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Improving College Students' Views and Beliefs Relative to Mathematics: A Systematic Literature Review followed by A Multiple Case Mixed Methods Exploration of the Experiences That Underpin Community College Students' Attitudes, Self-Efficacy, and Values in Mathematics

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University

by

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Abstract

Mathematics is a key subject that is used in daily life. Therefore, it is a major subject emphasized in grade school and in undergraduate curricula. Yet, many Americans openly declare their dislike for the subject and claim that it is difficult to grasp. These negative declarations may have a negative impact on student motivation and achievement in mathematics. This systematic literature review sought to determine what types of studies or initiatives have been conducted or designed to enhance students' views and beliefs relative to mathematics, including domain general and specific perceptions of math as well as their judgements of who is successful in mathematics and if they themselves can be successful. Specifically, the review centered on the components of interventions, curriculum, and instruction aimed at improving college students' views of mathematics. The findings of the literature review point to several promising strategies (e.g., instruction, curriculum, interventions) to inform future research and college mathematics teaching. Evidence was supplied for making mathematics relevant to students' lives; there were mixed results on the use of technology in mathematics; and reflective exercises yielded generally favorable results.

Keywords: belief, college, curriculum, improve, instruction, interventions, math, motivation, undergraduate, view

Improving College Students' Views and Beliefs Relative to Mathematics: A Systematic Literature Review

Mathematics is an extremely important subject that is a part of everyday life. For example, mathematics is central to determining the area or perimeter to place household items, shopping for discounts, measuring while cooking, managing finances and budgeting, determining likelihood of risks or gain, and much more. Importantly, it is universal. That is, there is typically one set of resulting truths in mathematics regardless of one's country of origin, language, culture, learning approaches, or problem-solving techniques. More broadly, learning mathematics is helpful in training the mind to think analytically and recognize patterns to make sound judgments. Consequently, it is one of the subjects central to pre-kindergarten through grade 12 as a learning expectation (National Council of Teachers of Mathematics, 2020). It is also frequently featured within general undergraduate curriculum and degree requirements (Burdman, 2015; Hart Research Associates, 2016). That is, many students—even those who do not declare a math major—must be able to complete a certain level of degree-related mathematics requirements necessary to earn their intended degree. Taken together, mathematical skills are critical in life and learning.

Despite the universal importance of math, countless Americans openly express that they despise the subject and assert that it is difficult to understand. According to a poll conducted on 1,000 adults, for example, 37% of the poll's respondents stated that mathematics was the subject they "hated the most" (Ipsos-Public Affairs, 2005). This percentage was more than double the percentage of any other subjects for which respondents indicated as their most hated. In a separate survey of parents (1,085) and teachers (810) of kindergarten through 12th grade students, 40% of the parents and 67% of the teachers declared mathematics as the subject that their students needed the most help with to complete homework (Knowledge Networks, 2006). These percentages were much larger than the percentages for any other subject, close to triple for parent respondents, and about six times larger for the teachers. Additionally, a Gallup poll conducted on 1,028 United States teens indicated that the highest percentage of the respondents (37%) deemed math as their most difficult subject (Saad, 2005). In summary, these opinion polls further indicate that mathematics is deemed a challenging and disliked subject for many students across school levels.

The aforementioned decrees shed light on deep-seated adverse views and beliefs relative to the subject. They are negative proclamations, which may have a detrimental effect on student motivation and achievement in a mathematics class. More specifically, such declarations reflect personal competence beliefs and may manifest in students’ mathematics achievement-related behaviors and outcomes. It is well-documented in the literature that students’ beliefs about their capabilities in mathematics are powerful predictors for their performance (Chen & Zimmerman, 2007; Muenks et al., 2018; Wigfield & Cambria, 2010). Thus, the development of more positive views toward mathematics -- including greater confidence regarding mathematics -- is likely to be beneficial in helping students achieve their highest attainable success despite any prior dispositions toward the subject.

Given these trends, it is unsurprising that many students are underprepared for college-level mathematics courses when they enter college (Madison et al., 2015; McCormick & Lucas, 2011). As a result, there is an increasing need for mathematics remediation in post-secondary education (Abraham et al., 2014). Students identified as not being ready for college mathematics are placed into remedial courses that do not count toward a college degree and must pass them before they can actually enroll into a college mathematics course. This can create a barrier in normal degree completion time and, furthermore, influence low self-judgments in mathematics. Students with previous experiences of inadequacy in mathematics are most prone to having apprehensions with regard to math while also doubting their math abilities (Shodahl & Diers, 1984). Thus, it is crucial to combat the adverse impact previous mathematical experiences may have in influencing negative views of and beliefs in mathematics at the college level.

