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THE MATH SELF-EFFICACY OF HOMESCHOOL PARENTS AND THE INFLUENCE OF MATH SELF-EFFICACY ON CURRICULUM CHOICE

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By

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DEDICATION

My dad always believed that I would one day have my doctorate, and although he is not here to see this accomplishment, I have felt his encouragement every step along the way. He and my mom always supported my endeavors, and she has continued to do so by taking far more than her share of daily responsibilities on her shoulders to make time for me to work on my schoolwork. They went above and beyond as parents doing all they could to help me succeed. I hope to similarly support my children.

My husband, Brian, has proofread, edited, listened to, and discussed my work since my first class. He has run errands on a moment's notice, sat with me while I worked, and never complained about the time I invested in schoolwork at his expense. Our children, Kate and Luke, have encouraged me and shared how proud they are of their mom working on a doctorate, even though they sometimes felt that their homeschool came second.

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Certainly not least, I am thankful that God knew the right time for me to accomplish this degree. He waited until I would have the humility to be a good researcher and to recognize that

each step along the way was only possible because He illuminated each step and enabled me to take each one. He truly does provide all that we need, and all glory goes to Him.

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The success of any writing endeavor relies on good editors who invest time and energy into diligently reviewing every word, punctuation, and citation. Thank you to Dr. Lopez from Graduate Writing Services and thank you to Dr. Hoskins for her thorough editing.

Abstract

The present study investigated the math self-efficacy of homeschool parents and whether there was a correlation between parental math self-efficacy (PMSE) and parents' choice of mathematics curriculum. A simple random sample of parents with at least one child enrolled in Classical Conversations ($N = 223$) completed a survey to measure their math self-efficacy and provide information about their homeschool and mathematics curriculum choice. The PMSE level was a statistically significant 4.17, indicating that the sample has much confidence in their ability to learn and do mathematics. The study revealed a significant though small correlation between PMSE and the level of involvement required by the curriculum. As PMSE increased, parental involvement in the curriculum also increased. As increasing numbers of parents choose to homeschool, understanding the academic characteristics of homeschool parents will allow homeschool support organizations and curriculum developers to best meet the needs of parents as they seek to educate their children.

Keywords: homeschooling, math self-efficacy, curriculum choice

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I. INTRODUCTION

Each May in central North Carolina, homeschool parents gather to buy and sell used curriculum materials as part of their annual quest to provide the best possible education for their children, aligning with McFall's (2020) finding that "Academic Instruction was the most important factor that impacted parents' decision to homeschool" (p. 462). Gathering with other parents to share experiences with curricula and their research into academic methodology results is essential to how homeschool parents choose their curricula (Bradford, 2018). Parents are committed to research to provide academic excellence within their homeschool. Still, little research is available to them for their professional development and to help them understand how their role as parent-teacher affects their children.

According to the United States Census Bureau, the number of families choosing to homeschool doubled from 5.4% at the beginning of the COVID-19 pandemic to 11% during the fall of 2020 (Eggleston & Fields, 2021). More than one in 10 families now opt to "determine the scope and sequence of the academic instruction, provide academic instruction, and determine additional sources of academic instruction" (North Carolina Department of Administration, n.d., para. 1) for their children. This growth was fastest for minority and lower-income households, which had previously accounted for a smaller percentage of the homeschooling population (Prothero & Samuels, 2020). A growing body of research illuminates the demographics of homeschooling, the reasons for homeschooling, and the outcomes of homeschooling (Ray,

2017), opening more opportunities to explore the homeschool schoolroom and the dual role of the parent-teacher.

Recognizing the homeschool parent-teacher as an academic professional worthy of research is a first step toward providing homeschool parent-teachers with the resources to improve their theoretical and pedagogical understanding. This study examined the math self-efficacy of the homeschool parent-teacher to understand better the relationship that homeschool parent-teachers have with mathematics and how that relationship may influence their curricular choices for their students.

Background of the Study

Since Albert Bandura published the seminal work on self-efficacy in 1977, hundreds of studies on self-efficacy in academia, healthcare, the workplace, the sports field, and relationships have been published. Within mathematics education, self-efficacy has been shown to negatively correlate with math anxiety and positively correlate with math achievement (Pérez Fuentes et al., 2020). Parental self-efficacy has been shown to impact educational choices in early childhood (Dixon-Elliott, 2019). A recent study demonstrated that parental self-efficacy predicted the level of parent-child conflict during the COVID-19 pandemic (de Jong et al., 2021). Extrapolating from studies that show a negative correlation between teacher math anxiety and student achievement (Ramirez et al., 2018) and between parent math anxiety and student achievement (Maloney et al., 2015), parents' self-efficacy may be a predictor of student achievement.

To address the question of parental efficacy and the impact of parents on the math education of homeschool students, Felso (2016) studied six parent-student dyads through a phenomenological qualitative study to explore the role that parental efficacy beliefs played in the mathematics education of the student. One theme from this study was that parents' teaching self-

efficacy is not dependent on their math self-efficacy (Felso, 2016). All parent participants expressed confidence in their ability to provide the necessary instruction to their children despite their personal relationship to mathematics. One of the participants clarified that though she felt confident in her ability to teach mathematics to her student, she was not willing to teach the subject and was one of several participants who had chosen to delegate mathematics instruction to someone outside of their home.

One source of confidence in parents' ability to provide a mathematics education was the number of resources available, including online courses, textbook-specific help, tutors, and teachers other than the parent (Felso, 2016). One participant clarified that her confidence was in finding the appropriate resources needed for her student to complete a math course rather than her ability to teach mathematics. In line with Bandura's (1986) assertion that self-efficacy can be generalized between similar situations, parents felt that their teaching self-efficacy informed their current math self-efficacy and confidence in their ability to learn alongside the students they were teaching (Felso, 2016).

In their work examining the self-efficacy of mentor-mentee dyads, Varghese and Finkelstein (2021) hypothesized that there would be a significant crossover between a mentor's and mentee's self-efficacy. Despite conflicting results regarding the mechanism of efficacy transfer, the mentees' self-efficacy increased after working with their mentors. Felso (2016) found a similar transference between parents and students. Both parents and students expressed that the parents' confidence in their ability to provide for their children's math education contributed to the students' confidence that they could learn mathematics.

Although a qualitative study allows for greater depth of response, small samples limit the generalizability of the findings (Creswell & Poth, 2018). The sample for Felso's (2016) study

was drawn from one homeschooling group in Northwest Atlanta and does not reflect the diversity of homeschooling families. Rather than using an instrument to measure self-efficacy, Felso relied on the parents' and students' perceptions of their self-efficacy. Though this study is the only study explicitly examining parental self-efficacy and homeschool mathematics instruction, it is limited in its generalizability. Direct measurement of self-efficacy would strengthen further studies.

Several studies have demonstrated a link between math self-efficacy and math anxiety (Akin & Kurbanoglu, 2011; Jameson & Fusco, 2014; Pérez Fuentes et al., 2020; Samuel & Warner, 2021; Villavicencio & Bernardo, 2016; Watts, 2011). Villavicencio and Bernardo (2016) observed that current research places an "inordinate amount of attention on negative emotions as it relates to mathematics learning, particularly on the negative emotion of math anxiety" (p. 415). Their study of 1,345 university students found a strong positive correlation between enjoyment and pride and student self-efficacy and suggested that considering positive emotions and self-efficacy offered more insight into variations of academic performance than the measurement of math anxiety offers.

Multiple studies have demonstrated a relationship between teacher math anxiety and both lower student achievement and higher student anxiety across all grade levels (Beilock et al., 2010; Maloney et al., 2015; Ramirez et al., 2018; Szczygiel, 2020). Examining data for 1,886 ninth graders from the National Mindset Study revealed that high math anxiety correlated to a fixed mindset and that students emulated the fixed mindset of their teachers (Ramirez et al., 2018). Silver et al. (2021) worked with 118 preschool students and their parents to study parent anxiety and student achievement in the context of math beliefs. Silver's work added insight into the mechanism in which parental anxiety may transmit to student achievement. Math anxiety

exhibited a magnifying effect on parental beliefs regarding mathematics. Highly anxious parents transmitted the messages that "mathematics is important" and "mathematics is not important" more strongly than parents who were not math anxious.

Gann and Carpenter (2019) explored the role homeschool parents fill in their children's science, technology, engineering, and mathematics (STEM) education. Their qualitative study of 29 parents revealed that parents fulfill three roles in the homeschool: facilitator, counselor, and teacher. As a facilitator, parents coordinate both daily activities and arrange for extension activities through homeschool co-ops, schools, and community programs. As counselors, parents ensure that standards are being met and the appropriate coursework is accomplished to meet state and college requirements. Some parents relied on outside sources of instruction for STEM content, while other parents provided direct instruction to their students.

Gann and Carpenter's (2019) work revealed a theme of parents wanting students to take ownership of their learning. For this reason, parents viewed themselves in the role of facilitator rather than teacher. Parents revealed a reliance on schools, libraries, co-ops, and other community resources to provide STEM activities and education. Still, this study did not address the parents' confidence in providing direct instruction in STEM subjects. The sample for this study was drawn from a single homeschool co-op in a southern United States city and may not be generalizable to the larger homeschool community.

Conceptual Framework/Theoretical Foundation

Bandura's early work on observational learning forms demonstrated that children's behavior was influenced by their observation of others and how they behaved in given circumstances (Bandura et al., 1966). As a psychologist, Bandura continued to study human behavior and the potential for that behavior to change, leading to his seminal 1977 work *Self-*

efficacy: Toward a Unifying Theory of Behavioral Change, in which he defined the four elements that determined self-efficacy: mastery experiences, vicarious experiences, social persuasion, and emotional state. By 1986, Bandura established social cognitive theory (SCT) as his theoretical framework for explaining human behavior.

Unlike other theories that place greater emphasis on either inward factors or outward forces, SCT explains human behavior "in terms of a model of triadic reciprocality in which behavior, cognitive and other personal factors, and environmental events all operate as interacting determinants of each other" (Bandura, 1986, p. 18). Bandura identified five basic human capabilities that together form human nature: the ability to use symbols, the ability to think forward, the ability to learn vicariously, the ability to self-regulate, and the ability to self-reflect (Bandura, 1986).

Using symbols allows for experiences to be translated from the concrete to the abstract. Symbols further enable humans to abstractly test outcomes without enacting concrete behaviors. Symbols are required for successful communication and form the basis for many human characteristics. According to SCT, the ability to use symbols is the foundation of human thought and an essential aspect of human behavior (Bandura, 1986). Related to the use of symbols is the capacity for forethought. Bandura described the ability for forethought as the antithesis of instinctive behavior, solely a reaction to their environment. Instead, humans can be purposeful, thinking through their behavior, setting goals, and anticipating consequences (Bandura, 1986).

Bandura's early work on observational learning is most clearly seen in the human capacity for vicarious learning. Rather than learning occurring solely through personal experiment, learning from responses to different actions, Bandura demonstrated that learning through personal experience could be duplicated through observation (Bandura et al., 1966).

Bandura (1986) stressed the importance of this capacity for survival: “One does not teach children to swim, adolescents to drive automobiles, and novice medical students to perform surgery by having them discover the requisite behavior from the consequences of their successes and failures” (p. 20). Specific weight is given to the influence of media on attitudes, behaviors, thought patterns, and values through the human capacity for vicarious learning (Bandura, 1986).

The roles of self-regulation and self-reflection in SCT are related. Self-regulation is the ability to determine the reaction to and exert influence over external factors (Bandura, 1986). Self-reflection is essential for creating meaning from experiences and changing one’s thinking (Bandura, 1986). Together with the capacity for symbolic thought, forethought, and vicarious learning, self-regulation and self-reflection form the underpinnings of human nature from the perspective of SCT and help to describe the three-way reciprocity between internal factors, external factors, and human behavior (Bandura, 1986).

Though the preceding tenets of SCT describe how human behavior develops, self-efficacy is central to human action (Bandura, 1986). Bandura (1977) differentiated self-efficacy from outcome expectation by describing outcome expectation as the belief that a given behavior would lead to a particular outcome, while self-efficacy is the belief in one’s ability to accomplish the given behavior. To achieve a goal, a person must believe the goal is the outcome of a course of action and that they can carry out the required course of action (Bandura, 1977). If people believe that they cannot carry out the needed tasks, they tend to avoid the situation or task, and if people believe that they can accomplish the tasks, they are more likely to be motivated to work toward the goal (Bandura, 1977).

Mastery experiences describe the mechanism by which successes raise self-efficacy while repeated failures lower self-efficacy (Bandura, 1977). The power of success is seen in the

reduced impact of failures after several successes and the success following failures increasing the effect by demonstrating an overcoming of the failure (Bandura, 1986). The tenet of SCT that, through symbology, humans can generalize their experiences is reflected in the extension of a well-established self-efficacy to other situations, especially those that are similar (Bandura, 1986).

Just as observational learning allows humans to gain knowledge from the behavior of others, various experiences contribute to self-efficacy (Bandura, 1986). Vicarious experiences are most powerful when the individual has little knowledge of their own ability, which is when observing the success or failure of others is likely to influence their belief in their own ability to succeed (Bandura, 1986). Beyond observing the success and failures of others, comparison with others is often crucial for defining success and failure: "When factual evidence for performance adequacy is lacking, personal efficacy must be gauged in terms of the performances of others" (Bandura, 1986, p. 400).

Verbal persuasion, also called social persuasion, is most effective in creating a sustained effort in the face of difficulties and has its greatest impact when the encouragement given is realistic. Unrealistic expectations may lead to failure and thus undermine the recipient's self-efficacy (Bandura, 1986). The psychological and physiological state of a person further contributes to self-efficacy, especially in the negative sense. A high degree of stress and anxiety usually debilitates performance; in a similar way, physical pain and weakness may indicate physical ineffectiveness (Bandura, 1986).

Understanding self-efficacy within SCT suggests that self-efficacy is not a fixed construct but rather one that can change over time and between circumstances as the interplay between behavior, internal factors, and external factors develop the sense of self-efficacy. Understanding

the mechanisms by which self-efficacy is determined suggests that self-efficacy can be purposefully increased (Bandura, 1986). Bandura (1986) specified four areas for potential growth of self-efficacy: familial sources, peers, school, and the transitional experiences of adolescence, with reappraisals of self-efficacy possible through adult life.

