant relationship to math performance.

It might be suggested to look instead for differences between genders within a race/ethnicity and determine if cultural norms persist within the race/ethnicity to elicit elevated math anxiety levels in one gender as compared to the other.

Conclusions of Research Question 4

To address Research Question 4, if math self-efficacy values differ among different ages, race/ethnicities, and genders, an ANCOVA was conducted and findings indicated there was no statistically significant difference ($p < .05$) in the levels of math self-efficacy among age, race/ethnicity, and gender groups. This study's results show that males averaged a math self-efficacy score of 48.42, while females averaged a much lower level of self-efficacy of 34.46. Seminal studies by Huang et al. (2018), Pajares (1996), and Steele and Aronson (1995) suggested math self-efficacy levels differ between male and female study participants, which is also shown in the results of this study. Math self-efficacy results from the HSE student participants suggest an average math self-efficacy level below the threshold for the median math self-efficacy of 54. The male participants in this study came closest to the median math self-efficacy scores, indicating a difference compared to female study participants; yet overall, both genders experienced lowered math self-efficacy.

Among the various race/ethnicity groups, White/Caucasians and Hispanic/Latinx participants averaged lower levels of math self-efficacy, a mean of 36.96 and 35.95 respectively, as compared to their Black/African American, AAPI, and Other/Mixed Race colleagues with scores of 43.44, 42.50, and 46.5 respectively. Among these five groups of study participants, the differences in math self-efficacy levels were not statistically significant; one might conclude one race/ethnicity of adult HSE students does not experience different levels of math self-efficacy as compared to others.

These results contrast with Pajares (2002b) who mentioned race as a component of self-efficacy; however, Pajares (2002b) suggested minority students had varying levels of math self-efficacy with positive self-concept in multiple other subject areas. The results of this study are consistent with the meta-analysis of Ma (1999) and Maloney et al. (2013) who determined there were no racial differences between a student's math self-efficacy level and their math performance. It is possible the relatively balanced self-efficacy levels indicated by my study results are not just reflective of math specifically but may be projected onto educational experiences generally for the HSE race/ethnic groups participating in this study. Studies of other racial groups are rare, as most studies focus on the differences in math performance of White/Caucasian as compared to Black/African American students.

Additional Limitations and Delimitations

One of the limitations encountered after the proposal was the agreement to participate by the sites approached. Of the five sites approached for participation in this study, one site declined to participate in any form, and a replacement site was approached. Of the five sites approached, four actively agreed to participate to varying degrees, of which Site E provided the most data. While Site D agreed to participate, it did not provide any data for this study.

A delimitation was the format of the survey instruments. The initial proposal intended both paper-based and electronic survey instruments; however, during Gardner-Webb University IRB approval, the reviewer questioned the instrument formats and requested I choose one or the other. At the time, COVID-19 restrictions at most educational settings were easing and I assumed, erroneously, most sites to be approached would have ample in-person classes providing study participants. I decided to make all data collection via paper-based survey instruments. The decision to use solely paper-based survey instruments negatively impacted the amount of data to be collected by limiting the ability to collect online data from remote students. For example, Site C had a large number of online students eligible to participate in this study; however, the online students were unable or unwilling to utilize a paper-based survey instrument as part of the study.

Implications

There are implications for HSE students at three crucial points of their educational journeys: before dropping out of high school, when students return to HSE programs after dropping out of high school, and when students have stopped out of an HSE program and return after the two previous "dropout" events in their educational history (Beilock et al., 2009; Jameson & Fusco, 2014; Johnson, 2013; Luttenberger et al., 2018; Nash & Kallenbach, 2009; Odom, 2010). In other words, there are multiple opportunities for math instructors to address or provide interventions related to student math self-efficacy levels. In this section, I discuss considerations for math teachers of lowered math self-efficacy students. My focus on self-efficacy is based on the results of this study suggesting a statistically significant relationship of math self-efficacy on math performance for HSE students.