Views and beliefs include a variety of constructs that will be reviewed according to the literature. These views and beliefs inform one's emotional and behavioral response(s) to situations. An individual's view of something is their perception of it based upon social or cultural norms, observation, and/or experience. One's beliefs relative to others and themselves are further shaped by these views. Encouraging students' belief in themselves in terms of confidence in mathematics has multiple benefits including improved learning behaviors, achievement, and likelihood they will persist in school (Wu & Fan, 2017). In particular, competence beliefs are extremely important for student success as they play a significant role in willingness to put forth effort toward learning information. Research has established that academic *self-efficacy*, a type of competence belief that centers on individual's perception of or level of confidence in his or her abilities to carry out a task (Bandura, 1982; Bandura, 1986; Pajares & Miller, 1994; Zimmerman, 2000), is positively related with numerous motivation constructs and predicts both achievement and further achievement-related behaviors (Barrows et al., 2013; Davis et al., 2011; Johnson & O'Keeffe, 2016; Larson et al., 2015; Muenks et al., 2018; Muenks et al., 2017; Parks-Stamm et al., 2010; Roick & Ringeisen, 2018; Villavicencio & Bernardo, 2016; Wu & Fan, 2017). Consequently, individual differences in student self-efficacy can have significant consequences on student learning and performance. Although the link between views, beliefs, and mathematics learning behaviors and outcomes are well-established, less is known about how to improve students' views and beliefs about mathematics.

The Current Review

Purpose Statement

Given the importance of mathematical proficiency in school and in the real world coupled with the unfortunate reality that many individuals find mathematics challenging and outwardly communicate their aversion for the subject, the overarching goal of my research is to improve students' views and beliefs of mathematics as a subject. Based upon the powerful role of competence beliefs in shaping learning and performance (Chen & Zimmerman, 2007; Muenks et al., 2018; Wigfield & Cambria, 2010), improving these viewpoints should motivate them to regulate themselves accordingly and ultimately perform better. To my knowledge, there are no current reviews in the literature encompassing empirical studies that have specifically aimed to influence student views and beliefs relative to mathematics. The findings from this systematic literature review aims to provide a comprehensive synthesis of promising approaches (e.g., instruction, curriculum, interventions) to inform future research and college mathematics teaching. Specifically, the goal of this literature review is to determine what types of studies have been conducted at the college level to target students' views and beliefs about mathematics for future improvement attempts. These views will be inclusive of a broad range of students' views and beliefs, including domain general and specific perceptions about mathematics and beliefs about who is successful in mathematics as well as whether they themselves can be successful. The following research questions guided this literature review:

1. What are the foundational features (i.e., frameworks, study design, sample context) of intervention studies that have been conducted with college students in an attempt to improve students' views and beliefs relative to mathematics?

2. What are the major components of existing approaches (e.g., interventions, curriculum, and/or instruction) that have been examined with college students seeking to improve students' views and beliefs in mathematics? How are these component features applied and/or measured?
3. What evidence has been established for these approaches for supporting college students' views and self-beliefs related to mathematics?

Accordingly, this literature review will focus on the aims, methods, and results of studies that have attempted to influence college student views and beliefs about mathematics. I will begin by explaining the search strategies and screening processes used to locate relevant articles for inclusion. I will then present a review of the relevant literature that includes relevant study aims, participant characteristics (e.g., community college, university, public, private), and study results that are specific to the above noted research questions.

Search Method

Two rounds of systematic, electronic searches were conducted. The first round search was conducted via the standalone databases ERIC and APA PsycInfo for peer-reviewed journal articles that could be found within the databases using the following search terms: (interven* OR strateg* OR teach* OR pedag* OR prog* OR instruct*) AND (college OR undergrad* OR "higher ed"* OR universit* OR postsecond*) AND student AND (feel* OR like OR perce* OR self-eff* OR competenc* OR concept* OR abilit* OR belie*) AND (math* OR stat* OR calc* OR quant*). The ERIC search resulted in 34 peer-reviewed journal articles with no boundaries on publication year; 33 within the last 20 years (2001 to present 6/26/2020). The APA PsychInfo search resulted in 34,346 peer-reviewed academic journals with 2,205 being restricted to college students with no bound on publication year; 1,671 in the past 20 years (2000 to present

6/26/2020); 1,415 in the past 15 years (2005 to present 6/26/2020); 1,055 in the past 10 years (2010 to present 6/26/2020); 584 in the past 5 years (2015 to present 6/26/2020). Following these results, the search terms were altered by deleting stat*, calc*, and quant* in order to note any possible changes in resulting numbers as follows: (interven* OR strateg* OR teach* OR pedag* OR prog* OR instruct*) AND (college OR undergrad* OR “higher ed”* OR universit* OR postsecond*) AND student AND (feel* OR like OR perce* OR self-eff* OR competenc* OR concept* OR abilit* OR belie*) AND math*. The ERIC search resulted in 32 peer-reviewed journal articles with no boundaries on publication year; 30 within the last 20 years (2001 to present 6/26/2020). The APA PsychInfo search resulted in 2,310 peer-reviewed academic journals with 93 being restricted to college students with no bound on publication year; 72 in the past 20 years (2000 to present 6/26/2020); 60 in the past 15 years (2005 to present 6/26/2020); 48 in the past 10 years (2010 to present 6/26/2020); 27 in the past 5 years (2015 to present 6/26/2020).