Since self-efficacy is domain-specific, measuring math self-efficacy is a specific measure of a person's perception of their ability to execute the behaviors necessary to understand mathematics and perform mathematics-related tasks (Bandura, 1977, 1986). Studies have demonstrated a relationship between math self-efficacy and both math anxiety and math achievement (Jameson & Fusco, 2014; Pérez Fuentes et al., 2020; Watts, 2011). Of these measures, math self-efficacy best reflects a person's confidence in their ability to control their motivation, behavior, and environment when it comes to mathematics. Achievement is a backward-looking measure of what has been done or accomplished. Anxiety is a present measure of a person's state of mind and emotion toward mathematics (Villavicencio & Bernardo, 2016). Self-efficacy is forward-looking and thus allows the researcher an opportunity to anticipate future behavior (Bandura, 1986).

Self-efficacy has a further predictive nature in determining tasks that may be avoided or pursued depending on the level of self-efficacy (Bandura, 1986). Examining parents' relationship with mathematics through the lens of self-efficacy may help to identify behaviors that parents will avoid, given a low self-efficacy, or the behaviors they will embrace if their self-efficacy is high. As a forward-looking measure with an opportunity for growth, understanding the math self-efficacy of parents may further offer insights into how to increase their math self-efficacy. Understanding the current level of math self-efficacy among parents may help future researchers identify interventions that will increase parental math self-efficacy (PMSE).

Problem Statement

Within homeschooling, anecdotal evidence of parental attitudes toward mathematics can be derived from conversations with homeschooling parents. Still, little research exists to affirm the assumptions about how homeschool parents approach mathematics education (Wenzel, 2020). Teachers' attitudes toward mathematics have been shown to significantly predict student achievement (Ramirez et al., 2018). Evidence that parent-teacher self-efficacy plays a role in homeschooled student self-efficacy suggests that parental self-efficacy may influence student math achievement (Felso, 2016). Understanding the homeschool parent and their attitudes toward mathematics is an essential step toward assessing and meeting the needs of homeschool parents to educate their children successfully.

Homeschooling parents have demonstrated a vested interest in and commitment to their children's education. This commitment is displayed in their research of curriculum, support organizations, and teaching methods (Wenzel, 2020). Understanding themselves and the potential implications of their attitudes towards mathematics would enable parents to make informed decisions regarding their students' education. Many companies have created homeschool versions of materials designed for traditional classrooms to meet the growing demand for homeschool curricula. A better understanding of homeschool parents would enable curriculum developers to develop products that meet the unique needs of homeschool parents. Areas for future study include examining the dual role of parent and teacher and how elements of each role impact the homeschooled student. A more extensive study to measure homeschool parents' math self-efficacy would eliminate the need to rely on anecdotal evidence and give future researchers a base understanding from which to begin.

Purpose Statement

The purpose of this quantitative study was to explore the math self-efficacy of homeschooling parents to measure the degree to which parents of students enrolled in a Classical Conversations community in the United States are self-efficacious for mathematics and to determine whether the degree of math self-efficacy predicts the parent's mathematics curricular choices. The independent variable PMSE was defined as the math self-efficacy of the parents as measured using the Mathematics Self-Efficacy Scale (MSES; Betz & Hackett, 1983). The dependent variable, curriculum choice (CC), was measured using parental self-report.

Overview of Methodology

The study was a non-experimental quantitative design. A random sample of Classical Conversations parents was identified and invited to participate by completing an online survey. The survey included demographic information about the parent and homeschooling family and used the MSES (Betz & Hackett, 1993) to answer the research questions.

Research Questions

This study addressed the following research questions:

1. To what degree are homeschool parents self-efficacious in mathematics?
2. To what degree does homeschool parents' level of self-efficacy in mathematics predict CC?

Research Hypotheses

1. To what degree are homeschool parents self-efficacious in mathematics?

   H_0: Homeschool parents will have some confidence in their math ability (PMSE = 3.0).

2. To what degree does homeschool parents' level of self-efficacy in mathematics predict CC?

   H_0: There will be no correlation between PMSE and CC.

Overview of Analyses

Preliminary Analysis

Survey data were collected and analyzed for data accuracy, participant response rates, missing data, and outliers. Data were examined for normality, and internal consistency was confirmed using Cronbach's alpha.

Data Analysis by Research Questions

To address the first question, descriptive and inferential statistical techniques were used. Measures of central tendency were used to measure the overall math self-efficacy of homeschool parents, and a *t* test was used to compare the resulting score to the expected mean of 3.0. The magnitude of the difference was assessed using Cohen's *d* to measure the effect size.

To address the second question, regression analysis was used to determine the significance of the relationship between PMSE and CC.

Delimitations

This study used a simple random sample of 223 Classical Conversations parents from throughout the United States contacted via email.

Definition of Key Terms

The following words and phrases are key terms for the study.

- **homeschooling**: Homeschooling is the educational choice by a parent to "determine the scope and sequence of the academic instruction, provide academic instruction,

and determine additional sources of academic instruction" (North Carolina Department of Administration, n.d., para. 1)

- **self-efficacy**: Self-efficacy is a domain-specific measure of a person's confidence in their ability to accomplish the tasks that lead to a specific outcome (Bandura, 1977).
- **curriculum**: Priestly (2019) broadly defined curriculum as "the totality of the learning experience of children and young people in school" (para. 6). This definition may include texts, online programs, co-ops, traditional classes, and activities that parents may choose to affect their children's education.
- **mathematics education**: The National Council of the Teachers of Mathematics lists five goals for K-12 students: "to learn to value mathematics, to learn to reason mathematically, to learn to communicate mathematically, to become confident of their mathematical abilities, and to become mathematical problem solvers" (Research Advisory Committee of the National Council of Teachers of Mathematics, 1988). Mathematics education includes the vocabulary needed to read, comprehend, and communicate about mathematics, the skills required to compute numbers and manipulate the letters and symbols of algebra, and the development of reasoning skills that enable students to solve problems.
- **math anxiety**: Math anxiety is a physiological response to mathematics that is related to yet separate from ability and performance and may include worry, tension, and anxiety (Dowker et al., 2016)

II. REVIEW OF LITERATURE

The National Household Education Survey of 2001 found that 49% of homeschool parents chose to homeschool with the express goal of providing a better education than available in their local traditional schools (Montes, 2006). Academic instruction continues to be the most important factor in choosing to homeschool (McFall, 2020), yet no scholarly literature addresses the professional development of the homeschool parent-teacher. Although Kunzman and Gaither (2020) acknowledged the growth of studies on homeschooling, the focus of past research was the demographics, motivations, and outcomes of homeschooling. Among the studies conducted to date are few extensive quantitative studies.

To determine the optimal professional development of homeschool parent-teachers, researchers first must better understand the academic characteristics of homeschool parent-teachers. The purpose of this quantitative study was to explore the math self-efficacy of homeschooling parents to measure the degree to which parents of students enrolled in a Classical Conversations community in the United States are self-efficacious for mathematics and to determine whether the degree of math self-efficacy predicts the parents' mathematics curricular choices. This chapter examines the literature regarding math self-efficacy, the relationship between math self-efficacy and math anxiety and math achievement, and the role of the teacher and parent in the development of student math self-efficacy.

Self-Efficacy

The tenets of self-efficacy were established by Bandura (1977, 1986) and reinforced by Usher and Pajares (2008). More recent studies have examined context-specific self-efficacy and the relationship between academic self-efficacy (ASE) and other academic factors. The 2017 study by Doménech-Betoret et al. examined ASE and the relationship between ASE and achievement to determine why and how ASE influences academic achievement.

A sample of 797 Spanish secondary school students from 36 settings and three schools participated in the study to determine whether motivation was a mediating variable between ASE and academic achievement (Doménech-Betoret et al., 2017). Domenech-Betoret et al. (2017) used expectancy-value as a measure of academic motivation and also measured students' satisfaction with their current courses. Using structural equation modeling, ASE significantly predicted expectancy value, which in turn significantly predicted student achievement and satisfaction.

The strength of the relationship between ASE measured early in the course and expectancy-value, achievement, and satisfaction indicates that knowing the ASE of a student provides opportunities to bolster the student's ASE and ultimately improve their outcomes in the course (Doménech-Betoret et al., 2017). Although these results were specific to a traditional academic setting with students, the results suggest that knowing and improving self-efficacy in other settings may lead to similar outcome improvements.

Roick and Ringeisen (2017) identified an opportunity for a longitudinal study of overlap between control value theory (CVT) and Schwarzer's theory of self-regulation. CVT recognizes a sequence of variables that predict emotions and outcomes (Pekrun, 2006, as cited in Roick & Ringeisen, 2017), although the theory of self-regulation suggests that self-efficacy is related to

each variable in the chain. The participants were 92 German university students from a single university enrolled in a psychology course. Repeated testing throughout the course yielded measures for ASE, test anxiety, expected grade, relevance of success, and received grade. A structural equation model demonstrated that ASE was related to all other five variables. Bivariate correlations revealed that ASE was negatively correlated to test anxiety and positively correlated to both expected and received grades.

Roick & Ringeisen (2017) acknowledged limitations in the study related to the small sample size and the narrow participant selection, in addition to errors from self-reported measures, yet were confident that their results were indicative of the importance of understanding student self-efficacy. Roick & Ringeisen (2017) stressed the necessity of strengthening ASE in schools and universities as a contributor to student success.

ASE has been consistently correlated with academic achievement for groups, but questions persist about whether an individual student's ASE correlates with their performance abilities (Talsma et al., 2019). Talsma et al. (2019) selected a sample of 207 first-year undergraduate psychology students from an Australian university who completed repeat online questionnaires to measure their ASE; the students' grades were provided by the university. Though self-efficacy was significantly positively correlated with outcomes, in the comparison of individual self-efficacy with academic performance, two tendencies emerged. Poorer-performing students tended to be over-efficacious, and higher-performing students tended to be under-efficacious.

The findings of Talsma et al. (2019) revealed that "many students who believe they can, actually cannot, and many students who believe they cannot, actually can" (p. 193). Rather than viewing ASE as a self-fulfilling prophecy where increasing self-efficacy leads to better

performance, the authors caution that self-efficacy is only one part of student achievement. Further research is needed to evaluate practical interventions designed to address under-efficaciousness, with the authors suggesting that a balanced approach is required to help reduce discrepancies between ASE and academic ability.

Math Self-Efficacy

Although general self-efficacy is a measure of self-belief in the ability to accomplish the tasks that lead to the desired outcome (Bandura, 1977), math self-efficacy specifically measures an individual's belief in their ability to successfully solve mathematical problems, navigate everyday math tasks, and complete mathematics-related college coursework (Hackett & Betz, 1982). Cited as a seminal study validating the sources of math self-efficacy, Usher and Pajares (2008, as cited in Usher et al., 2019) conducted a quantitative three-phase survey to determine sources of math self-efficacy and validate an instrument to measure math self-efficacy.

Based on Bandura's sources of self-efficacy, Usher and Pajares (2009) developed 73 items to measure mastery experience; vicarious experience through peers, adults, and self-modeling; social persuasion; and physiological state. With 1,111 middle school students in Phase 1, 824 students in Phase 2, and 803 students in Phase 3, there was a strong correlation between the sources of self-efficacy and the sources of math self-efficacy. The researchers emphasized the challenge of accurately accounting for vicarious experience and found that the results confirmed Bandura's earlier assertion that mastery experiences are the most significant contributor to self-efficacy and that students who succeed at challenging assignments see an improvement in their self-efficacy beliefs. Usher and Pajares encouraged teachers to provide opportunities for such experiences.

Arens et al. (2022) used data from the Project for the Analysis of Learning and

Achievement in Mathematics (PALMA; Pekrun et al., 2007, as cited in Arens et al., 2022), a large longitudinal study investigating math achievement during secondary school in Bavaria, Germany. The sample included 3,209 students measured annually from Years 5 to 10 and evenly divided among the three levels of German School. Examining the student data for Years 6 to 9, Arens et al. (2022) examined the relationship between math self-concept and math self-efficacy across time and the relationship of self-concept and self-efficacy to achievement test scores and school math grades.

Arens et al. (2022) hypothesized that math self-concept, a backward-looking, domain-specific construct, would be positively correlated to math self-efficacy, a forward-looking, domain- and task-specific construct. The researchers further hypothesized that self-concept would be more strongly correlated with math grades, and self-efficacy would be more strongly correlated with test scores. Self-concept was measured by the PALMA self-concept scale (Arens et al., 2017; Marsh et al., 2019) and self-efficacy by the MSES (Betz & Hackett, 1993). Grades were gathered from report cards, and the achievement test scores were from the PALMA math achievement test (Vom Hofe et al., 2002, 2005, as cited in Arens et al., 2022).

Using structural equation modeling, Arens et al. (2022) could confirm each construct's distinctiveness from the other. As expected, math self-concept had higher correlations with grades, and self-efficacy had higher correlations with test scores. Earlier math self-concept was a predictor of later math self-efficacy, suggesting that self-efficacy may be partially based on the earlier self-perception of competence, likely bolstered by mastery experiences. The authors further indicated that self-concept may motivate students to strive for better grades, while self-efficacy may motivate students on individual tasks such as tests. Considering adult learners outside of a formal class, math self-efficacy is an appropriate measure of their belief in their

ability to overcome obstacles in solving math problems and pursuing specific math knowledge.

The 2012 Programme for International Student Assessment (PISA) included 510,000 students from 65 countries between the ages of 15 and 16 years, along with school principals and parents. Data from PISA have been used in several studies, including Zhao and Ding's 2019 comparison of the data from the United States and China to examine the association between school-, parent-, and student-related factors and the student's math literacy. The sample for their study included 10,471 students evenly distributed between the United States and China and between boys and girls.

Zhao and Ding (2019) hypothesized that the same factors influencing math achievement would also influence math literacy. The factors studied included sense of belonging, math self-efficacy, student-perceived math norms, math anxiety, math self-concept, perceived control, math work ethic, teacher support, student-teacher relations, parent involvement, parent's perception of school quality, teacher's math professional development, and math student-teacher ratio. Using regression analysis, math self-efficacy and math self-concept showed a significant ($p = .000$) positive correlation with math literacy. In contrast, perceived peer math norms, math anxiety, and teacher math professional development showed a significant ($p = .000$) negative relationship.

Zhao and Ding (2019), comparing data from the United States and China, found that math self-efficacy was the only common predictor of math literacy. Among American students, the researchers found higher math anxiety and a perceived acceptability of not doing well in their mathematics study, contrary to the Chinese findings in which the students and their peers all reported doing well in math. Teacher professional development was not measured for the Chinese sample, and the effect size was small for the United States data, suggesting that there was little practical significance. Zhao and Ding (2019) suggested that math self-efficacy may

connote self-confidence and positive attitudes that lead to the accumulation of knowledge for life separate from studying only for tests and encourage the cultivation of math self-efficacy among students.