Improving preservice and in-service teacher math anxiety and improving math self-efficacy, in turn, affect student attitudes towards mathematical activities; conveying positive emotions and opinions of math to students is one facet of building positive self-efficacy of a skill (Bandura, 1997; Beilock et al., 2009; Beilock & Willingham, 2014; McGann, 2019; Ramirez et al., 2018; Skaalvik & Skaalvick, 2007). While not discussed in depth in the literature review due to the focus on research for more adult populations, Beilock et al. (2009), Furrer et al. (2014), and Ramirez et al. (2018) highlighted the impact preservice and elementary teachers have on affecting the math anxiety or math self-efficacy of elementary students, which carries over into future math performance in middle, high, and postsecondary school coursework.

At any grade level or educational environment, the verbal cues a teacher conveys to their students, as one of the key factors of self-efficacy, influence, positively or negatively, the student's own self-efficacy (Bandura, 1997). For students who have a negative educational history, using growth-mindset language can provide the verbal cues of grit and persistence needed for academic success in adult learners (Boaler, 2016; Dweck, 2016; Luttenberger et al., 2018; Malachias, 2018; Nash & Kallenbach, 2009; Odom, 2010).

A teacher with math anxiety who exhibits physiological arousal such as nervousness affects student self-efficacy through vicarious experience: The student sees their teacher's discomfort and interprets the experience as negative (Bandura, 1997; Beilock, 2010). Instructors of any age student can provide smaller, more frequent positive mathematical experiences for students and build positive math self-efficacy through positive performance experiences (Bandura, 1997; Beilock & Willingham, 2014; McGann, 2019). Improving student self-efficacy through small positive victories builds self-efficacy–building positive experiences even in challenging situations. Improved self-efficacy transfers to other endeavors, as heightened stress situations compromising a student's self-efficacy can linger into other subject matters (Wang, 2005, as cited in Beilock, 2010). Math instructors who are math anxious or exhibit low math self-efficacy and prefer to incorporate writing in their instruction can encourage students to write about their emotions before math assessment for improved math performance (Beilock, 2010; Beilock & Willingham, 2014).

Students may hold a chicken-and-egg theory about the relationship of their math skills and their math anxiety and low math self-efficacy levels: They are anxious and have low self-efficacy because of their low math skills. The students are not anxious because they are bad at math; they are bad at math because they are anxious and using their working memory to think about the concerns they have about math, diverting mental resources needed to perform the mathematical tasks (Ashcraft & Kirk, 2001; Beilock, 2010; Beilock & Willingham, 2014).

Recommendations for Further Study

The purpose of this study was to explore the relationship of math anxiety, math self-efficacy, and math performance of HSE students enrolled in HSE programs in a western North Carolina region. The overarching rationale was to collect quantitative data sufficient to determine if one construct affects student ability more on math assessments, assessments necessary for the completion of an HSC. Improving student credential attainment has residual effects in the student's local community through the ability to gain employment and to pursue further educational credentials such as community college, university or 4-year college, and vocational certifications (Murnane et al., 2000; Rose, 2013; U.S. Department of Education, NCES, 2019). HSE participant math self-efficacy improvements can provide wider community economic improvements stemming from increased levels of stable employment requiring an HSC and math-related skills necessary in advanced manufacturing, increased homeownership from stable employment and income, and increased educational attainment leading to greater employment opportunities. Increased self-efficacy of math skills impacts HSE student math performance and the likelihood of attaining the minimum requirements needed for an HSC (Murnane, 2013; Rose, 2013). The increased math self-efficacy may transfer to other academic and personal contexts (Wang, 2005, as cited in Beilock, 2010).