A second round of searches occurred due to a sizable lapse in time between searching and screening along with the sensed need to search additional databases. This round of searching was conducted using Virginia Commonwealth University Library’s online multiple database search access. The databases searched at that time were Academic Search Complete, Education Research Complete, ERIC, and APA PsycInfo. The results of this combined search using the terms (interven* OR strateg* OR teach* OR pedag* OR prog* OR instruct*) AND (college OR undergrad* OR “higher ed”* OR universit* OR postsecond*) AND student AND (feel* OR like OR perce* OR self-eff* OR competenc* OR concept* OR abilit* OR belie*) AND (math* OR stat* OR calc* OR quant*) resulted in 220,961 peer-reviewed scholarly journals with 218,440 being restricted to academic journals with no bound on publication year and 8,220 with an added constraint of college students; 7,474 in the past 20 years (2000 to present 8/8/2020); 7,047 in the past 15 years (2005 to present 8/8/2020); 5,830 in the past 10 years (2010 to present 8/8/2020); 3,549 in the past 5 years (2015 to present 8/8/2020). As with the first round, this was followed by the deletion of stat*, calc*, and quant* from the search terms in order to note any possible changes in resulting numbers as follows: (interven* OR strateg* OR teach* OR pedag* OR prog* OR instruct*) AND (college OR undergrad* OR “higher ed”* OR universit* OR postsecond*) AND student AND (feel* OR like OR perce* OR self-eff* OR competenc* OR concept* OR abilit* OR belie*) AND math*. This resulted in 47,154 peer-reviewed scholarly journals with 46,251 being restricted to academic journals with no bound on publication year and 1,433 with an added constraint of college students; 1,284 in the past 20 years (2000 to present 8/8/2020); 1,190 in the past 15 years (2005 to present 8/8/2020); 960 in the past 10 years (2010 to present 8/8/2020); 593 in the past 5 years (2015 to present 8/8/2020).

The decision was made to download the 960 peer-reviewed scholarly academic journals from the last 10 years (2010 to present 8/8/2020) restricted to college students using the terms (interven* OR strateg* OR teach* OR pedag* OR prog* OR instruct*) AND (college OR undergrad* OR “higher ed”* OR universit* OR postsecond*) AND student AND (feel* OR like OR perce* OR self-eff* OR competenc* OR concept* OR abilit* OR belie*) as I was looking for relatively up-to-date practices and programs with regard to college students. The choice to disregard stat*, calc*, and quant* was made in order to reference mathematics in general. There tends to be a differentiation between “math” and statistics or quantitative reasoning. Additionally, calc* could inflate results with articles referencing calculators. In hindsight, the “OR calc*” inclusion could have more to do with technology use than general mathematics. The 960 files were shared to EBSCOhost folder with a final number of 953 downloaded after the

EBSCOhost collection manager removed "exact duplicates" from the results. The files were then exported to Zotero, a program for managing references through which additional duplicate files were found and merged, leaving 943 articles. Full abstracts with titles of all 943 article files were uploaded to Abstrackr (Wallace et al., 2012), an online citation-screening tool, for screening according to predetermined inclusion and exclusion criteria.

Inclusion and Exclusion Criteria

The following inclusion/exclusion criteria, aligned to the research questions and aims, were applied during the screening process. Included studies: (a) have taken place with an undergraduate college or university sample within a college or university setting; (b) focused on mathematics of any type; (c) included a math intervention, math strategies, a math program, or math instruction; (d) examined students' self-belief, self-concept, self-efficacy, views/attitudes, or interests specific to math; (e) are empirical and published in a peer-reviewed journal; and (f) were conducted within the United States. Studies conducted outside of the United States were excluded due to varying cross-national contexts that may influence students' views and beliefs relative to mathematics. For example, students in some countries have been shown to have low self-beliefs with high anxiety or apprehension on average in relation to mathematics (Lee, 2009). In contrast, the reverse has been shown where students in other countries have high self-beliefs with low anxiety, on average (Lee, 2009). This is likely due to cultural differences or varying country-specific values (Shoho, 1996).

Title and Abstract Screening

Once all 944 (after duplicates removed and addition of 1 article from other source) full abstracts with titles had been uploaded to Abstrackr, each title and abstract was meticulously read and labeled as "relevant (1)" for inclusion, "maybe (0)" for indecision, or "irrelevant (-1)" for exclusion according to the pre-established inclusion/exclusion criteria. This process resulted in 798 exclusions, 89 “undecideds,” and 56 inclusions based on title and abstract alone in preparation for full-text screening. A review of inclusion and exclusion criteria was conducted to allow for better appraisal of citations labeled as undecided. All remaining “undecideds” were then screened further by myself and a second coder in order to make a decision to either include or exclude the articles for full-text screening. The pre-established exclusion codes were used to label them for inclusion or exclusion. See Figure 1 for a diagram illustrating the screening process flow.

Full-Text Screening

The remaining 31 studies were downloaded and thoroughly screened for the following information: (a) theoretical framework(s); (b) study design; (c) college student sample; (d) description of context (i.e., college type); (e) examined motivation constructs related to views and beliefs; (f) description of study approach; (g) study measures; (h) analyses applied; and (i) study results. Articles that no longer met inclusion criteria as noted above were coded accordingly and moved to the exclusion list. This procedure yielded 16 studies that fully met inclusion criteria.