Usher et al. (2019) noted that current math self-efficacy research primarily focused on quantitative studies in urban/suburban settings with undergraduate students. To add to the research outside these norms, the researchers identified a high-poverty rural community in Appalachia. They conducted a mixed-methods study of middle and high school students over 3 years. The researchers examined factors that might lower math self-efficacy in addition to factors that increase math self-efficacy.

Usher et al.'s (2019) sample of 673 students from one middle school and one high school in the same county spanned grades 6-12. The researchers did not differentiate between ages in either the quantitative or qualitative data, instead viewing the data as representative of about the same moment in the student's adolescent years. The researchers conducted the study in three phases: the quantitative, the qualitative, and the convergence of the data between the quantitative and qualitative data.

The quantitative phase of Usher et al.'s (2019) study used the Sources of Middle School Mathematics Self-Efficacy Scale (Usher & Pajares, 2008, as cited in Usher et al., 2019) to assess the sources of math self-efficacy in the spring of the first academic year and then compare the results to the math self-efficacy reported on a four-item scale the following October. The study's findings were slightly different from those of previous research, as social persuasion was not a significant predictor of math self-efficacy. The researchers stressed the importance for teachers to offer students mastery experiences for students to improve their self-efficacy and to take available steps to decrease negative feelings while doing math.

Qualitative responses confirmed that mastery experiences and grades strongly influence math self-efficacy (Usher et al., 2019). Social persuasion, though not strongly indicated in the quantitative results, was a common code assigned to student responses during the qualitative analysis. In responding to what factors raised or lowered students' confidence, physiological state, class content, and task difficulty were associated with reduced confidence. In contrast, social persuasion, help availability, and performance evaluations were associated with raising self-efficacy.

An outcome of the integrative analysis was the suggestion that students with low self-efficacy may overlook successful experiences (Usher et al., 2019). The researchers suggested that future researchers examining efficacy interventions should consider students' preconceptions. For teachers, the researchers emphasized the importance of mastery experiences and regular performance feedback. Teacher feedback was found to be received by students as meaningful of ability, talent, and prospects. Hence, teachers should be attentive to both the implicit and explicit messages they send to students.

Masitoh and Fitriyani (2018) examined 35 students in Indonesia to determine the effect of problem-based learning on math self-efficacy. Researchers used surveys to measure self-efficacy, observations of lessons, interviews with teachers, and tests to measure math achievement. Following two cycles of problem-based learning, students who had begun with low and medium levels of self-efficacy had increased their self-efficacy to medium and high levels of self-efficacy. The researchers believed that problem-based learning allowed students to build understanding and confidence in their problem-solving abilities in a supportive group, as expected by Bandura's (1977) sources of self-efficacy, mastery, social persuasion, vicarious experience, and physiological state.

Borgonovi and Pokropek (2019) used the data available from the 2012 PISA study to examine the effect task exposure had on developing student self-efficacy. The sample consisted of 290,738 students between the ages of 15 and 16 from 33 countries and 11,536 schools. The self-efficacy and achievement scales were embedded in the PISA survey, as were questions related to students' familiarity with pure and applied math problems.

Borgonovi and Pokropek (2019) used a series of multiple indicator multiple causes models to examine the relationship between task exposure and math self-efficacy. The models supported the researchers' expectation that task exposure was correlated with increased self-efficacy but did not support their expectation that the strength of the relationship would depend on the student's math anxiety or socioeconomic condition. Although task exposure does provide the opportunity for mastery experiences, vicarious experiences, and verbal persuasion, the researchers found that it plays a key role independently of these known sources of self-efficacy.

Task exposure affects task-specific self-efficacy (Borgonovi & Pokropek, 2019). The effect of task exposure suggests that students should be exposed to a wide variety of problems requiring various content knowledge and cognitive skills. As students build task-specific math self-efficacy, overall student math self-efficacy will improve. Researchers further found that exposure to problems considered easy led to more mastery experiences and thus had a greater effect on increasing the self-efficacy. Still, they stressed that all exposure was related to higher levels of self-efficacy, reinforcing the independent contribution task exposure makes to student self-efficacy.

The Relationship between Math Self-Efficacy, Math Achievement, and Math Anxiety

A study of 2,789 Chinese students examined the longitudinal relationship between math interest, math anxiety, math self-efficacy, and math achievement using a cross-lagged panel

design (Du et al., 2021). Using scales derived from the 2012 PISA survey, the researchers measured math interest, math anxiety, and math self-efficacy at two points in time: the beginning of Grade 4 and the end of Grade 6. A 34-item multiple-choice test measured math achievement.

Though effect sizes were small, a significant relationship was found between prior math achievement and later math interest, $\beta = 0.18$ (Du et al., 2021). Prior math interest was not a predictor of math achievement. Bidirectional negative relationships were found between math anxiety and math achievement, $\beta = -0.14/-0.17$ respectively, and bidirectional positive associations were found between math self-efficacy and math achievement, $\beta = 0.09/0.23$. Though effect sizes were small, the study further revealed a relationship between math anxiety and math self-efficacy, as well as a predictive relationship between math anxiety and math interest and between math self-efficacy and math interest. These results supported previous findings but were the first examined together in one study.

To offer deeper insight into the relationship between math anxiety and math self-efficacy, Reyes (2019) conducted a descriptive phenomenological qualitative study of nine ninth-grade students in Pampanga, Philippines. The researcher followed interviews with observations and videos. The themes that emerged from the data included self-efficacy and anxiety in addition to student effort, teachers' coping techniques, physical and emotional feelings, learning environment, and past academic performance.

The students' responses indicated that self-efficacy was related to student effort (feeling proud, enjoying the subject, self-confidence, and praise from classmates) and teacher's coping strategies (teacher effort, praise from teachers, ease of lesson, and peer tutoring (Reyes, 2019). These responses echo Bandura's (1977) sources of self-efficacy of mastery experiences, vicarious learning, and social persuasion. Students specified feeling good when receiving good

comments and experiencing success when learning the material (Reyes, 2019).

Math anxiety was connected to a lack of self-confidence and nervousness, including increased anxiety when working in front of the class (Reyes, 2019). Several respondents described fear in math class, including shivering and emotional upset. Emotional upset is also a factor in self-efficacy and may be related to a decrease in self-efficacy (Bandura, 1986). Others shared the lingering embarrassment from past failures, which led to a hesitancy to ask clarifying questions, and suggested that the learning environment contributes to math anxiety (Reyes, 2019).

Reyes (2019) encouraged teachers to take steps to increase self-efficacy and decrease math anxiety. These steps include using instructional techniques that help students successfully learn the material, verbally encouraging students, assisting the students to be involved in math activities, and providing incremental successes for students to build confidence and self-efficacy. Professional development for educators that helps them understand the role that self-efficacy and math anxiety play may improve outcomes in the classroom.

Palestro and Jameson (2020) sought to understand better the relationship between math self-efficacy, math anxiety, and math achievement. Specifically, the researchers studied whether math self-efficacy or emotional self-efficacy or both mediated or moderated the inverse relationship between anxiety and achievement. The sample consisted of 115 undergraduate students from a single public university. The researchers anticipated that undergraduate students would display a greater level of emotional self-efficacy than middle or high school students. Thus, emotional self-efficacy may play a greater role in mediating or moderating the relationship between anxiety and achievement.

Palestro and Jameson (2020), using the Abbreviated Math Anxiety Scale (Hopko et al.,

2003, as cited in Palestro & Jameson, 2020), the Mathematics Self-Efficacy Scale (Nielsen & Moore, 2003, as cited in Palestro & Jameson, 2020), the Emotional Self-Efficacy Scale (Kirk et al., 2008, as cited in Palestro & Jameson, 2020), and the math subset of the Wide Range Achievement Scale, 4th edition (Wilkinson & Robertson, n.d., as cited in Palestro & Jameson, 2020), tested the students. The researchers conducted correlation analyses between the study variables. A significant, moderate, negative correlation was found between anxiety and both achievement and math self-efficacy. Math self-efficacy was moderately and positively correlated with math achievement, emotional self-efficacy was negatively correlated with anxiety but not achievement.

Moderation analyses with both emotional and math self-efficacy failed to find any significant relationships (Palestro & Jameson, 2020). The researchers then used bootstrapping to look for mediation relationships. The mediation analysis revealed no significant mediating effect on emotional self-efficacy. Still, there was a significant mediating effect of math self-efficacy upon the anxiety-achievement relationship. As math self-efficacy increases, the relationship between anxiety and achievement decreases. These results suggest that teachers and institutions interested in addressing math-anxious students should target math self-efficacy over emotional self-efficacy. Providing opportunities for students to succeed in math continues to be the most effective way to improve student math self-efficacy.

Pérez Fuentes et al. (2020) examined the relationship between math self-efficacy and math achievement to determine the degree to which math anxiety mediates or moderates the relationship. The researchers used the Inventory of Attitudes towards Mathematics and the Triarchic Intelligence Test (Sternberg, 1984, as cited in Pérez Fuentes et al., 2020) along with school grades for a sample of 2,245 seventh- to 10th-grade Spanish students. Using correlation

analyses, the results showed a decline in math achievement, math self-efficacy, and math anxiety as students aged and suggested a significant positive correlation between achievement, self-efficacy, and anxiety.

Meditation analysis confirmed the significant positive relationship between math self-efficacy and math achievement. It supported the expectation that math anxiety is a significant mediating variable in the self-efficacy achievement relationship, though with very small to small effect sizes (Pérez Fuentes et al., 2020). Moderation analysis suggested that anxiety may moderate the self-efficacy achievement relationship. Although the relationship was significant and positive for all levels of anxiety, the effect size increased as anxiety increased, with the highest levels of anxiety correlated to a large effect size.

Pérez Fuentes et al. (2020) could not definitively determine whether math anxiety is mainly a mediating or moderating influence on the self-efficacy achievement relationship. Still, the results suggest that the influence is more a moderating one. The researchers emphasized the importance of high self-efficacy, especially for highly anxious students. However, they cautioned that external factors may have contributed to the anxiety, such as parental pressure and teacher expectations. The researchers further offered that the anxiety measured by the study may be more generalized than math-specific anxiety, including a sense of responsibility or fear of failing to perform as expected. Broader anxiety may explain the reverse relationship between anxiety and self-efficacy found in other studies.

Ozkal (2019) examined the relationship between math self-efficacy, math achievement, and student engagement with 651 sixth- through eighth-grade students in Turkey. Using the Engagement and Disaffection Scale (Guneri & Guvenc, 2013, as cited in Ozkal, 2019) and the Motivated Strategies for Learning Questionnaire (Pintrich et al., 1993, as cited in Ozkal, 2019),

Ozkal compared achievement with self-efficacy, behavioral engagement, affective engagement, behavioral disaffection, and affective disaffection. Linear regression revealed a significant positive relationship between achievement and self-efficacy, behavioral engagement, and affective engagement, as well as a significant negative relationship between achievement and behavioral disaffection and affective disaffection. A significant positive relationship was found between self-efficacy and both behavioral and affective engagement, though a significant negative relationship existed between self-efficacy and both behavioral and affective disaffection.

Using multiple linear regression, self-efficacy, behavioral disaffection, and affective disaffection were significant predictors of math achievement (Ozkal, 2019). However, behavioral and affective engagement were not significant contributors to the model (Ozkal, 2019). The findings were in line with the expectation that students who are "bored and anxious in math classes and who participate in activities unwillingly, and students who display negative behaviors…are less successful in math classes" (Ozkal, 2019, p. 196). The research suggested that students with higher self-efficacy were more likely to engage in class. As with other studies discussed here, the researchers encouraged teachers to provide opportunities for students to experience success in mathematics.

Samuel and Warner (2021) conducted an embedded experimental mixed methods study to examine the effectiveness of growth mindset training in decreasing math anxiety and increasing math self-efficacy. Working with a sample of 40 students enrolled in two sections of a two-semester developmental statistics course at a community college, the researchers randomly chose one section to receive the intervention. In contrast, the other course was the control group. Thirty-two students completed the Revised Math Anxiety Rating Scale (Richardson & Suinn,

1972, as cited in Samuel & Warner, 2021) and the MSES (Betz & Hackett, 1983) at the beginning and end of the first semester.

Quantitative data did not reveal significant findings at the end of the first semester (Samuel & Warner, 2021). Still, the qualitative findings indicated that students valued the growth mindset activities and felt lessened anxiety and increased confidence (self-efficacy; Samuel & Warner, 2021). Students specifically mentioned the deep breathing exercises as a way to lessen anxiety, the affirmations as more believable when spoken aloud, the routine as establishing a new pattern of behavior and thought, and a resulting sense of control when working through multistep problems.

Due to attrition, the sections were combined for the second semester (Samuel & Warner, 2021). All students in the combined section participated in the growth mindset exercises and completed both assessments. Samuel and Warner (2021) focused their analysis on self-efficacy for statistics. They found a significant increase in statistics self-efficacy from the beginning to the end of the course with a large effect size. This result was confirmed through the qualitative results that included the additional codes: low math test anxiety and increased confidence in math.

Though the sample size for Samuel and Warner's (2021) study was fairly small, the researchers could confirm the quantitative results with data from the qualitative focus group. Although the growth mindset activities did not significantly increase overall math self-efficacy, statistics self-efficacy was significantly increased. The researchers stressed the importance of understanding the psychological aspects of education, such as anxiety and self-efficacy, and for instructors to seek support for students to lessen anxiety and improve self-efficacy.

The Effect of Teacher Self-Efficacy and Anxiety

Evans and Field (2020) used data from the Avon Longitudinal Study of Parents and Children conducted in southwest England to investigate the predictive factors of math achievement from age 7 to 16 years. The sample of 6,490 students was measured at the end of each key stage of education, ages 7, 11, 14, and 16 years. The researchers used two latent growth models, one for primary-aged students and one for secondary-aged students.

The only significant predictor of math achievement for primary-aged students was children's attitudes toward math, though with a small effect size (Evans & Field, 2020). For secondary-aged students, school belonging, math attitudes, student-teacher relationships, and teacher fairness were significant predictors of achievement. Teacher fairness included the teacher's perceived efficacy, encouragement, and emphasis on effort. The importance of teacher fairness highlights the importance of teachers treating students equally without regard to their abilities or characteristics. Teacher fairness was a more important factor than the quality of the teacher or the math knowledge of the teacher.

The researchers emphasized math attitude as the most predictive factor of math achievement (Evans & Field, 2020). The researchers identified student-teacher relationships and teacher fairness as contributors to math attitude and stressed the importance of developing positive attitudes towards mathematics in the classroom. For homeschool parents, maintaining a positive relationship with their students in relation to math may include encouragement and recognizing the students' efforts even if the results do not match. Homeschool parents may also be encouraged that math competency was not a teacher factor that influenced student achievement.