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Appendix A

Mathematics Anxiety Rating Scale 30-Item (Suinn & Winston, 2003)

MATHEMATICS ANXIETY RATING SCALE: SHORT VERSION (MARS-SV)

The items in the questionnaire refer to things that may cause fear or apprehension. For each item decide which of the ratings best describes how much you are frightened by it nowadays - "Not at all" "A little" "A fair amount" "Much" or "Very much". Mark your answers on the answer sheet only. On the answer sheet, fill in "1" for Not at all; "2" for A little, "3" for A fair amount, "4" for Much or "5" for Very much.
Do not mark this question sheet. Work quickly but be sure to consider each item individually.

	Not at all	A little	A fair amount	Much	Very much
1. Taking an examination (final) in a math course.	_	_	_	_	_
2. Thinking about an upcoming math test one week before.	_	_	_	_	_
3. Thinking about an upcoming math test one day before.	_	_	_	_	_
4. Thinking about an upcoming math test one hour before.	_	_	_	_	_
5. Thinking about an upcoming math test five minutes before.	_	_	_	_	_
6. Waiting to get a math test returned in which you expected to do well.	_	_	_	_	_
7. Receiving your final math grade in the mail.	_	_	_	_	_
8. Realizing that you have to take a certain number of math classes to fulfill the requirements in your major.	_	_	_	_	_
9. Being given a "pop" quiz in a math class.	_	_	_	_	_
10. Studying for a math test.	_	_	_	_	_
11. Taking the math section of a college entrance exam.	_	_	_	_	_
12. Taking an examination (quiz) in a math course.	_	_	_	_	_
13. Picking up the math text book to begin working on a homework assignment.	_	_	_	_	_
14. Being given a homework assignment of many difficult problems which is due the	_	_	_	_	_

next class meeting.					
15. Getting ready to study for a math test.	_	_	_	_	_
16. Dividing a five digit number by a two digit number in private with pencil and paper.	_	_	_	_	_
17. Adding up 976 + 777 on paper.	_	_	_	_	_
18. Reading a cash register receipt after your purchase.	_	_	_	_	_
19. Figuring the sales tax on a purchase that costs more than $1.00.	_	_	_	_	_
20. Figuring out your monthly budget.	_	_	_	_	_
21. Being given a set of numerical problems involving addition to solve on paper.	_	_	_	_	_
22. Having someone watch you as you total up a column of figures.	_	_	_	_	_
23. Totaling up a dinner bill that you think overcharged you.	_	_	_	_	_
24. Being responsible for collecting dues for an organization and keeping track of the amount.	_	_	_	_	_
25. Studying for a driver's license test and memorizing the figure involved, such as the distance it takes to stop a car going at different speeds.	_	_	_	_	_
26. Totaling up the dues received and the expenses of a club you belong to.	_	_	_	_	_
27. Watching someone work with a calculator.	_	_	_	_	_
28. Being given a set of division problems to solve.	_	_	_	_	_
29. Being given a set of subtraction problems to solve.	_	_	_	_	_
30. Being given a set of multiplication problems to solve.	_	_	_	_	_

Appendix B

Math Self-Efficacy Survey (Nielsen & Moore, 2003)

The Role of Mathematics Anxiety and Math Self-efficacy on High School Equivalency Student Math Performance.
Student Math Self-Efficacy Survey (Nielsen & Moore, 2003)

Please respond as truthfully as you can. Each part of this survey should take you about 5 minutes to complete. Responding to this survey is voluntary. You can stop the survey at any time. Information you give on this survey is confidential.

Completing the Math Self-efficacy Survey

Classroom Context: The following questions ask you to estimate your own mathematics ability in the classroom. On a scale of 1 to 5, *how confident are you* that you can perform each of the following mathematics tasks *in the classroom*?

		Not at all Confident				*Very Confident*
1	A simultaneous equation / system of equations	1	2	3	4	5
2	Work with decimals	1	2	3	4	5
3	Determine the degrees of a missing angle	1	2	3	4	5
4	An algebra problem	1	2	3	4	5
5	A problem in trigonometry	1	2	3	4	5
6	Calculate values of area and volume	1	2	3	4	5
7	Sketch a curve	1	2	3	4	5
8	Work with fractions	1	2	3	4	5
9	Determine the value of a missing side length	1	2	3	4	5

Test Context: The following questions ask you to estimate your own mathematics ability on a math test. On a scale of 1 to 5, *how confident are you* that you can perform each of the following mathematics tasks *on a math test*?