Literature Review

This review specifically covers studies and their approaches centering on the improvement of students’ views and beliefs relative to mathematics, including their perceptions of the people who are successful in the domain, and/or their self-beliefs related to the subject.

Theoretical Frameworks Drawn Upon

The studies reviewed drew from a large range of theoretical frameworks. Some studies (7) drew upon multiple frameworks (Hagerty et al., 2010; Hekimoglu & Kittrell, 2010; Henrich et al. 2016; Huang & Mayer, 2019; Karaali, 2015; Wang et al., 2011; Zimmerman et al., 2011). Others (6), drew from a single theory (Butler & Butler, 2011; Crocco et al., 2016; Dewar et al., 2011; Meagher, 2012; Mills & Mills, 2018; Van Dyke et al., 2015). Three studies were atheoretical and did not specify a guiding theory for their study (Collins & Winnington, 2010; Cunningham, 2010; Ward et al., 2010). Both Collins & Winnington's (2010) and Ward et al.'s (2010) research were based upon literature on quantitative literacy and the need for individuals to be quantitatively literate (i.e., be able to view real-world situations with a mathematical lens, be mindful of math's usefulness, and be content while doing so). See Table 1 for important study characteristics and Table 2 for an overview of frameworks by study.

Study Design

Study designs included qualitative, quantitative, or mixed methods. Mixed method research allows for the inclusion of both qualitative and quantitative approaches for answering research questions in a single study on a continuum so that each approach can be used to the enhance the findings of the other (Creswell & Plano Clark, 2018; DeCuir-Gunby & Schutz, 2017; Ercikan & Roth, 2006; Johnson et al., 2007; Onwuegbuzie et al., 2009; Teddlie & Yu, 2007). Notably, studies that utilized both qualitative and quantitative methods will be categorized as "mixed" method for the current review as many authors did not explicitly state the specific design used. The reviewed studies included: 7 mixed (Dewar et al., 2011; Hagerty et al., 2010; Henrich et al., 2016; Van Dyke et al., 2015; Wang et al., 2011; Ward et al., 2010; Zimmerman et al., 2011); 5 quantitative (Butler & Butler, 2011; Collins & Winnington, 2010; Crocco et al., 2016; Huang & Mayer, 2019; Mills & Mills, 2018); and 4 qualitative (Cunningham, 2010; Hekimoglu & Kittrell, 2010; Karaali, 2015; Meagher, 2012).

College Student Sample

Student populations also varied considerably. All studies were conducted at postsecondary institutions with students at the undergraduate level of their education: 4 community colleges (Collins & Winnington, 2010; Crocco et al., 2016; Cunningham, 2010; Hekimoglu & Kittrell, 2010); 1 public technical college (Zimmerman et al., 2011); 1 private college (Karaali, 2015); 2 public universities (Butler & Butler, 2011; Hagerty et al., 2010); and 4 private universities (Dewar et al., 2011; Henrich et al., 2016; Van Dyke et al., 2015; Ward et al., 2010). Other studies (4) did not indicate the college or university type and did not identify the examined institution's name for information retrieval. The authors of these studies identified the institutions as either a small liberal arts college (Mills & Mills, 2018); a large research university (Wang et al., 2011); or simply as a Midwestern university (Huang & Mayer, 2019; Meagher, 2012).

Major Components of Approaches

Studies within the literature found for this review have attempted to influence students' mathematical view and beliefs via provision of direct math support for conceptual understanding and/or skill development (Butler & Butler, 2011; Collins & Winnington, 2010; Cunningham, 2010; Dewar et al., 2011; Hagerty et al., 2010; Henrich et al., 2016; Meagher, 2012; Van Dyke et al., 2015; Wang et al., 2011; Ward et al., 2010), expression of the truths surrounding mathematics (Butler & Butler, 2011; Collins & Winnington, 2010; Dewar et al., 2011; Hagerty et al., 2010; Hekimoglu & Kittrell, 2010; Henrich et al., 2016; Mills & Mills, 2018; Ward et al., 2010), allocation of mathematics discourse opportunities (Butler & Butler, 2011; Collins & Winnington, 2010; Crocco et al., 2016; Dewar et al., 2011; Hagerty et al., 2010; Hekimoglu & Kittrell, 2010; Henrich et al., 2016; Karaali, 2015; Meagher, 2012; Van Dyke et al., 2015; Ward et al., 2010; Zimmerman et al., 2011), integration of technology (Butler & Butler, 2011; Hagerty et al., 2010; Meagher, 2012; Wang et al., 2011), affordances of experiential learning (Collins & Winnington, 2010; Crocco et al., 2016; Dewar et al., 2011; Henrich et al., 2016), employment of social cognitive and anxiety coping strategies (Huang & Mayer, 2019; Zimmerman et al., 2011), application of self-regulated learning tasks (Karaali, 2015; Zimmerman et al., 2011), and utilization of inquiry learning techniques (Butler & Butler, 2011; Ward et al., 2010). Each of these major components are reviewed in more detail next. Of note, some studies fell into more than one component, thus are reviewed in multiple sections (see Table 1).