Ramirez et al. (2018) sought to address the unanswered question of whether teacher math

anxiety predicts ninth-grade math achievement. The researchers also asked the follow-up questions of whether students' perceptions of the teachers' mindsets explain the relationship between teacher math anxiety and student performance and whether teaching practice or math knowledge is the mechanism for students' perceptions of teachers' mindsets. The sample included 1,886 ninth-grade students from 11 public high schools across the United States drawn from the national experimental study, the National Mindset Study.

Sixty teachers completed a survey that included a single-item measure of math anxiety and participated in a classroom video analysis assessment (Ramirez et al., 2018). Student grades were obtained from school records. Students completed questionnaires to measure their perceptions of the teachers' mindsets and teaching practices. Path and mediation analyses were performed on the data. As the researchers expected, teacher anxiety had a significant negative relationship with student grade point average (GPA), thus confirming that higher levels of math anxiety are associated with lower math achievement in ninth grade.

Teacher math anxiety did not predict the teachers' mathematical knowledge or the students' perception of teacher mindset (Ramirez et al., 2018). Math anxious teachers did lack process-oriented teaching strategies, which, with a potential to spend less time on questions, may communicate to students that not everyone can learn math and do well. For teachers, "the way [they] feel in the classroom and the indirect messages they convey through their practice may be an important factor shaping student math learning" (Ramirez et al., 2018, p. 10).

Peker et al. (2018) utilized a survey to collect demographic and self-efficacy information from 158 math teachers in western Turkey. Teachers' responses on the Teachers' Sense of Efficacy Scale (Tschannen-Moran & Hoy, 2001, as cited in Peker et al., 2018) revealed that teachers were significantly self-efficacious with higher scores for the subscales of instructional

strategies and classroom management and slightly lower scores for student engagement. Using analysis of variance (ANOVA) to compare the self-efficacy of different teachers revealed that male teachers had significantly higher self-efficacy and more experienced teachers had significantly higher self-efficacy. When comparing teacher backgrounds, no significant differences were found between teachers whether they had graduated from a math teacher preparation program or an elementary education program. This result is encouraging for homeschool parents who come from a variety of backgrounds.

In a study of 610 children and 31 teachers in Dutch fourth-grade classrooms, researchers sought to determine the degree to which student factors and teacher factors contributed to arithmetic fluency and mathematical problem solving (Kaskens et al., 2020). Children were measured using the Speeded Arithmetic Test (De Vos, 2010, as cited in Kaskens et al., 2020) and the Dutch national mathematics test. Teachers self-assessed their mathematical teaching knowledge and completed the Teachers' Sense of Self-Efficacy Scale (Tschannen-Moran & Hoy, 2001, as cited in Kaskens et al., 2020).

In line with previous studies, children's math self-concept, self-efficacy, and anxiety correlated significantly with math achievement (Kaskens et al., 2020). When considered separately, only math self-concept was found to predict arithmetic fluency. The researchers suggested that self-efficacy may be more malleable at a young age and, therefore, a lesser predictor of specific attainment. Likewise, math anxiety has been shown to develop as children age and may not be a significant factor at younger ages.

The researchers found unexpected results when considering the teacher characteristics (Kaskens et al., 2020). The resultant negative relationships found between teaching behavior and student achievement may be explained by teachers with greater confidence in their abilities being

less flexible in class and more likely to flex to meet the needs of the students. Considering these findings, the researchers suggested that teachers be helped to understand which aspects of their teaching are most effective and be given decision-making tools for selecting the best methods to meet the needs of the students.

Perera and John (2020) used Australian data from the Grade 4 Trends in International Mathematics and Science Study of 2015 to address the effect of math teaching self-efficacy on job satisfaction, class math achievement, and teacher-student interaction. The sample included 452 teachers from across Australia and 6,057 associated students. Teacher domain-specific self-efficacy, job satisfaction, student math self-concept, perception of student-teacher relationships, and math achievement were all measured using discrete items on the Trends in International Mathematics and Science Study. The researchers used structural equation modeling to determine which variables were correlated with one another.

The study's results confirmed earlier findings that teachers with a greater self-efficacy for teaching math had higher job satisfaction, though with a small effect size (Perera & John, 2020). Higher teacher self-efficacy was also significantly correlated with class achievement and better student-teacher relationships. The potential impact of teacher self-efficacy on improving multiple outcomes in schools suggests that professional development for teachers should include activities and opportunities that would elevate teacher self-efficacy.

Although Perera and John (2020) examined domain-specific teacher self-efficacy, Zee et al. (2018) considered general teacher self-efficacy and student-specific self-efficacy. Using the Teacher Self-Efficacy Scale (Tschannen-Moran & Hoy, 2001, as cited in Zee et al., 2018) and the Student-Specific Teacher Self-Efficacy Scale (Zee & Koomen, 2016, as cited in Zee et al., 2018) along with student data from the Dutch national exams, the researchers applied structural

equation modeling to determine the degree to which teacher self-efficacy and student self-efficacy influenced student outcomes in literacy and mathematics for a sample of 49 teachers and 360 students in fourth to sixth grade.

When considering the effect of student-specific teacher self-efficacy, the researchers found a positive correlation with both literacy and mathematics, with a stronger correlation between student-specific self-efficacy and mathematics achievement (Zee et al., 2018). Zee et al. (2018) suggested that in mathematics, students may be affected by motivational processes and teacher persistence in continuing to work with individual students to understand a traditionally complex subject. When aggregating student-specific teacher self-efficacy, the researchers found a moderate correlation with general teacher self-efficacy, yet the two measures had opposite direction correlations with class achievement. Although the aggregate was positively correlated, the general self-efficacy showed a slightly negative correlation to class achievement. The researchers suggested that the general teacher self-efficacy may be less reliable. Perera and John (2020) suggested that general teacher self-efficacy may not be as appropriate a measure as domain-specific teacher self-efficacy. For homeschool parents, the implication is that teacher self-efficacy for their own students may predict mathematics achievement in their homeschool.

Parental Math Attitudes

To examine the direct and indirect effects of parental involvement on student math achievement, Myers (2021) analyzed data relating to mathematics achievement and parental involvement for 23,415 students collected through the 2009 High School Longitudinal Study. Using linear regression techniques, indirect parent support as expressed by high expectations, discussing college plans, and encouragement to study math were strongly correlated to higher senior year GPA ($p < .001$).

Assessing parental math attitudes as self-reported by parents revealed that parents were the least confident in helping directly with math homework when compared to help with science and English homework: 31% of parents surveyed indicated they were very confident, 40% of parents indicated they were somewhat confident, and 29% of parents indicated they were not at all confident (Myers, 2021). Although the mechanism that may explain any transference of low parent confidence in mathematics to their students was not identified, direct involvement, defined as helping students with their homework, correlated to a lower senior GPA ($p < .001$). Researchers further extrapolated that direct parental involvement may not only allow for transference of poor math attitudes but may also be related to learned helplessness by the students.

Macmull and Ashkenazi (2019) surveyed 204 Israeli student-parent dyads to determine parenting style's effect on student self-efficacy. The convenience sample was recruited through social media, and the data collection was completed online. The researchers used the Parental Authority Questionnaire (Buri, 1991, as cited in Macmull & Ashkenazi, 2019) to determine the mother's parenting style as authoritarian, authoritative, or permissive. Student math anxiety was measured by a version of the Mathematics Anxiety Rating Scale (Suinn et al., 1972 and Suinn & Winston, 2003, as cited in Macmull & Ashkenazi, 2019), and student self-efficacy was measured by a modified version of the Teacher Efficacy Beliefs Scale (Enochs & Riggs, 1990, as cited in Macmull & Ashkenazi, 2019). Authoritarian parenting style was correlated with both higher math anxiety and lower achievement ($p < .05$; Macmull & Ashkenazi, 2019). Authoritative parenting was associated with increased student math anxiety but also with increased student self-efficacy ($p < .05$), which mitigated the impact of authoritative parenting on math anxiety to make the effect of the greater math anxiety negligible.

Choi and Han (2020) examined the relationship between parental attitudes toward mathematics and student math anxiety using a meta-analysis of seven studies conducted between 1980 and 2013. The researchers extracted 20 correlation coefficients from the studies to describe the relationship between student mathematic anxiety and parental attitudes. The average correlation between student mathematics anxiety and parental attitude was −0.26, which indicates that as parental attitudes increase in positivity, student anxiety diminishes.

The studies included data from elementary to college, allowing the researchers to compare the relationship between student self-efficacy and parental attitudes at different students' ages (Choi & Han, 2020). Though the overall average was small, the difference between age groups was significant ($p = .0011$) as the relationship between parental attitudes and college anxiety was small, $r = -.0462$, and the relationship between elementary and middle school anxiety and parental attitudes was larger, $r = -.4174$. The researchers suggested that equipping parents to display positive attitudes at home may be an effective intervention, especially in homes where greater involvement in the student's educational experiences is hindered.

Jay et al. (2018) sought to understand the factors impacting parental involvement in students' mathematics education through a qualitative study in southwest England. Conducting 19 group interviews, the researchers gathered data from 87 parents representing primary school students from a diverse cross-section of schools. A thematic analysis revealed themes in two broad categories: school-centered and parent-centered approaches.

The discussion of school-centered approaches revealed that parents struggled with how best to support the school experiences of their children (Jay et al., 2018). Frustration over different methods and techniques left many parents feeling unable to help their children. These

feelings were further compounded by perceived low levels of communication from the school-specific to mathematics. Parent-centered approaches yielded a more positive response as parents discussed helping to engender positive attitudes, using the student-as-teacher strategies, and everyday mathematics to support the general mathematics experiences of their children.

Parents expressed concern about passing on math anxiety, particularly from mother to daughter (Jay et al., 2018). Parents acknowledged the importance of fostering positive math attitudes but had few concrete strategies to help their students. A popular technique used at home to aid with mathematics understanding was having older children help younger children or having children teach the concept to the parent. Parents found this strategy to be highly effective. Beyond supporting the school math assignments, parents reported encouraging everyday use of mathematics primarily through cooking or finances. The researchers suggested that building upon the parent-centered approaches would benefit parents and students. The researchers suggested first steps by equipping parents with strategies for improving math attitudes and providing examples of everyday math from a greater diversity of domains.

Effects of Parental Math Self-Efficacy

Seeking a better understanding of parental attitudes towards math and the influence of these attitudes on students' attitudes, Mohr-Schroeder et al. (2017) conducted a quantitative survey study over 7 years. Data from 468 adults and 770 students were collected at family math night events. The researchers acknowledged that families attending the events might have a more positive attitude toward mathematics; thus, the results may not be generalizable beyond the convenience sample. Parents and students completed surveys adapted from the Attitudes Toward Mathematics Inventory (Tapia, 1996, as cited in Mohr-Schroeder et al., 2017), indicating the corresponding parent or student on their survey so that surveys could be matched for a total of

146 matched cases.

Parent attitudes averaged 3.989 on a scale ranging from 1 to 5, indicating an overall positive attitude toward mathematics (Mohr-Schroeder et al., 2017). Student attitudes on the same scale averaged 3.244, indicating a slightly positive attitude toward mathematics. Using regression analysis, researchers compared parental attitudes with student attitudes. They discovered a significant positive correlation ($p = .004$), indicating that the variation in the parent attitude accounts for 5.6% of the variation in student attitude. Though the effect size was small, the study's results confirm past findings indicating the importance of parental attitudes in determining student attitudes towards mathematics. The researchers emphasized the importance of helping parents learn strategies to help their children at home. By fostering positive parental attitudes, both student achievement and interest may be bolstered.

Silver et al. (2021) sought to identify how parents' math beliefs and anxiety relate to parent practices to support preschool-age children. The sample consisting of 114 children with an average age of 4 years and one of their parents was evaluated twice, 2 months apart. Researchers used questionnaires and observations to gather data on parental beliefs, anxiety, and math performance, and children's inhibitory control, math performance, and vocabulary. Researchers additionally gathered data on home math activities and parent number talk.

Using regression analysis, the researchers found that a model including both math beliefs and anxiety significantly ($p = .002$) predicted 19% of the variance in child math abilities, although parental math anxiety alone was not a significant predictor of children's math abilities (Silver et al., 2021). Parents with stronger math beliefs reported more formal math activities, and the association was stronger among parents with higher math anxiety. The researchers suggested that math anxiety "may shape the way that parents' beliefs are transmitted into action and lead to

better outcomes" (Silver et al., 2021, p. 12). Higher math anxiety may motivate parents to act upon strong beliefs in the importance of mathematics. Although previous research had found that parental anxiety was a predictor of math performance, such a relationship was not found in Silver et al.'s study, perhaps due to the age of the children.

Utilizing data from an ongoing longitudinal study, Berkowitz (2018) conducted four related studies to examine the relationship between parent math anxiety and early childhood mathematical development. In Study 1, 36 parent-child dyads were observed repeatedly between the ages of 1year and 6 years, with transcripts coded for number talk. Parents completed the Short Mathematics Anxiety Rating (Alexander & Martray, 1989, as cited in Berkowitz, 2018). Using regression analysis, researchers found that parents' math anxiety is significantly related to both the quantity and quality of math talk.

In Study 2A, 537 pre-K students and their parents were selected to participate with parents completing the Short Mathematics Anxiety Rating Scale as well as completing a questionnaire to assess their math and reading self-efficacies, reporting the frequency of home math activity, and reporting their math expectations for their children (Berkowitz, 2018). Student math achievement was measured using the Woodcock-Johnson III (Woodcock, 1997, as cited in Berkowitz, 2018). Researchers used paired sample *t* tests to examine the data. The results confirmed the researchers' expectation that PMSE would be significantly lower than the parent reading self-efficacy. The results further revealed that parent math anxiety predicted the frequency of parent-led math activities and parental expectations of student math achievement, with PMSE a mediator in the relationship.

Study 2B examined 44 mother-child dyads via survey and observation in a lab where the dyads were asked to play with a specific toy both with and without mathematical prompts

(Berkowitz, 2018). Researchers found that parent math anxiety is related to differences in the quality of math interactions between parents and children. Low math-anxious parents were more likely to talk about numbers and other aspects of math, give better feedback to incorrect answers, and persevere if children did not want to continue.