		Not at all Confident				*Very Confident*
1	A simultaneous equation / system of equations	1	2	3	4	5
2	Work with decimals	1	2	3	4	5
3	Determine the degrees of a missing angle	1	2	3	4	5
4	An algebra problem	1	2	3	4	5
5	A problem in trigonometry	1	2	3	4	5
6	Calculate values of area and volume	1	2	3	4	5
7	Sketch a curve	1	2	3	4	5
8	Work with fractions	1	2	3	4	5
9	Determine the value of a missing side length	1	2	3	4	5

<u>If you have questions about the survey contact:</u>

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Appendix C

HSE Student Demographic Survey

The Role of Mathematics Anxiety and Math Self-efficacy on High School Equivalency Student Math Performance.
Student Demographic Survey

Instructions: Please respond to each question as truthfully as you can. This survey should take you about 5 minutes complete. *You can skip any question that causes discomfort and stop the survey at any time. Responding to this survey is voluntary. Information you give on this survey is confidential.*

1. What is your age? Provide birth month and birth year only. _____Month ______Year

2. What is your gender? _____Male _____Female _____Non-binary

3. What is your race/ethnicity? Please choose the race/ethnicity you most identify with.

_____White/Caucasian _____Black/African American _____Hispanic/Latinx

_____Asian American/Pacific Islander (AAPI) _____Other/mixed-race

4. As you can best remember, when was the last time you attended school? Provide month and year only. _____Month _____Year

5. As you can best remember, when was the last time you attended any math class? Provide month and year only. _____Month _____Year

If you have questions about the survey contact:

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Appendix D

Gardner-Webb University IRB Approval

GARDNER-WEBB UNIVERSITY

Institutional Review Board

THIS IS TO CERTIFY THAT THE RESEARCH PROJECT TITLED

The Role of Mathematics Anxiety and Math Self-efficacy Levels on High School Equivalency Student

being conducted by ____Barbara Clarke____________________________

has received approval by the Gardner-Webb University IRB. Date _06/23/2021_______________

Exempt Research

Signed _Sydney Brown____

IRB Institutional Administrator

Expedited Research

Signed ____

IRB Institutional Administrator

____

IRB Chair

Full Review

Signed ____

IRB Administrator

____

IRB Chair

____

Member

Expiration Date: __06/22/2022_______ **IRB # 21060802**

IRB Approval: __X___ Exempt _____ Expedited ______ Full

Appendix E

Site C IRB Approval

LEVEL I REVIEW

Case Number

[redacted]

EXEMPT PROTOCOL SUMMARY FORM

ACTIVITIES EXEMPT FROM COMMITTEE REVIEW

Research activities involving human subjects in the following categories may be exempt from review by [redacted] The principal investigator/project director is authorized to make the first determination of eligibility for exemption; however, [redacted] bears the responsibility for concurring in that determination based on notice provided by the principal investigator to the Institutional Review Board.

The following exemptions do ***NOT*** *apply when (a)* ***deception*** *of subjects may be an element of the research; (b) subjects are* ***under the age of eighteen****; (c) the activity may* ***expose the subject to discomfort or harassment*** *beyond levels encountered in daily life; or (d)* ***fetuses, pregnant women, human in vitro fertilization, children, or individuals involuntarily confined or detained in penal institutions*** *are subjects of the activity.*

EXCEPT FOR THE ABOVE EXCLUSIONS, the federally-approved Categories of Exemption are:

1. Research conducted in established or commonly accepted educational settings involving normal educational practices, such as: (a) research on regular and special education instructional strategies; (b) research on the effectiveness of or the comparison among instructional techniques curricula, or classroom management methods.

2. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; **and** (b) any disclosure of the human subjects' responses outside the research reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

3. Research involving the use of educational tests (cognitive, diagnostic, aptitude, or achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under Category 2 if: (a) the human subjects are elected or appointed public officials, or candidates for public office, **or** (b) federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

4. Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified directly or through identifiers linked to the subjects.

5. Research and demonstration projects which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (a) public benefit or service programs; (b) procedures for obtaining benefits or services under those programs; (c) possible changes in or alternatives to those programs or procedures; or (d) possible changes in methods or levels of payment for benefits or services under those programs.

6. Taste and food quality evaluation and consumer acceptance studies: (a) if wholesome foods without additives are consumed, or (b) if a food is consumed that contains a food ingredient or at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe by the U.S. Food and Drug Administration or approved by the U.S. Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

Exempting an activity from review does not absolve the investigator(s) of the activity from ensuring that the welfare of subjects in the activity is protected and that methods used and information provided to gain subject consent are appropriate to the activity.

Questions about whether a research activity may be exempt from human subjects review can be directed to the IRB Chair.

[redacted]

Page 2

07/20/2021 | [redacted] |
Date Submitted | Institutional Review Board | Case Number

Exempt Protocol Summary Form

The Role of Math Anxiety and Math Self-efficacy level on high school equivalency student math performance.

Title of Research Project

Barbara A Clarke [redacted]

Principal Investigator/Project Director **Department** **Phone Extension** **Email address**

Co-investigator/Student Investigator **Department** **Phone Extension** **Email address**

Co-investigator/Student Investigator **Department** **Phone Extension** **Email address**

Anticipated Funding Source: none

Projected Duration of Research: 2 months **months** **Projected Starting Date:** 07/20/2021

Other organizations and/or agencies, if any, involved in the study: none, [redacted] students only

Exempt under code (see definitions on page one – check one) 1☐ 2☑ 3☐ 4☐ 5☐ 6☐

SUMMARY ABSTRACT. Please supply the following information: BRIEF description of the participants, the location(s) of the project, the procedures to be used for data collection, whether data will be confidential or anonymous, disposition of the data, who will have access to the data. Attach copy of the Informed Consent Form and/or the measures (questionnaires) to be used in the project.

RESPONSIBILITIES OF THE PRINCIPAL INVESTIGATOR:

- Any additions or changes in procedures in the protocol will be submitted to the IRB for written approval prior to these changes being implemented
- Any problems connected with the use of human subjects once the project has begun must be communicated to the IRB Chair
- The principal investigator is responsible for retaining informed consent documents for a period of three years after the project.

7 Ag 2021 ___ / /

Principal Investigator Signature | Co-Investigator/Student Signature (if appropriate)

Signature of IRB Committee Chair: [redacted]	**Date:** / /
IRB Chair: Check 1 box: ☐ Approved ☐ Approved with Conditions	☐ Refer to Full Committee Review

Appendix F

Site E IRB Approval

[redacted]

[redacted]

Ms. Barbara Clarke
Delivered electronically to bclarke@gardner-webb.edu

Ms. Clarke,

This letter is to confirm that the research project titled "The Role of Mathematics Anxiety and Math Self-efficacy Levels on High School Equivalency Student Math Achievement" proposed by Ms. Barbara Clarke, has been reviewed, approved and is supported by [redacted] external research review.

[redacted]

The research project is designed to explore and identify possible relationships between math anxiety, self-efficacy, and high school equivalency math performance.

Research questions include

- What is the relationship between math anxiety, math self-efficacy, and math performance in students enrolled in a high school equivalency program?
- Which factor had a greater impact on student math performance: math anxiety or math self-efficacy?
- How does math anxiety differ across gender, age, and race groups?
- How does math self-efficacy differ across gender, age, and race groups?