Math Support for Conceptual Understanding and Skill Development

Academic support in math is assistance given to students with the intention of helping them with their mathematical undertakings, including mathematical ways of thinking and knowing, both in and outside of school (e.g., the ability to apply mathematical knowledge to real-world issues). This support can come in many forms, including a focus on conceptual and/or skills development. Conceptual understanding is the grasping of foundational information related to a particular concept and associated ideas, which allows for knowledge transfer with regard to novel situations (Mills, 2019; Rittle-Johnson et al., 2001). Skill development, on the other hand, refers to disciplinary practices in mathematics, such as the ability to perform mathematical processes in a reliable, precise, effective, and sufficient manner (Walshaw & Anthony, 2008). In the studies reviewed, studies have attempted to influence college students' views and beliefs relative to mathematics through math support by fostering deep conceptual understanding (Butler & Butler, 2011; Collins & Winnington, 2010; Cunningham, 2010; Dewar et al., 2011; Hagerty et al., 2010; Henrich et al., 2016; Van Dyke et al., 2015; Wang et al., 2011; Ward et al., 2010), or have observed in-place strategies attempting to do so (Meagher, 2012). Studies have also endeavored to influence students' views and beliefs with regard to mathematics by supporting skill development (Butler & Butler, 2011; Dewar et al., 2011; Hagerty et al., 2010; Ward et al., 2010).

Butler and Butler (2011) and Cunningham (2010) conducted studies with students enrolled in mathematics courses with the goal of showing the rationale behind mathematical procedures and promoting knowledge retention. Butler and Butler (2011) incorporated a weekly recitation class day into Liberal Arts Math courses through which students were provided with traditional lecture (control section) or directed toward meaningful understanding of mathematical concepts with minimal instructor interference to cultivate quantitative problem solving skills, that is, students' ability to apply basic mathematical knowledge to real-world situations (experimental section). In the experimental group, rather than receiving a PowerPoint lecture as the control section did, students were assigned to smaller (about 36% of the typical class size) computer labs in which they completed application activities. For instance, using piano and tiling java applets, students were able to identify mathematical patterns in music and analyze regular polygon combinations for certain tiling conditions (Butler & Butler, 2011). Cunningham (2010) reported on the use of a pedagogical approach for comprehension by logic demonstration (i.e., showing the sense behind the rules) with an emphasis on long-term conceptual understanding of signed numbers, exponents, scientific notation, and greatest common factors over short-range memorization of rules. The authors demonstrated the value of using varying mathematical approaches to solving problems through a combination of verbal and pictorial methods (Cunningham, 2010). For instance, Cunningham (2010) used diagrams to show students how to work with signed numbers via number line as well as the traditional counting with detailed justifications for steps and solutions. Collins and Winnington (2010) conducted a study with pre-service elementary school teachers taking two reformed undergraduate mathematics courses, a prerequisite mathematics content course and a mathematics pedagogy course that follows. The authors sought to have students complete the courses with a profound understanding of mathematics' purpose while, similar to Cunningham (2010), making sense of its use as opposed to viewing the subject as rote-based (Collins & Winnington, 2010). In place of learning algorithms, students were urged to have open-ended dialogues concerning problem solving strategies amongst themselves while considering and uncovering alternate approaches to solving problems (Collins and Winnington, 2010). This allowed students to discern the "why and how" to test against "rules and algorithms" (Collins and Winnington, 2010, p. 43).

Dewar et al. (2011) conducted an experimental study with students enrolled in a reformed Quantitative Literacy course with a civic engagement component (treatment) in comparison to students enrolled in the standard Quantitative Literacy course (control). The authors used a project-based approach to learning so that students would gain a deeper understanding of mathematical concepts while sharpening their real-world logic and reasoning skills (Dewar et al., 2011). Students completed open-ended projects concerning community-related topics (e.g., comparing student expenses of living on-campus versus off-campus regarding cost, living standards, and accessibility of living on-campus contrasted with off-campus) in four stages (i.e., background investigation; planning and preparation; action, analysis, and conclusion; response dissemination) with the assistance of rubrics and feedback (Dewar et al., 2011). Henrich et al. (2016) conducted a mixed method analysis with students enrolled in a Quantitative Literacy and Social Justice (QLSJ) course to determine how students' attitudes toward mathematics shifted as a result of engaging in regular community service activity. In order to gain a deep understanding of course concepts, students completed intermittent group activities (Henrich et al., 2016). For example, to enrich learning of population size estimation through the capture-recapture method, groups received a large bag of candy and instructed to approximate the quantity of candy in the bag using the capture-recapture technique. They then compared their approximations to the actual amount of candy in the bag. Van Dyke et al. (2015) conducted an experimental study with students enrolled in either a Calculus or Finite Mathematics course in an effort to improve conceptual understanding through conceptual writing exercises (treatment) and students enrolled in a traditional Calculus or Finite Mathematics course (control). Students in the standard classes completed homework problems related to course concepts. Whereas, students in the treatment group completed structured writing assignments regarding course concepts and a smaller quantity of problems. For example, rather than simply solving traditional mathematics problems about a function's rate of change, writing group students were charged with writing exercises that permitted them to focus on terminology, make connections with previous understanding, utilize references, present both supporting and refuting examples, and pinpoint any remaining uncertainties (Van Dyke et al., 2015). Ward et al. (2010) conducted a study with students enrolled in a Mathematics Inquiry course designed to stimulate abstract and critical thinking about mathematics that will, in turn, increase their valuation of math, improve math attitudes, and change misconceptions about math. The course explored a wide range of subject matter inclusive of historical achievements and modern topics while encouraging student engagement, creativity, investigation, and the development of problem solving skills (Ward et al., 2010).