In Study 3, 587 first-grade students and their families were given iPads preloaded with a math app to guide parents on engaging in math activities at home (Berkowitz, 2018). The results demonstrated that the iPad app ameliorated the negative relationship between parent math anxiety and student achievement. At the end of the year, students in the high-anxiety group made similar gains to those in the low-anxiety group. Berkowitz suggested that though parents may transmit negative attitudes about math to their children, parent-child interactions around math problems or activities help the students to make gains in achievement by the end of the year.

Casad et al. (2015) sought to understand the factors that contribute to student math anxiety, focusing on parental math anxiety. The sample of 683 parents and their middle-school-aged students completed questionnaires to determine math anxiety and self-efficacy; student achievement was measured by GPA. Student math anxiety was significantly negatively related to student math self-efficacy (p= .003). Results further supported the researchers' expectations that parent math anxiety contributes to child math anxiety. This effect was particularly strong in mother-daughter dyads, although student anxiety was the better predictor of student self-efficacy and GPA.

Generational Transfer of Math Attitudes

Maloney et al. (2015) studied 379 children to assess the relationship between parental math anxiety and student achievement. Researchers measured parent math anxiety using the Mathematics Anxiety Rating Scale (Alexander & Martray, 1989, as cited in Maloney et al., 2015)

and surveyed parents for the time spent on homework help. Maloney et al. (2015) compared those measures through regression and mediation analysis to student achievement on the Woodcock-Johnson III (Blackwell, 2001, as cited in Maloney et al., 2015) test and the Child Math Anxiety Questionnaire (Ramirez et al., 2013 and Suinn et al., 1988, as cited in Maloney et al., 2015). Through moderated mediation analysis, the frequency of homework help was found to moderate the effect of parental math anxiety on student achievement. A higher frequency of homework help negatively correlated to math achievement for students with parents with high math anxiety ($p = .03$). The researchers identified a positive correlation between parental and student math anxiety, with math achievement a confirming factor in the student's math anxiety (Maloney et al., 2015).

A sample of 172 Belgian sixth-grade students and both parents were studied to examine how parental math attitudes relate to child math attitudes and performance (Vanbinst et al., 2020). Children completed the Tempo Test Arithmetic (De Vos, 2010, as cited in Vanbinst et al., 2020) and the Mathematics Anxiety Rating Scale (Suinn & Edwards, 1982, as cited in Vanbinst et al., 2020). Parents completed the Mathematics Anxiety Rating Scale-Revised (Plake & Parker, 1982, as cited in Vanbinst, 2020) and a survey of their educational level and the primary caregiver. Researchers confirmed previous findings that arithmetic ability is significantly negatively correlated with math anxiety ($p < .001$). Girls were significantly more math-anxious than boys ($p = .002$), although there was no significant difference in their arithmetic ability.

Researchers found a significant positive correlation between child anxiety and maternal anxiety ($p = .018$) but no significant correlation with paternal anxiety (Vanbinst et al., 2020). No significant association was found between child anxiety and parental education. Researchers conducted moderation analysis to examine whether the primary caregiver affected the

relationship between maternal anxiety and child anxiety. The interaction between maternal anxiety and care was significant ($p = .025$), suggesting that mothers as the predominant caregiver may explain the positive correlation between maternal anxiety and child anxiety. Parents who spend more time with their children may be more likely to pass on their attitudes towards mathematics.

Varghese and Finkelstein (2021) examined the mechanisms that may contribute to the improvement of protege self-efficacy as a result of mentoring relationships. Three studies used experimental (Study 1 and Study 2), and survey (Study 3) designs. The first study, with a sample of 205 participants, used a 2 x 2 design to compare similar or not similar experiences crossed with high or low mentor self-efficacy. Using linear regression, shared experience was significantly positively associated with perspective-taking ($p = .001$). Perspective-taking significantly moderated the transfer of mentor self-efficacy to protege self-efficacy ($p < .001$).

Study 2 sought to confirm the findings from Study 1 with a separate sample of 204 participants but with shared experience held constant (Varghese & Finkelstein, 2021). Mentor self-efficacy was strongly and positively correlated with protege self-efficacy ($p = .005$). A closer identification between the mentor and protege strengthened the transfer of self-efficacy from mentor to protege. Study 3 utilized a survey to examine a sample of 148 students. The survey results indicated that the protege perception of the mentor's self-efficacy was significantly positively correlated with protege self-efficacy ($p < .001$). Other survey results contradicted findings from Study 2 and suggested that greater identification with a mentor lessoned the transfer of efficacy beliefs. For homeschool parents, the relationship between parent-teacher and student may have elements in common with a mentoring relationship, and parents may be able to contribute to their students' self-efficacy through perspective-taking/vicarious experience in

addition to social persuasion and providing for mastery experiences.

Mathematics in Homeschool Settings

Bradford (2018) conducted a qualitative study to determine the factors that guided curriculum selection and development in Texas homeschools. Researchers conducted interviews with 10 parents from 10 homeschools in predominantly rural settings. Five themes emerged from the interviews. The participants wanted children to "experience a real and practical curriculum, quality time with the family, a safe learning environment, a strong Biblical [*sic*] training program, and a wholesome, well-grounded social life" (Bradford, 2018, p. 97). Parents expressed that developing their homeschool curriculum was challenging, and methods for achieving their goals ranged from purchasing CD-based learning materials to building a curriculum with the assistance of local homeschooling support groups.

In a qualitative case study, 29 parents completed a survey about how they provided STEM instruction in their homeschool (Gann & Carpenter, 2019). Two main themes emerged during the analysis: curricular activities and curricular extensions. Curricular activities included the activities parents used to accomplish a specific course of study. These activities included online courses, co-op classes, tutors, and self-study programs. Additionally, parents provided videos, labs, manipulatives, and experiments to accompany the curriculum chosen as the primary instruction. Curricular extensions were separate from the primary curriculum and included clubs, field trips, and family activities. Parents reported reliance on community resources such as co-ops, support groups, libraries, and tutors to provide a complete STEM education for both the curricular activities and the curricular extensions. Gann and Carpenter (2019) further analyzed parents' roles in delivering STEM education in the homeschool. Parents acted as managers or facilitators in which they oversaw their children's education by making and enforcing schedules

and ensuring that students completed assignments. As counselors, parents researched the academic requirements to achieve their students' goals and chose the appropriate courses and activities needed to complete those requirements. Parents also filled the role of the teacher in which they provided direct instruction to their students.

Wenzel (2020) conducted a phenomenological qualitative study with a snowball sample of 13 homeschool parents from western New York, seeking to better understand the mathematics experience within homeschools. Nine parents had experience with middle and high school mathematics, two parents only had younger students, and two parents had opted to enroll their older children in a traditional school. Two of the nine parents with older students had taught their students directly, four chose to utilize an online curriculum, and three hired tutors to teach mathematics. Several parents reported stopping mathematics education because it was hard and time-consuming.

Parents reported using similar aids for teaching mathematics that ranged from support groups, online resources, tutoring for the parent, and online classes for the parents (Wenzel, 2020). All families reported using a purchased curriculum such as Abeka, Saxon, and Teaching Textbooks to teach their students, although not all families used all the parts of the chosen curriculum. Parents stressed the importance of choosing a curriculum that matched the needs of their children and emphasized not pushing children to become weary of mathematics. Many parents reported that they assessed their student's success in mathematics by their understanding of everyday mathematics, while others relied on state testing to measure the student's achievement.

Reaburn (2021) sought to understand homeschool parents' attitudes toward mathematics. Eighty parents from Australia completed the survey. Data from the survey were analyzed using

factor analysis and correlation. Parents were largely very involved in their children's mathematics education and believed their children were doing well. Parents reported high levels of confidence in homeschooling their children for mathematics. However, in open-response items, parents expressed they had times of difficulty and had engaged tutors or sought other help for mathematics beyond their understanding. Parents specifically mentioned being unsure when children became frustrated or needed more help to achieve understanding.

Felso (2016) conducted a phenomenological qualitative study, interviewing six parent-student dyads from northern Georgia, including both those active and those not involved with local homeschool support groups. Among the themes to emerge was that parental self-efficacy for providing a mathematics education was separate from PMSE. Parental teaching self-efficacy was not based on personal ability but instead on the availability of resources and the parent's confidence in finding and using the resources appropriately. Parents denied that their own math self-efficacy influenced their choices in how to provide math education in their homeschool. Parents claimed that they could teach mathematics but chose not to.

Another theme from the analysis was that parents and students believed that parental self-efficacy for finding and utilizing resources transferred to the students (Felso, 2016). As with the parents, students reported that their math self-efficacy was primarily based on their confidence in finding and using resources and aids to understand. Seeing their parents research math topics and math resources provided a model of learning for students that increased the students' self-efficacy.

Summary

Bandura (1977) established the construct of self-efficacy with his work examining ways to treat phobias. Since then, researchers in multiple domains have studied self-efficacy and the

relationship between present self-efficacy and future achievement. Within education, researchers have examined self-efficacy to understand the mechanisms that explain the predicted gains in achievement. One such finding was that self-efficacy predicted expectancy-value, predicting student satisfaction and achievement (Doménech-Betoret et al., 2017). ASE was also linked to test anxiety, expected grade, relevance of success, and received grade (Roick & Ringeisen, 2017). Talsma (2019) extended the study of ASE and achievement from groups to individuals, finding that poorer performing students were over-efficacious and better performing students were under-efficacious.

Usher and Pajares (2009) validated the sources of math self-efficacy and confirmed that mastery experiences, social persuasion, vicarious experience, and physiological state are the sources of math self-efficacy. Self-efficacy was demonstrated as a distinct construct from self-concept, with self-efficacy a better predictor of test scores and self-concept a better predictor of grades (Arens et al., 2022). Zhao and Ding (2019) found that math self-efficacy was the only predictor of math literacy common to the United States and China and suggested that math self-efficacy may contribute to the gaining of general math knowledge beyond the knowledge needed to do well on tests.

Usher et al. (2019) sought to extend the study of student math self-efficacy to rural, high-poverty communities, confirming the link between self-efficacy and achievement but also finding that low self-efficacy students tend to overlook successes. Seeking ways to improve student math self-efficacy, Masitoh and Fitriyani (2018) found that using problem-based learning offered students the chance to build understanding and confidence, leading to higher self-efficacy. Task exposure was also found to improve math self-efficacy through the known sources of self-efficacy and an independent contribution (Borgonovi & Pokropek, 2019).

Du et al. (2021) confirmed a bidirectional negative correlation between math self-efficacy and math achievement and the predictive relationship between self-efficacy and math interest. Self-efficacy was related to student effort, while the emotional upset accompanying math anxiety was related to a decrease in self-efficacy (Reyes, 2019). Palestro and Jameson (2020) further confirmed the relationship between anxiety and self-efficacy and achievement and demonstrated that self-efficacy had a mediating effect such that the relationship between anxiety and achievement decreases as self-efficacy increases. Pérez Fuentes et al. (2020) found that math anxiety is a likely moderator of the self-efficacy achievement relationship as the effect size increased as anxiety increased. When considering self-efficacy, math achievement, and student engagement, highly self-efficacious students showed higher levels of engagement in class (Ozkal, 2019).

Growth mindset activities were demonstrated to positively affect class-specific self-efficacy, emphasizing the importance of psychological aspects of education (Samuel & Warner, 2021). Within classes, teachers also have a significant impact on student achievement. Student-teacher relationships and teacher efficacy, encouragement, and emphasis on effort significantly correlated with student achievement (Evans & Field, 2020). Teacher math anxiety was not correlated with teachers' math knowledge, but math-anxious teachers may communicate that math is not for everyone through their teaching strategies (Ramirez et al., 2018). Although male teachers tend to have higher math self-efficacy than women teachers, no significant difference was found between teachers from different preparation backgrounds (Peker et al., 2018). Kaskens et al. (2020) suggested that teachers with greater confidence may be less flexible in class and less likely to meet the needs of individual students. Other studies showed that higher teacher self-efficacy was related to higher job satisfaction, higher class achievement, and better

student-teacher relationships (Perera & John, 2020). Zee et al. (2018) further found that student-specific teacher self-efficacy was positively related to student outcomes.

Teacher impacts on student attitudes and achievement are apparent, but parental attitudes also significantly impact student attitudes and achievement. Myers (2021) found that parents were less confident helping with math homework than science and English homework and that direct involvement was negatively correlated to senior GPA. Choi and Han (2020) also examined the relationship between parent and student attitudes and found that more positive parental attitudes were associated with lower student anxiety.

Considering the effect of parenting style, Macmull and Ashkenazi (2019) found that authoritarian parenting was associated with higher anxiety and lower achievement, while authoritative parenting was associated with higher anxiety and higher self-efficacy. Parents worried about passing on their anxiety and often struggled to understand school approaches to mathematics but reported seeking to promote positive attitudes and incorporating everyday math (Jay et al., 2018). Mohr-Schroeder et al. (2017) conducted a 7-year study to confirm the importance of parental attitudes in determining student math attitudes. Silver et al. (2021) and Berkowitz (2018) examined the early childhood effects of parental attitudes and anxiety. Parents with stronger math beliefs and lower anxiety demonstrated greater numbers and better quality of math activities and number talk.

At the middle-school level, parent math anxiety contributed to student anxiety (Casad et al., 2015). Maloney et al. (2015) demonstrated that more frequent homework help moderated the effect of parental anxiety on achievement such that higher parental anxiety was negatively correlated to student achievement. Time spent with the child as the care-er, not specifically in homework help, was also shown to influence the transfer of math attitudes from parent to child

(Vanbinst et al., 2020). The work by Varghese and Finkelstein (2021) suggested that shared experiences led to greater perspective-taking and greater transfer of efficacy, perhaps explaining some of the effects of time spent together.

In seeking to understand mathematics education within homeschools, both Bradford (2018) and Gann and Carpenter (2019) stressed the importance of outside support and resources to parents seeking to choose and implement a curriculum. Additionally, families reported seeking outside instruction through online resources, support groups, and tutors, with few parents choosing to directly educate their children in mathematics (Felso, 2016; Reaburn, 2021; Wenzel, 2020).

Math self-efficacy is important in mathematics interest, literacy, and achievement. It is influenced by both teachers' and parents' attitudes and activities. Homeschooling parents have teaching self-efficacy separate from and stronger than their math self-efficacy, but many parents choose to find outside sources of math education. Instructional techniques and habits may increase parents' and students' self-efficacy.

III. METHODOLOGY

The purpose of the study was to evaluate the math self-efficacy of homeschooling parents. Moreover, a focus of the study was to determine the degree to which mathematics self-efficacy predicts parent mathematics curricular choices. The study's primary independent variable, PMSE, was defined as the mathematics self-efficacy of the parent study participants as measured using the MSES (Betz & Hackett, 1993). The study's dependent variable, CC, was measured using parental self-report. The following represents a presentation of the essential elements of the study's methodology.