The request is for access to human subjects through survey and collection of CASAS Goals math performance scale score or TABE 11/12 math scale score data from the department. While your college sponsor, [redacted] is out of the office, please contact [redacted] for data access and any necessary protocols.

If you need to make any changes to the protocols outlined in your application, you must obtain written approval from my office or the office of Planning and Research. You will receive confirmation with a status update of the request within seven business days of submission of the notice and are not permitted to implement changes prior to receiving approval. Once change approval is received, you may implement approved changes.

You have the permission of the External Research Review Committee and the support of the college with this study.

Please contact me if you have further questions and we would appreciate updates.

Much success!

Sincerely,

[redacted]

Appendix G

Example of CASAS Goals Math Performance Score by Competency

CASAS

Student Performance

by Competency Category

01/05/2020
10:57:38

Page 1 of 2
SCPCC

Agency:	4908 - Rolling Hills Adult School (RHAS)	**Teacher:**	Teacher20@rhas.org
Site:	01 - RHAS: North Campus	**Form Level:**	D
Class:	020101 - AM: HSD/HSE	**Student:**	Sample, Student **ID:** 5615969
Course:	020101	**Total Tests:**	1

Comp No.	Correct	Competency Description	No. of Items
2.8	100 %	Interpret information about the educational system, from early childhood to post-secondary	4
7.7	100 %	Identify common information and communication technology and other electronic devices and their uses, and how they work together	5
4.9	75 %	Understand how social and technological systems work	4
5.7	66 %	Understand environmental and science related issues	3
5.1	60 %	Understand voting and political process	5
4.4	50 %	Understand concepts and materials related to job performance	4
4.6	50 %	Communicate effectively in the workplace	4
5.8	50 %	Understand concepts of economics	4
4.1	20 %	Understand basic principles of getting a job	5
3.3	0 %	Understand how to select and use medications	2

Note: Test records using raw score override are not represented.

Appendix H

Sample TABE Math Performance Score Report

DATA RECOGNITION DRC CORPORATION

Individual Profile: STUDENT, SAMPLE

Report Criteria			
ID:	12345	State:	
Test Name:	TABE 11 ALL	District:	SAMPLE DISTRICT
Report:	ALL	School:	SAMPLE SCHOOL
Report Date:	10-18-2019		

Test Results	Test Date	Level	Number of Points		Items Attempted	Scale Score	SEM	NRS Level	MSG
			Total	Obtained					
Reading	10/25/2018	M	47	44	40	575+	52	4	Y
Mathematics	10/26/2018	M	39	31	35	570	20	4	Y
Language	10/26/2018	M	39	30	35	552	19	4	N

If a student scores more than one NRS level above the targeted level, then a (+) sign will appear next to the scale score and their score will be set to the highest possible scale score, which is one above the targeted level. In this case, students may want to test with a higher TABE test in order to better assess their ability.

Scale scores with a minus (-) sign next to them are indicators that the student performed at the lower end of the performance range of that level of TABE and the student will likely need to have extended instruction to be ready to demonstrate an NRS Gain on a post test.

The Measurable Skills Gain (MSG) is designed to measure interim progress made by students during an academic year. N denotes the student either did not have enough data to measure a gain or did not receive a gain; and Y denotes the student received an MSG in the academic year.

Performance on Domains	Number of Items	Number of Points		Performance Category		
		Total	Obtained	Non-Proficiency	Partial Proficiency	Proficiency
Reading						
Key Ideas and Details	18	18	17			3
Craft and Structure	17	20	19			3
Integration of Knowledge and Ideas	5	9	8			3
Mathematics						
Measurement and Data	6	6	5			3
Numbers and Operations - Fractions	7	7	5		3	
Numbers and Operations - Base Ten	5	6	5		3	
Operations and Algebraic Thinking	4	5	5			3
Geometry	4	6	5			3
Expressions and Equations	4	4	2		3	
Language						
Conventions of Standard English	18	21	16		3	
Vocabulary Acquisition and Use	5	5	4		3	
Text Types and Purposes	10	11	8		3	

Some levels may have too few items within the domain to show proficiency.