Hagerty et al. (2010), Wang et al. (2011), and Meagher (2012) examined the use of modules with the assistance of computer programs for deep learning of concepts. Hagerty et al. (2010) conducted an experimental study with students enrolled in a College Algebra course reformed to include computer-based mastery learning through an adaptive learning program (treatment) and students enrolled in a traditional College Algebra course (control). Wang et al.

(2011) conducted an experimental study employing a stand-alone introductory statistics learning module to develop students' conceptual understanding through animation (3 groups with differing levels of treatment; 1 control group with static instruction simulating traditional lecture). Meagher (2012) conducted a case study with students enrolled in a self-directed Calculus & Mathematica course using a mathematical software system to execute mathematical calculations so that students are able to spend more time grasping concepts.

Humanizing Math

There are disciplinary truths regarding mathematics that may be helpful for students to acknowledge in order for them to be open to learn. Mason (2003) asserts that students' epistemological beliefs (i.e., socially constructed notions regarding the nature of knowledge and learning) about mathematics in general interact with their beliefs surrounding the learning of mathematics, which can either support or hinder intentional learning. Studies have strived to sway college students' views and beliefs about mathematics by emphasizing fundamental truths about the subject in relation to the historical foundations and achievements (Hagerty et al., 2010; Hekimoglu & Kittrell, 2010; Ward et al., 2010), normalcies (Hagerty et al., 2010; Hekimoglu & Kittrell, 2010; Mills & Mills, 2018), and utility (Butler & Butler, 2011; Collins & Winnington, 2010; Dewar et al., 2011; Hagerty et al., 2010; Henrich et al., 2016; Ward et al., 2010) of mathematics.

Stories of struggle in mathematics. Emphasis has been placed on enlightening students of mathematical breakthroughs and coinciding obstacles. Hagerty et al. (2010), Hekimoglu and Kittrell (2010), and Ward et al. (2010) showed what math entails by educating students on the historical development of mathematical concepts and historic achievements. Hagerty et al. (2010), Hekimoglu and Kittrell (2010), and Mills and Mills (2018) further strived to show the normalcy of challenge in mathematics and the need to expend effort while being persistent and resilient. The authors emphasized the value of productive struggle and the incremental nature of knowledge building in mathematics (Hagerty et al., 2010; Hekimoglu & Kittrell, 2010; Mills & Mills, 2018). In particular, Hagerty et al.'s (2010) treatment group completed learning modules focused on the theoretical foundations and historical evolution of mathematical ideas specific to course content by units. Further, weekly 50-minute theoretical discussions were held and always began with a 5 to 10 minute historical introduction so that students gained greater awareness of how particular concepts progressed over time. This, in turn, was stated to reflect the humanistic nature of mathematics that evolves from generation to generation, and applies to the modern real-world issues. Hekimoglu and Kittrell (2010) conducted a study with college students enrolled in various math courses (i.e., College Algebra, Pre-Calculus, and Calculus) in which they presented a 55-minute documentary that demonstrates the true essence of mathematics and provides a real-life model of how mathematicians think about and solve problems. The documentary used centers on a highly acclaimed mathematician's (Andrew Wiles) challenges and efforts expended while attempting to prove a well-known theorem in number theory (Fermat's Last Theorem). The documentary shows his declaration of success in achieving this goal after years of working on it, directly followed by his frustration after finding an error in the proof, and finally proving the theorem without flaw after an additional year of efforts (Hekimoglu and Kittrell, 2010). Mills and Mills (2018) conducted an experimental study with students enrolled in developmental mathematics seeking to teach growth mindset through four 30-minute weekly lessons (treatment group) and compared them with developmental math students who did not receive growth mindset instruction (control group). During the growth mindset lessons, stories concerning the struggles, defeats, and persistence of influential individuals were shared with students (Mills and Mills, 2018). Students were also requested to reflect on and share personal accounts of the same nature with regard to individuals they know (Mills and Mills, 2018).