Description of Methodology

A non-experimental, quantitative research design was used to address the study's topic (Edmonds & Kennedy, 2017). The specific research methodology employed in the study was a survey research approach. Survey research approaches provide the benefit of generating a considerable amount of data on a topic of interest. Surveying also allows for efficiency of response and data compilation, affordability of implementation, statistical power, and consistency of application across the sample (Jones et al., 2013).

Study Participants

The sample selected for study participation was accessed using a simple random sample of parents with students currently enrolled in Classical Conversations, a homeschool academic support network. To maintain the personal data integrity of the selected parents, 1,000 parents

were originally requested to participate in the study, which required their email being shared outside of the organization. A total of 595 parents agreed to have their emails made available for study purposes and were subsequently emailed a link to the survey hosted on Mindgarden.com (see Appendix A for informed consent).

Parent participants were asked to provide information about their respective homeschools including number and ages of children, years enrolled in Classical Conversations, and years the respondent spent as a Classical Conversations tutor. Parent participants were then asked a series of questions related to their math experience including number of math courses beyond high school and years since their last math class. Questions related to the parents' homeschool math experience included who made the math curriculum decisions, the type of curriculum used, and whether they had any experience with the Classical Conversations math curriculum in development, The Math Map (see Appendix B for survey questions).

Statistical Power Analysis

Statistical power analysis (a priori) was conducted using the G*Power statistical software (3.1.9.2, Universität Düsseldorf, Germany) for sample size estimation purposes. Using an alpha level of $p = .05$ and power index $(1 - \beta)$ of .80, an anticipated medium response effect in Research Question 1 ($d = 0.50$) would require a sample size of 27 to detect a statistically significant finding and a sample size of 12 for an anticipated large effect for the use of the one-sample *t* test. In Research Question 2, an anticipated medium predictive effect in research question one ($f^2 = .15$) would require a sample size of 55 to detect a statistically significant finding and a sample size of 25 for an anticipated large effect ($f^2 = .35$) in the predictive analysis using simple linear regression (Faul et al., 2009).

Research Instrumentation

The MSES (Betz & Hackett, 1993) was used to measure the mathematics self-efficacy of the participants. The survey was hosted by Mindgarden.com and consisted of 34 items to measure the individual's belief in their ability to complete math-related tasks and behaviors. Participants were asked to rate their confidence in accomplishing each task on a scale from 0 (*no confidence at all*) to 9 (*complete confidence*), with the median score 4.5 indicating some confidence. The version utilized for this study was the 1993 update of the original 1983 instrument.

Validity of the MSES

The development of the MSES was based on a comprehensive and detailed specification of the behaviors related to mathematics self-efficacy (Betz & Hackett, 1993). Concurrent validity is based on significant correlations between MSES scores and other measures of mathematics attitudes. Betz and Hackett (1993) reported correlations that included math anxiety (r = .56), motivation in math (r = .46), perceived usefulness of math (r = .47), and confidence in doing math (r = .66). Further evidence for the validity of the MSES is the correlation between MSES scores and educational and vocational behaviors. Higher MSES scores were related to the choice of math-related college majors and math-related careers.

Reliability of the MSES

Betz and Hackett (1993) reported solid evidence for the reliability of the MSES with internal consistency reliability values (Cronbach's alpha) of .96 for the total scale, .92 for the math tasks subscale, .96 for math problems subscale, and .92 for the math-related course subscale. Cronbach's alpha provides a measure, between 0 and 1, of the interrelatedness of test items (Tavakol & Dennick, 2011). A higher alpha value indicates a reduced fraction of the test

score attributable to error. Acceptable alpha scores range between 0.70 and 0.95. Higher alpha scores may suggest redundancy in the items.

Study Procedures

Study data were collected via Mindgarden.com. Study participants were provided with a link to the survey via email. The survey required the completion of the informed consent prior to accessing the remainder of the instrument. Participants entered a username and password on the Mindgarden.com site to enhance the security of the response data. The researcher selected the data privacy option within the survey administration options so names and emails were not reported with the responses and no personally identifiable information was available with data.

Survey data were imported into the 28th version of IBM's Statistical Package for the Social Sciences for analytic and reporting purposes. Descriptive and inferential statistical techniques were used in the initial analysis of the data, including examining distributions, normality, measures of central tendency, and standard deviations for each variable.

Data Analysis

Descriptive and inferential statistical techniques were used to analyze the study data at the foundational level and by research question. The analysis of the study data was addressed in the following manner.

Preliminary Foundational Analyses

Survey data were collected and analyzed for data accuracy, participant response rates, initial descriptive statistical findings, and internal reliability. Essential response set data were evaluated for assumption testing purposes. Data were, moreover, converted from the existing 9-point scale used in the instruments to a 5-point Likert-type scale. Internal reliability of study participant responses to survey items on the research instruments was evaluated using the

Cronbach's alpha statistical technique (Field, 2018). The conventions of alpha interpretation proposed by George and Mallery (2020) were applied to findings achieved in the analyses of internal reliability.

Analysis by Research Question

Research Question 1

To what degree do homeschool parents perceive themselves as self-efficacious in mathematics?

Descriptive and inferential statistical techniques were used to address Research Question 1. Measures of central tendency and variability (standard deviation) were used to measure the overall math self-efficacy of homeschool parents. The assumption of normality was assessed through an evaluation of the dependent variable's skew and kurtosis values. The conventions proposed by George and Mallery (2020) for data normality using skew and kurtosis values were applied to the dependent variable of mathematics self-efficacy.

A one-sample *t* test was used to compare study participant mean perceptions of mathematics self-efficacy to the expected mean of 3.0 for statistical significance testing purposes. The magnitude of the response effect for perceptions of self-efficacy was assessed using Cohen's *d*. The conventions of effect size interpretation offered by Sawilowsky (2009) were used for study purposes.

Research Question 2.

To what degree does homeschool parents' level of self-efficacy in mathematics predict CC?

The simple linear regression statistical technique was used to evaluate the statistical significance of the predictive relationship between PMSE and CC. Predictive model fitness was

evaluated through the interpretation of the ANOVA *F* value. The predictive model's effect was evaluated through the interpretation of the model summary r^2 value. The assumptions of linear regression were addressed through statistical means (independence of error; normality of residuals) and visual inspection (linearity, influential outliers, and homoscedasticity).

Summary

The purpose of the study was to evaluate the math self-efficacy of homeschool parents and assess the degree of predictive relationship between mathematics self-efficacy and subsequent CC. A simple random sample of parents completed a survey with questions about their homeschool, math experience, and CCs in addition to completing the MSES. A non-experimental, quantitative research design was used to address the study's topic and research problem. Survey research represented the specific research methodology used to achieve the study's essential response data. Descriptive and inferential statistical techniques were used at the preliminary, foundational level of analysis, and for the study's two research questions. Chapter IV contains the formal reporting of findings achieved in the study.

IV. RESULTS

The purpose of the study was to evaluate the math self-efficacy of homeschooling parents. Specific focus was placed upon evaluating the degree to which parents of students enrolled in a Classical Conversations community in the United States are self-efficacious for mathematics and the degree to which math self-efficacy might predict mathematics CC.

A formal reporting of findings achieved in the study is presented in Chapter IV. Study data were achieved through a survey research methodological approach using a quantitative, non-experimental research design. Two research questions and hypotheses were stated to address the study's topic and research problem. Descriptive and inferential statistical techniques were used to analyze study data at the foundational level and by research question stated. The analysis of study data was addressed using the 28th version of IBM's Statistical package for the Social Sciences.

The following represents the formal reporting of findings achieved at the foundational descriptive statistical level and by research question stated in the study.

Demographic Analysis

The study's demographic information was evaluated using descriptive statistical techniques. Specifically, demographic identifying information was addressed using the descriptive statistical techniques of frequencies and percentages.

Table 1 contains a summary of finding for the descriptive statistical analysis of the

study's demographic identifying information for study participant education level and grade level taught in homeschooling.

Table 1

Descriptive Statistics Summary Table: Demographic Information

Demographic Variable	*n*	%	Cumulative %
Degree			
HS diploma/GED	25	11.21	11.21
AA degree	22	9.87	21.08
Bachelor's degree	121	54.26	75.34
Master's degree	43	19.28	94.62
Professional degree	5	2.24	96.86
Doctoral degree	7	3.14	100.00
Missing	0	0.00	100.00
Grade preK			
No	182	81.61	81.61
Yes	41	18.39	100.00
Missing	0	0.00	100.00
Grade K-3			
No	80	35.87	35.87
Yes	143	64.13	100.00
Missing	0	0.00	100.00
Grade 4-6			
No	86	38.57	38.57
Yes	137	61.43	100.00
Missing	0	0.00	100.00
Grade 7-9			
No	123	55.16	55.16
Yes	100	44.84	100.00
Missing	0	0.00	100.00
Grade 10-12			
No	175	78.48	78.48
Yes	48	21.52	100.00
Missing	0	0.00	100.00

Descriptive Statistics: Curriculum Adoption (Mathematics)

Table 2 contains a summary of finding for the descriptive statistical analysis of the study's demographic identifying information for study participant mathematics curriculum adoption.

Table 2

Descriptive Statistics Summary Table: Math Curriculum Adoption

Curriculum Adoption	*n*	%	Cumulative %
Math curriculum			
Saxon/self-directed	95	42.60	42.60
Private tutor-directed	60	26.91	69.51
Teacher-directed	31	13.90	83.41
On-line/video individual math curriculum	35	15.70	99.10
Missing	2	0.90	100.00

Descriptive Statistics: Select Response Set Items

Descriptive statistical techniques were used to assess the study's data by select response sets. The study's response data were specifically addressed using the descriptive statistical techniques of frequencies, measures of typicality (mean scores), variability (minimum/maximum and standard deviations), standard errors of the mean (*SEM*) and data normality (skew and kurtosis).

Table 3 contains a summary of finding for the descriptive statistical analysis of the study's response set data associated with study participant years since last mathematics class, mathematics classes enrolled in after high school, years in homeschooling, years in Classical Conversations, and years as a Classical Conversations tutor.

Table 3

Descriptive Statistics Summary Table: Select Demographic Information Items

Survey Item	*M*	*SD*	*SEM*	Min	Max	Skew	Kurtosis
Years since last math class	19.88	7.15	0.48	2.00	50.00	0.78	1.97
Math classes taken after HS	3.55	3.61	0.24	0.00	25.00	3.01	12.53
Years in homeschooling	7.96	5.61	0.38	1.00	35.00	1.62	3.72
Years Classical Conversations	5.85	3.48	0.23	1.00	18.00	0.62	−0.14
Years as Classical Conversations tutor	3.15	3.38	0.23	0.00	18.00	1.46	2.30

Note. *N = 223; SEM* = standard error of the mean; Min = minimum; Max = maximum; HS = high school

Confidence in Completing Mathematics Coursework (A or B Grade)

Table 4 contains a summary of finding for the descriptive statistical analysis of the study's response set data associated with study participant confidence in completing prescribed mathematics tasks.

Internal Reliability: Mathematics Tasks

The internal reliability of study participant response across the 18 mathematics task completion confidence items on the research instrument was addressed using the Cronbach's alpha statistical technique (Field, 2018). As a result, using the conventions of alpha interpretation offered by George and Mallery (2020), the internal reliability levels achieved across the 18 mathematics task completion confidence items on the research instrument were considered excellent at $\alpha = .93$.

Table 5 contains a summary of finding for the internal reliability achieved for study participant response across the 18 mathematics task completion confidence items on the research instrument.

Table 4

Descriptive Statistic Summary Table: Perceptions of Confidence in Completing Mathematics Courses

Mathematics Course	*M*	*SD*	*SEM*	Min	Max	Skew	Kurtosis
Basic college math	4.39	0.88	0.06	1.00	5.00	−1.51	2.13
Economics	3.73	1.06	0.07	1.00	5.00	−0.49	−0.61
Statistics	3.52	1.21	0.08	1.00	5.00	−0.37	−0.83
Calculus	3.00	1.30	0.09	1.00	5.00	0.16	−1.12
Algebra 2	3.99	1.12	0.07	1.00	5.00	−0.87	−0.22
Geometry	3.90	1.05	0.07	1.00	5.00	−0.76	−0.08
Algebra 1	4.27	0.99	0.07	1.00	5.00	−1.22	0.54
Accounting	3.71	1.09	0.07	1.00	5.00	−0.50	−0.61
Trigonometry	3.30	1.32	0.09	1.00	5.00	−0.26	−1.10
Advanced calculus	2.59	1.29	0.09	1.00	5.00	0.32	−0.99

Note. $N = 223$; *SEM* = standard error of the mean; Min = minimum; Max = maximum

Table 5

Internal Reliability Summary Table for Mathematics Task Completion Confidence

Scale	# of Items	α	Lower Bound	Upper Bound
Math task completion confidence	18	.93	.91	.94

Note. The lower and upper bounds of Cronbach's alpha were calculated using a 95% confidence interval.

Internal Reliability: Mathematics Coursework

The internal reliability of study participant response across the 10 mathematics coursework confidence items on the research instrument was addressed using the Cronbach's alpha statistical technique (Field, 2018). As a result, using the conventions of alpha interpretation offered by George and Mallery (2020), the internal reliability levels achieved across the 10

mathematics coursework confidence items on the research instrument was considered excellent at α = .95.

Table 6 contains a summary of finding for the internal reliability achieved for study participant response across the 10 mathematics coursework confidence items on the research instrument.

Table 6

Internal Reliability Summary Table for Mathematics Coursework Confidence

Scale	# of Items	α	Lower Bound	Upper Bound
Math course confidence	10	.95	.94	.96

Note. The lower and upper bounds of Cronbach's alpha were calculated using a 95% confidence interval.

Findings by Research Question

The study's two research questions were addressed using descriptive and inferential statistical techniques. The probability level of $p \leq .05$ was adopted for use as the threshold value for findings achieved to be considered statistically significant. Numeric effect sizes achieved in the analyses were interpreted using the conventions of effect size interpretations proposed by Sawilowsky (2009).

The following represents the findings achieved in the study by research question stated.

Research Question 1

To what degree are homeschool parents self-efficacious in mathematics?

Hypothesis

H_0: Homeschool parents will have some confidence in their math ability (PMSE = 3.0).