Appendix I

Invitation to Participate

Invitation to Participate

Dear Student,

My name is Barbara Clarke. I am a doctoral student at Gardner-Webb University's School of Education. I am asking for your participation in a doctoral research study I am conducting titled: "The Role of Mathematics Anxiety and Math Self-efficacy Levels on High School Equivalency Student Math Performance." The purpose of the study is to measure math anxiety and math self-efficacy levels in high school equivalency students to understanding how they affect math achievement.

The study involves completing three surveys in your HSE classroom and collecting your most recent CASAS Goals or TABE math test scores. One survey asks your age, race, and gender plus some other questions about your math history. The other two surveys are: the Math Self-Efficacy Survey (MSES) and the Mathematics Anxiety Rating Scale – A Brief Version (MARS-S) (Nielsen & Moore, 2003; Suinn & Winston, 2003). Both surveys are anonymous and your test scores will be collected without any of your identifying data so that your score also remains completely anonymous. These surveys can be completed in one class period or in two separate class periods if you prefer to complete them separately. If you complete them in one class period, you are encouraged to take a break between the surveys. They should take you about 45 minutes to complete in all.

Participation is completely voluntary, anonymous and you may withdraw from the study at any time. If there are any questions in the survey(s) that make you uncomfortable, you can skip the question(s). Since the study is anonymous, it does not require your name or any identifying information. You will be given a code so you can get your results after the study has completed.

If you would like to participate, please read and sign the Informed Consent letter below and return it to your classroom teacher. Your teacher will then provide you with a survey packet to complete. Your participation in the study is important to assist high school equivalency students suffering from math anxiety and reduced math performance. I hope you will consider participating!

Sincerely,
Barbara Clarke, M.S,
Doctoral Candidate, Gardner-Webb University
828.414.1666
bclarke@gardner-webb.edu

Appendix J

Informed Consent

Gardner-Webb University IRB
Informed Consent Form

Title of Study: "The Role of Mathematics Anxiety and Math Self-efficacy on High School Equivalency Student Math Performance."

Researcher: Barbara A. Clarke, Doctoral Student, Gardner-Webb University School of Education.

Purpose: The purpose of the study is to measure math anxiety and math self-efficacy levels in high school equivalency students, understanding how math anxiety and math self-efficacy levels affect math performance.

Procedure: The study involves completing three surveys in your HSE classroom and collecting your most recent CASAS Goals or TABE math test scores. One survey asks your age, race, and gender plus some other questions about your math history. The other two surveys are: the Math Self-Efficacy Survey (MSES) and the Mathematics Anxiety Rating Scale – A Brief Version (MARS-S) (Nielsen & Moore, 2003; Suinn & Winston, 2003). Both surveys are anonymous and your test scores will be collected without any of your identifying data so that your score also remains completely anonymous. These surveys can be completed in one class period or in two separate class periods if you prefer to complete them separately. You are encouraged to take a break between the two surveys. They should take you about 45 minutes at most to complete. *You can skip any question that causes discomfort and stop the survey at any time.*

Time Required: It is anticipated that the study will require about 45 *minutes* of your time. *You can take one or two surveys on two separate days, if you wish.*

Voluntary Participation: Participation in this study is voluntary. You have the right to withdraw from the research study at any time without penalty. You also have the right to refuse to answer any question(s) for any reason without penalty. If you choose to withdraw from the study, you may request that any of your data which has been collected be destroyed unless it is in a de-identified state.

Confidentiality: The information that you give in the study will be handled confidentially. Your information will be assigned a *code number.* The list connecting your name to this code will be kept in a *locked file.* When the study has been completed and the data have been analyzed, this list will be destroyed. Your name will not be used in any report.