Real-world applications of mathematics. Studies also sought to deepen participants' understanding of mathematics through demonstration of the subjects' practicality by showing its relevance, usefulness, and value through real-world applications (Butler & Butler, 2011; Collins & Winnington, 2010; Dewar et al., 2011; Hagerty et al., 2010; Henrich et al., 2016; Ward et al., 2010). Butler and Butler (2011) utilized applets to help treatment students recognize mathematical patterns embedded within real-world applications of interest. Collins and Winnington (2010) carefully chose problems for students that specifically dealt with everyday life. For example, to show the importance of signed numbers, students were presented with problems concerning account balances and expenses such as car payments, gas, school supplies, lunch, tuition, and gifts (Collins & Winnington, 2010). Dewar et al.'s (2011) treatment utilized group projects regarding problems in the local community according to student interests. Topics included student loan debt, insect species in the neighboring wetlands, on-campus contrasted with off-campus living expenses, mathematics department homework help sessions, current versus proposed social security receipts and payments, use of the campus' Student Health Center, textbook pricing, adequacy and efficiency of campus parking, student work hour impacts, and financial planning. In order to make relevant mathematical connections, Hagerty et al. (2010) devoted one class per week to thought-provoking applications correlated with students' previous mathematical knowledge. Henrich et al. (2016) attempted to do so through hands-on experience within the real world. QLSJ students had to satisfy weekly tutoring requirements with local schools or a community tutoring program where they were expected to help struggling students with math, facilitate math activities, or give individualized homework help (Henrich et al., 2016). Ward et al.'s (2010) study consisted of a course exploring an extensive variety of topics, from classical to modern as well as from theoretical proofs to practical situations with regard to "number properties, symbolic logic, inductive and deductive reasoning, counting principles, infinity, paradoxes and proofs, Fermat's Last Theorem, discrete dynamical systems, chaos and fractals, recurrence relations, risk, exotic geometry, and voting methods" (p. 185).

Mathematics Discourse

Discourse is the verbal or written communication of information relative to a particular topic of focus. Classroom discourse is situated within a system of emerging processes between students, their peers, and their instructors through the exchange of ideas and knowledge within a classroom setting (Lloyd et al., 2016; Walshaw & Anthony, 2008). Batista and Chapin (2019) assert that interactions with classmates and teachers in the mathematics classroom aids in the development of mathematical concept comprehension. Studies have attempted to shift college student's views and beliefs surrounding mathematics through discourse by means of class discussion (Collins & Winnington, 2010; Hagerty et al., 2010; Hekimoglu & Kittrell, 2010; Henrich et al., 2016; Mills & Mills, 2018), writing (Butler & Butler, 2011; Collins & Winnington, 2010; Hekimoglu & Kittrell, 2010; Henrich et al., 2016; Karaali, 2015; Van Dyke et al., 2015), reflection and critical thinking (Butler & Butler, 2011; Crocco et al., 2016; Hekimoglu & Kittrell, 2010; Henrich et al., 2016; Karaali, 2015; Ward et al., 2010; Zimmerman et al., 2011), as well as peer-to-peer collaboration (Butler & Butler, 2011; Collins & Winnington, 2010; Crocco et al., 2016; Dewar et al., 2011; Hagerty et al., 2010; Meagher, 2012; Zimmerman et al., 2011).

Mills and Mills (2018) held discussions where stories were shared pertaining to accomplishments individuals have had after persevering through difficulties and setbacks in mathematics to show that struggle is not a sign of intellect or lack of ability. Collins and Winnington (2010) included open-ended class discussions where students collaborated, deliberated, and sought to resolve each other's questions while explaining how they arrived at their solutions, which occurred with very little teacher interference. After discussions, student groups gave descriptions (both oral and written) of their problem solving strategies using pictures and real objects for hands-on manipulation (Collins & Winnington, 2010). Hagerty et al.'s (2010) discussions began with the historical development of a particular concept, further moved into dialogue regarding an explicit example, and finally toward procedures related to the concept in general along with the significance of such procedures with deep consideration of subcomponent associations (Hagerty et al., 2010). Activities were then created for students to collaboratively make connections between the discussion sessions and real-world applications (Hagerty et al., 2010). Hekimoglu and Kittrell (2010) held in-class discussions both prior to watching a documentary and directly after students wrote reflection papers focused on their reactions to the documentary. A pre-documentary discussion was held to help students understand that the aim of the documentary was not to understand specific concepts, but to exemplify how mathematicians interact with and execute mathematical tasks (Hekimoglu & Kittrell, 2010). Post documentary, students had to complete a reflection paper explaining whether or not their views of or beliefs about mathematicians, mathematics, and mathematics learning shifted as a result of viewing the documentary. Additionally, students were asked to describe how they would teach the current math course and what they would hope to achieve by semester end if they were the course instructor (Hekimoglu & Kittrell, 2010). The aim of the 25-

minute post-documentary discussion was to reflect further and consider Andrew Wiles' mathematical characteristics as well as the importance of proofs in mathematics (Hekimoglu & Kittrell, 2010). Henrich et al.'s (2016) students wrote numerous reflection papers regarding course content, readings, and their community service learning experiences. Additionally, the beginning 30 minutes of each class was dedicated to student presentations of homework problems while non-presenting students asked the presenters questions, proposed possible revisions, and took notes (Henrich et al., 2016). Students also collaborated in groups with activities intended to aid in a more profound connection with course content (Henrich et al., 2016).