Analysis

A one-sample *t* test was used to evaluate the statistical significance of study participant mean score perceptions of mathematics self-efficacy. The assumption of normality for the dependent variable of mathematics self-efficacy was assessed through inspection of the respective skew and kurtosis values. Using the conventions of data normality proposed by George and Mallery (2020), the skew value of −1.04 and kurtosis value of 1.38 were well within the normality range for skewness (−/+2.0) and kurtosis (−/+7.0), and as a result, the assumption of normality was satisfied.

Findings

The study participant mean score of 4.17 (*SD* = 0.62) for perceptions of mathematics self-efficacy was statistically significant, $t(222) = 28.08$, $p < .001$. The magnitude of effect for study participant perceptions of mathematics self-efficacy was an approximate huge effect at $d = 1.88$.

Table 7 contains a summary of finding for study participant perceptions of mathematics self-efficacy.

Table 7

Summary Table: Study Participant Perception of Mathematics Self-Efficacy

Variable	*M*	*SD*	μ	*t*(222)	*p*	*d*
Mathematics self-efficacy	4.17	0.62	3.0	28.08	< .001	1.88

Mathematics Self-Efficacy by Education Level

A 1 x 6 ANOVA was conducted to evaluate the overall effect of study participant education level upon perceptions of mathematics self-efficacy. The assumption of homogeneity of variances was addressed through the interpretation of Levene's *F* value. The resultant Levene's *F* was non-statistically significant, $F(5, 217) = 1.82$, $p = .09$, thereby satisfying the

assumption of homogeneity of variances. The assumption of data normality for each level of the dependent variable was satisfied as all skew and kurtosis values were within the parameters for data normality proposed by George and Mallery (2020).

The finding for study participant education level was statistically non-significant, $F(5, 217) = 2.13$, $p = .06$, indicating the differences in perception of mathematics self-efficacy among the levels of education level were all similar. The results are reported in Table 8. The magnitude of effect for education level upon study participant perceptions of mathematics self-efficacy was considered medium ($\eta^2 = .05$).

The means and standard deviations of the ANOVA analysis are presented in Table 9.

Table 8

Analysis of Variance Summary Table: Effect of Education Level Upon Perceptions of Mathematical Self-Efficacy

Model	*SS*	*df*	*F*	*p*	η^2
Education level	4.05	5	2.13	.06	0.05
Residuals	82.45	217			

Table 9

Mean, Standard Deviation, and Sample Size for Perceptions of Mathematics Self-Efficacy by Education Level

Educational level	*M*	*SD*	*n*
HS diploma/GED	3.99	0.66	25
AA degree	4.02	0.86	22
BS degree	4.18	0.58	121
MA/MS degree	4.22	0.61	43
Professional degree	4.53	0.18	5
Doctoral degree	4.71	0.28	7

Note. HS = high school

Research Question 2

To what degree does homeschool parents' level of self-efficacy in mathematics predict CC?

Hypothesis

H_0: There will be no correlation between PMSE and CC.

Analysis

A simple linear regression statistical technique was used to evaluate the predictive ability of study participant mathematics self-efficacy for mathematics curriculum adoption. The assumptions of linear regression were addressed and satisfied by statistical means (independence of error, normality of residuals, and influential outliers) and visual inspection of scatter plots (linearity and homoscedasticity).

Findings

The predictive model was statistically significant, $F(1, 219) = 4.69$, $p = .03$, $R^2 = .02$, indicating that 2.10% of the variance in mathematics curriculum adoption is explainable by perceptions of self-efficacy. Mathematics self-efficacy was statistically significant in predicting mathematics curriculum adopting, $B = -0.26$, $t(219) = -2.17$, $p = .03$, indicating that, on average, a one-unit increase of perceptions of mathematics self-efficacy will decrease the value of mathematics curriculum adoption by 0.26 units.

Table 10 contains a summary of finding for the predictive model used in Research Question 2, and the means, standard deviations, and sample size for mathematics self-efficacy level for each respective mathematics curriculum reported in Table 11.

Table 10

Predicting Mathematics Curriculum Adoption by Study Participant Perceptions of Mathematics Self-Efficacy

Model	*B*	*SE*	95% CI	β	*t*	*p*
(Intercept)	3.10	0.50	[2.11, 4.08]	0.00	6.20	< .001
Mathematics self-efficacy	−0.26	0.12	[−0.49, −0.02]	−0.14	−2.17	.03

Table 11

Mean, Standard Deviation, and Sample Size for Mathematics Self-Efficacy by Math Curriculum Adoption

Curriculum	*M*	*SD*	*n*
Saxon/self-directed	4.22	0.56	95
Private tutor directed	4.35	0.54	60
Teacher directed	3.88	0.79	31
On-line/video individual math	4.05	0.65	35

Follow-up Ancillary Analysis: Mediation

Formal mediation analysis was conducted to evaluate whether study participant perceptions of attaining a grade of "A" or "B" in a basic college mathematics course exerted a mediating effect upon the relationship between years as a Classical Conversations tutor and perceptions of mathematics self-efficacy. Study participant perceptions of attaining a grade of A or B in a basic college mathematics course was selected for mediation analysis as it represented the most robust correlate, $r = .64$, $p < .001$, and predictor, $B = 0.21$, $t(212) = 3.59$, $p < .001$, of study participant perceptions of mathematics self-efficacy amongst mathematics courses identified for study purposes. The direct effect between years of experience as a Classical

Conversations tutor and mathematics self-efficacy was not statistically significant, indicating that full mediation by perceptions of attaining a grade of A or B in a basic college mathematics course may be supported. Full mediation was evaluated using the indirect and total effects of perceptions of attaining a grade of A or B in a basic college mathematics course upon the relationship between years of experience as a Classical Conversations tutor and mathematics self-efficacy.

The indirect effect of perceptions of attaining a grade of A or B in a basic college mathematics course on the relationship of mathematics self-efficacy regressed on years of experience as a Classical Conversations tutor was statistically significant, $B = 0.02$, $z = 2.27$, $p = .02$, indicating a one-unit increase in years of experience as a Classical Conversations tutor, based on its effect on perceptions of attaining a grade of A or B in a basic college mathematics course, will increase the expected value of mathematics self-efficacy by 0.02 units. The total effect of years of experience as a Classical Conversations tutor on mathematics self-efficacy was statistically significant, $B = 0.03$, $z = 2.66$, $p = .008$, indicating that a one-unit increase in years of experience as a Classical Conversations tutor will increase the expected value of mathematics self-efficacy by 0.03 units. Considering the statistical significance of the indirect and total effects in the modeling process, full mediation was supported by perceptions of attaining a grade of A or B in a basic college mathematics course (Gunzler et al., 2013).

Table 12 contains a summary of finding for the structural equation modeling path model used to evaluate the mediating effect of study participant perceptions of attaining a grade of A or B in a basic college mathematics course upon the relationship between years of experience as a Classical Conversations tutor and mathematics self-efficacy.

Table 12

Unstandardized Loadings (Standard Errors), Standardized Loadings, and Significance Levels for Each Parameter in the Path Analysis Model

Parameter Estimate	Unstandardized (*SE*)	Standardized	*p*
	Regressions		
Years Classical Conversations tutor → self-efficacy	0.01 (0.010)	0.08	.12
Years Classical Conversations tutor → basic college math	0.04 (0.020)	0.15	.02
Basic college math → self-efficacy	0.44 (0.040)	0.62	< .001
	Indirect effect		
Self-efficacy on years Classical Conversations tutor by basic college math	0.02 (0.008)	0.10	.02
	Total effect		
Self-efficacy on years Classical Conversations tutor	0.03 (0.010)	0.18	.008
	Errors		
Error in self-efficacy	0.23 (0.020)	0.59	< .001
Error in basic college math	0.75 (0.070)	0.98	< .001
Error in years Classical Conversations tutor	11.38 (1.080)	1.00	< .001

Note. $N = 223$

V. DISCUSSION

The purpose of this quantitative study was to explore the math self-efficacy of homeschooling parents to measure the degree to which parents of students enrolled in a Classical Conversations community in the United States are self-efficacious for mathematics and to determine whether the degree of math self-efficacy predicts the parents' mathematics curriculum choices. The independent variable PMSE was defined as the math self-efficacy of the parents as measured using the MSES (Betz & Hackett, 1993). The dependent variable CC was measured using parental self-report.

This chapter includes a discussion of findings as related to the literature on self-efficacy and mathematics education within the homeschool setting. Also included is a discussion on the implications of the research for homeschool parents and the entities that serve the homeschool community. The chapter concludes with a discussion of the limitations of the study, areas for future research, and a summary. This chapter contains a discussion of future research possibilities to help answer two research questions: To what degree are homeschool parents self-efficacious in mathematics? and To what degree does homeschool parents' level of self-efficacy in mathematics predict CC?

Review of Methodology

Using a non-experimental research design, a simple random sample of Classical Conversations parents were invited to complete a survey that included questions about their

homeschool, their mathematics experience, as well as the questions from the MSES (Betz & Hackett, 1993). Of the 595 parents invited to complete the survey, 223 parents completed the survey by the deadline, for a participation rate of 37%. Data were analyzed using the 28th version of IBM's Statistical package for the Social Sciences. The following represents a discussion of the findings that were achieved and reported in Chapter 4 for preliminary analysis and analyses by research question.

Preliminary Analysis

Descriptive statistics revealed the following characteristics of the sample, which can be generalized with 95% confidence to the population of Classical Conversations parents. The average parent has chosen homeschooling to educate their children for 8 years, 6 years of which have included enrollment in Classical Conversations. The families represented by the participants included 18% with pre-school-aged children, 64% with Foundations-aged (grades K-3) students, 61% with Essentials-aged (grades 4-6) students, 45% with Challenge A-I-aged (grades 7-9) students, and 22% with Challenge II-IV-aged (grades 10-12) students. Parents averaged 3 years as a Classical Conversations tutor.

Respondents to the survey indicated an average of 20 years since their last math class. Parents averaged four formal math classes after high school. For 54% of participants, these classes led to a bachelor's degree; for 25% of participants, they were pursued as part of an advanced degree. When asked about their choice of curriculum, only two parents indicated that someone other than them evaluated and graded their students. The remaining parents were fairly evenly split between a parent- or student-led curriculum (42%), a tutor-directed curriculum (27%), and a teacher- or video-led curriculum (30%).

Though not a statistically significant result, a noteworthy finding was the relationship

between level of education and mathematics self-efficacy. The average PMSE of parents with a high-school diploma was 3.99. The PMSE increased consistently for each increased level of education with parents with doctoral degrees averaging a PMSE score of 4.71. With only 12 parents reporting a professional or doctoral degree, the relationship did not achieve the level of significance but is a noteworthy finding in the data.

The MSES (Betz & Hackett, 1993) has demonstrated a high level of internal reliability for the normative population and this was confirmed for the sample of Classical Conversations parents who participated in this study. For the 18 math tasks subsection of the instrument, the Cronbach's alpha was .93 and for the 10 math course items, the Cronbach's alpha was .95, thus validating the use of this instrument for this sample and demonstrating the results are both accurate and reliable.

Discussion by Research Question

For each research question, the discussion below addresses the results of the survey, the findings with regard to the hypotheses and how the findings add to the existing literature on self-efficacy and homeschool math education.

Research Question 1

To what degree are homeschool parents self-efficacious in mathematics?

Given the statistically significant finding of PMSE = 4.17, the null hypothesis, homeschool parents will have some confidence in their math ability (PMSE = 3.0), can be rejected in favor of the finding that homeschool parents have much confidence in their math abilities. A one sample *t* test was used to evaluate the statistical significance of participant mathematics self-efficacy. Statistical analyses were used to confirm the assumption of normality for the dependent variable of mathematics self-efficacy. The mean PMSE score of 4.17 was

statistically significant with an approximately huge effect.

The results of this study offer a novel measure of homeschool PMSE, which is somewhat surprising in light of previous research. In a traditional school setting, parents are less confident in helping their students with their mathematics homework than their English homework and direct parental involvement was correlated with lower senior GPA (Myers, 2021). Among homeschool parents, Wenzel (2020) discovered that parents reported that educating their children in mathematics was hard, leading many to cease directing their children in mathematics. Although those studies do not offer a comparative measure of math self-efficacy, they suggest that parents are not highly confident in their own mathematics abilities.

Two researchers—Felso (2016) from the southeastern United States and Reaburn (2021) from Australia—found similar results in their studies of homeschool parents. Both researchers found that parents expressed a high level of self-efficacy for homeschooling mathematics. Reaburn (2021) contrasted the high teaching self-efficacy with individual parents who reported being challenged by their lack of mathematical knowledge. Felso (2016) identified two distinct self-efficacies: one for homeschooling mathematics and the other being the parent's personal math self-efficacy. Nearly all parents were highly self-effective for homeschooling mathematics, while there were mixed assessments for each parent's personal math self-efficacy.

With no broad measure of mathematics self-efficacy across the homeschool spectrum, it is not possible to compare the sample of this study to previous results, nor is it possible to statistically compare the math self-efficacy of Classical Conversations parents to parents who choose other homeschool programs. Based on the limited research available, these results may suggest either that Classical Conversations parents have a greater math self-efficacy than the general homeschool population or that homeschool parents have a higher math self-efficacy

when measured by a reliable instrument than when asked to self-assess their confidence. Among American students, Zhao and Ding (2019) discovered a societal acceptance, possibly even a societal preference, for having low mathematics confidence. These contradictory results could suggest a similar trend among parents. Parents may express a lower personal math self-efficacy when asked broad questions about their relationship with mathematics, but when asked about their confidence in completing specific math skills or attaining an A or B in mathematics-related courses, parents' measured math self-efficacy is higher.

The statistically significant result with an approximately huge effect, that Classical Conversations parents have much confidence, is a novel finding and adds to our understanding of homeschool parents with children enrolled in Classical Conversations. Vanbinst et al. (2020) found that the transfer of math self-efficacy from parent to child was strongest for the parent that spent the most time with the child. A high PMSE is an encouraging result that suggests that children enrolled in Classical Conversations may benefit from a corresponding higher math self-efficacy.

Research Question 2

To what degree does homeschool parents' level of self-efficacy in mathematics predict CC?

Based on the statistically significant results of linear regression, the null hypothesis, that there will be no correlation between PMSE and CC, is rejected. A simple linear regression was used to evaluate the predictive ability of PMSE for mathematics curriculum adoption. Statistical means were used to confirm the assumptions of linear regression. The predictive model was statistically significant, indicating that 2.10% of the variance in mathematics curriculum adoption is explainable by PMSE. On average, a one-unit increase in PMSE will decrease the

value of mathematics curriculum adoption by 0.26 units.