Risks: There are no anticipated risks in this study. If, as a result of the study, you experience discomfort and would like to discuss your thoughts or feelings with a counselor, please contact the researcher for assistance: Barbara A Clarke, 828.414.1666, bclarke@gardner-webb.edu.

Benefits: There are no direct benefits associated with participation in this study. The study may help us to understand how math anxiety and math self-efficacy affect math performance and the ability to earn a high school credential. The Institutional Review Board at Gardner-Webb University has determined that participation in this study poses minimal risk to participants.

Payment: You will receive no payment for participating in the study. You will earn attendance hours for your time spent participating in this study.

Right to Withdraw From the Study: You have the right to withdraw from the study at any time without penalty.

How to Withdraw From the Study: If you want to withdraw from the study, please tell the classroom teacher or the researcher you wish to withdraw. There is no penalty for withdrawing. If you would like to withdraw after your materials have been submitted, please contact Barbara Clarke, 828.414.1666.

If you have questions about the study, contact:
Barbara A Clarke
EdD Candidate
School of Education, Gardner-Webb University
828.414.1666
bclarke@gardner-webb.edu

Dr. Sara Newell
Faculty Research Advisor
School of Education, Gardner-Webb University
704.796.1515
snewell@gardner-webb.edu

If you have concerns about your rights or how you are being treated, or if you have questions, want more information, or have suggestions, please contact the IRB Institutional Administrator listed below.

Dr. Sydney K. Brown
IRB Institutional Administrator
Gardner-Webb University
Telephone: 704-406-3019
Email: skbrown@gardner-webb.edu

Voluntary Consent by Participant
I have read the information in this consent form and fully understand the contents of this document. I have had a chance to ask any questions concerning this study and they have been answered for me. I agree to participate in this study.

__________________________________ Date: ______________
Participant Printed Name

__________________________________ Date: ______________
Participant Signature
You will receive a copy of this form for your records.

Appendix K

Sample Effect Size Data Analysis

Raosoft®

Sample size calculator

What margin of error can you accept? 5% is a common choice	5 %	The margin of error is the amount of error that you can tolerate. If 90% of respondents answer *yes*, while 10% answer *no*, you may be able to tolerate a larger amount of error than if the respondents are split 50-50 or 45-55. Lower margin of error requires a larger sample size.
What confidence level do you need? Typical choices are 90%, 95%, or 99%	95 %	The confidence level is the amount of uncertainty you can tolerate. Suppose that you have 20 yes-no questions in your survey. With a confidence level of 95%, you would expect that for one of the questions (1 in 20), the percentage of people who answer *yes* would be more than the margin of error away from the true answer. The true answer is the percentage you would get if you exhaustively interviewed everyone. Higher confidence level requires a larger sample size.
What is the population size? If you don't know, use 20000	722	How many people are there to choose your random sample from? The sample size doesn't change much for populations larger than 20,000.
What is the response distribution? Leave this as 50%	20 %	For each question, what do you expect the results will be? If the sample is skewed highly one way or the other,the population probably is, too. If you don't know, use 50%, which gives the largest sample size. See below under **More information** if this is confusing.
Your recommended sample size is	**184**	This is the minimum recommended size of your survey. If you create a sample of this many people and get responses from everyone, you're more likely to get a correct answer than you would from a large sample where only a small percentage of the sample responds to your survey.

Alternate scenarios

With a sample size of	100	200	300	With a confidence level of	90	95	99
Your margin of error would be	**7.28%**	**4.72%**	**3.46%**	Your sample size would need to be	**140**	**184**	**268**

More information

If 50% of all the people in a population of 20000 people drink coffee in the morning, and if you were repeat the survey of 377 people ("Did you drink coffee this morning?") many times, then 95% of the time, your survey would find that between 45% and 55% of the people in your sample answered "Yes".

The remaining 5% of the time, or for 1 in 20 survey questions, you would expect the survey response to more than the margin of error away from the true answer.