The results of this study offer a new insight into the relationship between PMSE and parents' choice of mathematics curriculum for their homeschool. A small but significant portion of CC is accounted for by PMSE, indicating that more confident parents are more likely to choose a curriculum in which they are an active participant as teacher and grader. Kaskens et al. (2020) interpreted their study results to suggest that higher teacher confidence was related to less flexibility in class, which may be one factor explaining why more confident parents are more likely to personally direct their children's math education.

The small effect size of PMSE on CC echoes the previous assertion by parents that their personal math self-efficacy did not influence their CC (Felso, 2016). These parents claimed an ability to direct their children's math education even though they frequently chose not to. Felso (2016) found that parents' self-efficacy for providing their children's math education was separate from their personal math self-efficacy, thus suggesting a limited role of PMSE in the selection of their children's curricula.

Many other factors independent from PMSE are likely to factor into a parent's choice of homeschool curriculum. In his study specific to homeschooling families, Wenzel (2020) found that parents highly valued choosing curricula that met individual student's needs, even if it meant different curricula with different delivery methods for different children. Gann and Carpenter (2019) and Bradford (2018) both found that homeschool parents relied heavily on outside support for providing mathematics education to their children, both for curriculum delivery through co-ops and support groups and for added activities through clubs and field trips. These findings were in line with Felso's (2016) findings that parents were confident in managing and facilitating these activities even if they did not have high personal math self-efficacy.

This study's finding that PMSE is a significant predictor of CC adds to the literature a novel finding not previously examined. The small effect is in line with research that suggests multiple factors influence homeschool parents' choice of mathematics curriculum. Though the significant result contradicts prior claims by parents that their personal math self-efficacy does not influence their CC, the small effect size supports their perception that other factors play the greater role.

Additional Findings

Although not addressed as a research question in the study, a mediation relationship was discovered when considering the relationships between confidence in attaining an A or B in specified math courses and PMSE and between years as a Classical Conversations tutor and PMSE. Confidence in achieving an A or B in basic college mathematics was significantly and positively related to PMSE. Years as a Classical Conversations tutor was significantly and positively related to confidence in achieving an A or B in basic college mathematics but did not have a significant direct relationship to PMSE. Using structural equation modeling, confidence in achieving an A or B in basic college mathematics significantly mediated the relationship between years as a Classical Conversations tutor and PMSE. This finding suggests that the longer parents serve as Classical Conversations tutors, the more confidence they gain in achieving an A or B in a basic college mathematics course and, in turn, the higher their personal math self-efficacy.

Study Limitations

Although the results of the study are generalizable to Classical Conversations parents living in the United States, they are not generalizable to all homeschooling parents or to Classical Conversations parents enrolled in international communities. With regard to the relationship between educational level and math self-efficacy, there were too few parents with professional or

doctorate degrees sampled to achieve significant results.

Inherent in the quantitative design, the study is limited to broad universal results without depth of understanding into particular parent mathematical attitudes or factors that relate to CC.

The current study offered parents broad categories to report their homeschool CC. Forcing parents into these categories may fail to capture all the nuances of CC within their homeschools, including the use of multiple curricula within one homeschool.

Implications for Future Practice

The research in this study was undertaken with a goal of establishing a baseline measurement for future studies on how best to support homeschool parents in providing their children's mathematics education. In conjunction with findings from previous research, the results suggest ways presently to support homeschool parents based on a better understanding of their math self-efficacy.

Qualitative studies by Felso (2016) and Reaburn (2021) reported parents expressing less confidence in their ability to learn and do higher levels of mathematics, yet the quantitative results of this study suggest that parents may have a higher self-efficacy than they perceive. Prevalent on jewelry, journal covers, wall hangings, and social media posts, the words "She believed she could, so she did" emphasize the importance of self-efficacy in goal achievement. Though examining measures to increase the math self-efficacy of homeschool parents is a recommendation for future study, helping parents to have an accurate view of their own self-efficacy is one way for parents to "believe they can." Rather than speaking of math confidence in general terms such as "How confident are you in your ability to learn and do mathematics," parents may be better served by asking them specific question such as "How confident are you that you can learn the rule for finding the derivative of x^2?" As parents are given the opportunity

to recognize their task-specific self-efficacy, their perception of their general math self-efficacy will be more accurate.

Wenzel (2020) reported that parents stopped personally teaching their children because the math became too hard, and Reaburn (2021) cited parents who were challenged by their lack of mathematical knowledge. Ramirez et al. (2018) found that teacher math self-efficacy was not correlated with the teacher math knowledge. Together, these studies suggest that a greater barrier to parents directing their children's math education may be their level of math knowledge rather than their personal math self-efficacy. As the results of this study show, parents have a high level of math self-efficacy, which suggests that they are confident that they can gain the math knowledge they may be lacking.

Although parents are confident in their ability to learn the mathematics needed to teach their students, they may lack the tools and opportunities needed to attend to their own mathematics education. Providing parent-specific tools and training that is designed to be accessible to a busy homeschool parent will enable them to learn the mathematics needed even if they do not currently possess the knowledge. These tools might include schemas for organizing their mathematical knowledge, parent-paced tutorials that take advantage of parents' broader body of knowledge, and short explanations aimed at the parents to accompany their children's work. The significant PMSE revealed by this study suggests that parents can take advantage of teaching tools and guidance to learn the math needed by their students, without oversimplifying or trivializing the mathematics.

When considering the full range of PMSE values, it is evident that while Classical Conversations parents have a higher PMSE as a group, there are parents who have very little confidence in their ability to learn mathematics. Strategies to help these parents must be different

than those employed with parents with greater confidence. In their work with mentor groups, Varghese and Finkelstein (2021) suggested that shared experiences may lead to a greater transfer of self-efficacy from mentor to mentee. The shared homeschool experience, especially with a common curriculum such as Classical Conversations, may provide an avenue to support mentor relationships between parents who have a higher math self-efficacy and parents who have a lower math self-efficacy.

Parents with low math self-efficacy may be primary candidates for interventions aimed at increasing their math self-efficacy. Providing mastery experiences and social persuasion are the two most effective methods for increasing self-efficacy (Bandura, 1986). Offering graduated mathematics materials for parents to complete would enable parents to begin at a level where mastery is possible and then gradually increase the difficulty as they master each level. Combining these mastery experiences with public encouragement to the homeschool parent population and private encouragement through a mentoring relationship may help to increase the math self-efficacy of parents to the level where they are able to take advantage of the math education tools suggested above.

The significant but small role that PMSE plays in CC has implications for curriculum developers. To address the self-efficacy of parents, highlighting specific concepts and skills more than general topics may help parents assess the curriculum. Parents may find the statement “This curriculum covers advanced topics including differential and integral calculus in addition to topics from linear algebra” a barrier to implementation. A specific statement such as “Students will learn the rules for finding the derivative and integral of the 16 foundational functions and will be introduced to the matrix as a method for finding common solutions to multiple equations” addresses the higher task-specific math self-efficacy as found in this study.

Though including aids to parents as suggested above may help parents to participate in their child's mathematics education more directly, developers may be aided by a more robust understanding of other factors that parents use when choosing their child's math curriculum. Wenzel (2020), Bradford (2018), and Gann and Carpenter (2019) highlighted the interest parents have in providing a well-rounded curricular experience that includes activities beyond a textbook.

Recognizing that only a small portion of their curriculum decisions stem from their own math self-efficacy may be affirming for parents who seek to make the best choice possible. Individual parents with low math self-efficacy may be bolstered in their confidence to choose a mathematics curriculum that meets the needs of their students if they know that their more math self-efficacious counterparts similarly evaluate mathematics curricula based on the needs of their students rather than their own ability to master the material included.

Recommendations for Future Research

Future studies would benefit from drawing a sample from the wider homeschooling community to give researchers a broader understanding of the math self-efficacy of homeschooling parents. Extending the study to all homeschooling families would also allow for deeper understanding of the factors that influence the choice of homeschooling methodology for mathematics and beyond.

The data from the present study provide a baseline for future research of methods that may increase PMSE. Methods of providing mastery experiences, social persuasion, and vicarious experiences could be tested in an experimental design to determine which methods are the most effective and which methods are the best received by homeschool parents. Such interventions may include sending affirmations to parents with task-specific encouragement as well as general

affirmations of ability to learn and teach mathematics.

Findings from the PISA suggested that international mathematics attitudes among students differ to those of students in the United States (Zhao & Ding, 2019). Including international parents in the sample would enable researchers to extend this comparison to homeschool parents.

A future qualitative study would complement the results of this study by allowing for a deeper understanding of the factors that determine PMSE, the effects of parental attitudes and self-efficacy within the homeschool, and a fuller understanding of the math curriculum choices made by homeschooling families.

Several studies (Evans & Field, 2020; Ramirez et al., 2018; Zee et al., 2018) have shown a connection between teacher self-efficacy and student outcomes including student self-efficacy, while others (Casad et al., 2015; Jay et al., 2018; Mohr-Schroeder et al., 2017) found a relationship between parent math attitudes and student achievement. Although these studies illuminate the individual roles of the homeschool parent, there is an opportunity for future studies to examine the relationship between the math attitudes and self-efficacy of the combined roll of the homeschool parent-teacher and their students.

Masitoh and Fitriyani (2018) demonstrated that problem-solving based curricula was correlated to higher student math self-efficacy, and Samuel and Warner (2021) showed similar results for curricula that included instruction on growth mindsets. Both studies were conducted in traditional education settings. Future studies on problem-solving and growth mindset instruction in homeschool curriculum would help to identify the potential for such strategies to improve the math self-efficacy of students and their parents.

To answer the question about the relationship between math self-efficacy and academic

degree attainment, a longitudinal study would provide insights into whether former math self-efficacy is predictive of future attainment or whether degree attainment is predictive of future math self-efficacy. The same longitudinal study could include the math self-efficacy of any children of the participants, thus offering insight into the relationship between PMSE and child math self-efficacy.

Conclusion

In the Bible, Paul exhorts believers,

> by the mercies of God, to present your bodies as a living and holy sacrifice, acceptable to God, which is your spiritual service of worship. And do not be conformed to this world, but be transformed by the renewing of your mind, so that you may prove what the will of God is, that which is good and acceptable and perfect. (*New American Standard Bible*, 1995/2020, Romans 12:1-2)

For homeschool parents, being a living sacrifice often means pursuing understanding in all academic subjects regardless of the level of comfort the parent has with each one. Regarding mathematics, parents often underestimate their confidence and may approach the subject with some trepidation. Given the opportunity to respond to a task-specific instrument to measure their math self-efficacy, parents have a significantly high math self-efficacy. Helping parents to accurately assess their math self-efficacy may encourage parents to renew their mathematical minds by taking advantage of tools and training designed for homeschooling parents. A key responsibility of homeschooling parents is the choice of curriculum for their students, a decision significantly but slightly influenced by PMSE. This study of homeschool parents adds to the existing literature a new measure of homeschool PMSE specific to Classical Conversations

parents and opens the door to future studies that examine ways to improve the homeschool PMSE.

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Appendix A

Informed Consent

CONSENT FORM

You are invited to take part in a research survey about the math self-efficacy of homeschool parents. You were randomly selected to participate in this research. Please read this form and ask any questions you have before agreeing to be part of the study.

This interview is being conducted by a researcher named Kirsty Gilpin, who is a doctoral candidate at Southeastern University.

Background Information:

The purpose of this study is to explore the math self-efficacy of homeschool parents and any influence math self-efficacy may have on curriculum choice.

Procedures:

If you agree, you will be asked to complete an online survey that should take no more than fifteen minutes to complete.

Voluntary Nature of the Interview:

Your participation in this interview is voluntary. This means that everyone will respect your decision of whether or not you want to be in the interview. No one at Southeastern University will treat you differently if you decide not to be in the interview. If you decide to join the interview now, you can still change your mind later. If you feel stressed during the interview, you may stop at any time. You may skip any questions that you feel are too personal.

Risks and Benefits of Being in the Interview:

There is a minimal risk of revealing personal information about your children (ages) during the survey. Identifying information will be stripped from the data and individual responses will not be identifiable. The benefit of participating in this study is the knowledge that you contributed to the understanding of the math self-efficacy of homeschool parents and the potential for future development of homeschool parent professional development.

Compensation:

There is no compensation for participating in this interview.

Confidentiality:

Any information you provide will be kept confidential. The researcher will not use your information for any purposes outside of this study. Also, the researcher will not include your name or anything information that could identify you in any research reports.

Contacts and Questions:

The researcher's name is Kirsty Gilpin. You may ask any questions you have now. Or if you have questions later, you may contact the researcher via email at kwgilpin@seu.edu or SEU's Internal Review Board at irb@seu.edu.

The researcher will give you a copy of this form to keep.

Statement of Consent:

☐ I have read the above information. I have received answers to any questions I have at this time. I am 18 years of age or older, and I consent to participate in the interview.

Printed Name of Participant	_____
Participant's Written Signature	_____

Appendix B

Additional survey questions to customize the MSES instrument

Mandatory: What is your highest degree earned?

High school diploma or equivalent
Associates degree
Bachelors degree
Masters degree
Professional degree (i.e. JD, MD)
Doctorate degree

Mandatory: How many years has it been since your last formal math class?

Short answer numerical

Mandatory: How many math courses have you taken beyond high school?

Short answer numerical

Mandatory: How many years have you chosen to homeschool (answer 1 if this is your first year)?

Short answer numerical

Mandatory: How many years have you been enrolled in Classical Conversations (answer 1 if this is your first year)?

Short answer numerical

Mandatory: How many years have you been a Classical Conversations tutor (answer 0 if you are not a tutor)?

Short answer numerical

Mandatory: What ages of children are enrolled in your homeschool (check all that apply)?

pre-K
Foundations only (grades K-3)
Essentials (grades 4-6)
Challenge A - I (grades 7-9)
Challenge II - IV (grades 10-12)

Mandatory: Which parent/guardian makes math-related curriculum decisions in your homeschool?

Short answer

Mandatory: Which option best describes the math curriculum used in your homeschool (for students enrolled in CC+, please consider the high school assessment)?

Parent chosen, Parent Instruction, Parent assigned grades
Parent chosen, student-led with parent guidance, parent-assigned grades
Parent chosen, Tutor or video provided instruction, parent-assigned grades
Parent chosen, tutor or video provided instruction, tutor- or curriculum-assigned grades
School or co-op choice of curriculum, Teacher provided instruction, Teacher-assigned grades

Mandatory: Have you or your student completed any curricular materials associated with The Math Map (check all that apply)?

Parent-teacher
Student
Neither

Optional: Provide your email if you would be interested in being interviewed for a follow-up study on homeschool parents and mathematics?

Optional: Provide your email if you would like to be notified when the study is completed and available for review?