Butler and Butler's (2011) treatment students worked together in small groups on laboratory activities. On these tasks, the students collaborated to create, refine, and validate their theories (Butler & Butler, 2011). After each of these assignments, students wrote reflection essays centered on the most important aspects of the particular lab (Butler & Butler, 2011). Karaali (2015) conducted a study with students enrolled in a college-level math-for-liberal-arts course primarily directed towards for non-STEM majors. Weekly metacognitive activities were held through which students assessed their progress and analyzed their growth taking into account specific objectives they set for themselves in order to influence positive changes in student motivation and self-regulation of learning (Karaali, 2015). For instance, for their first writing assignment, students were asked to (1) describe their general educational history as well as their history with mathematics and statistics; (2) list their previous courses involving mathematics and/or statistics and to give a detailed account of their experiences as well as their subjective reactions to them; (3) describe their primary goals for the course; (4) discuss their anxieties relative to taking the course; (5) communicate what they hope to gain from the course

(Karaali, 2015). Van Dyke et al.'s (2015) treatment group completed regular writing assignments about mathematical concepts in an attempt to influence grades, understanding, visual skills, and math attitudes. Student views and beliefs about writing in mathematics was also measured (Van Dyke et al., 2015). For instance, while studying rate of change relative to functions, students were asked to write an intuitive paper describing the meaning behind a function's average rate of change on an interval. Additionally, students had to write a subsequent theme paper answering the same intuitive question while also being directed to through the thinking process with questions asking whether a function can be increasing and have a decreasing rate of change or vice versa (i.e., decreasing with an increasing rate of change) (Van Dyke et al., 2015). In answering these questions, students were to give explanations for their answers along with representative examples. Further, students were asked to describe and distinguish between the changes of linear in contrast with exponential functions (Van Dyke et al., 2015).

Crocco et al. (2016) conducted an experimental study with three cohorts of students (English, Science, and Math). This review focuses solely on the Math cohort, which was inclusive of students enrolled in one of six sections of Remedial Algebra courses (3 control; 3 treatment). The treatment sections were taught using game-based learning (GBL). Whereas, the control sections employed traditional instruction, with no games. Students in the treatment group played games in which they were divided into teams and competed to solve problems using various quiz show techniques (Crocco et al., 2016). For example, one game consisted of teams being given coin-filled envelopes that had a word problem on its exterior for the team to translate algebraically and further solve. If the problem was translated and solved correctly, the teams were entitled to retain the coins. Post lesson, students were asked to reflect on and respond to a survey regarding their feelings toward the lesson (Crocco et al., 2016).

Ward et al. (2010) conducted their study with students enrolled in Mathematics Inquiry courses aimed at encouraging abstract and critical thinking. Zimmerman et al. (2011) conducted an experimental study with students enrolled in one of six developmental mathematics courses or one of twelve introductory college-level mathematics courses. The study's control group received conventional instruction while the treatment group received self-regulated learning (SRL) instruction driven by the following three stages: forethought, performance control, and self-reflection (Zimmerman et al., 2011). The SRL instruction focused on strengthening at-risk math students' academic feedback self-reflection skills through error correction modeled by instructors, guided reflection opportunities, and incentives for subsequent learning endeavors in order to improve academic feedback views/beliefs while, in turn, improving achievement as well as self-efficacy appraisals and self-evaluative views/beliefs (Zimmerman et al., 2011). Upon receipt of graded quizzes, students in the treatment group completed "self-reflection forms" to support in their correction of errors (Zimmerman et al., 2011, p. 146). More specifically, students were asked to contrast their self-efficacy and self-evaluative decisions on their original answers, describe the unsuccessful methods used, develop new successful strategies, express their confidence in solving a new similar problem, and finally solve comparable while stating the approaches and specific techniques used (Zimmerman et al., 2011). Further, collaborative efforts were made in holding in-class activities where groups of students worked together on erroneously completed problems in order to find and resolve mistakes while also learning to explain how various mathematical techniques apply and can be employed (Zimmerman et al., 2011).

Dewar et al. (2011) supplied students with a space to research collaboratively using a project-based approach with real-world applications. Meagher's (2012) study focused on students enrolled in a class where groups of three collaborated weekly on modules comprising four sections titled: (1) Basics; (2) Tutorial; (3) Give it a Try; and (4) Literacy. Students worked through the Basics and Tutorial sections individually to gain foundational understanding and then collaboratively within their groups on the Give it a Try and Literacy sections (Meagher, 2012).

Technology

Technological learning system, device (hardware such as calculators), and software (e.g., Wolfram Mathematica) usage in mathematics can enhance course delivery and support student learning. Some of the studies have aimed to shift college students' views and beliefs about mathematics with the aid of technology (Butler & Butler, 2011; Hagerty et al., 2010; Meagher, 2012; Wang et al., 2011). Butler and Butler (2011) made use of a learning management system to assist with course information and content delivery. Further, the authors employed constructivist-based interactive computer activities for learning support (Butler & Butler, 2011). Wang et al. (2011) also utilized computer interactivity by means of an interactive animation program for learning support. Hagerty et al. (2010) employed computer-based master learning through Assessment and Learning in Knowledge Spaces (ALEKS), an adaptive learning program. Meagher (2012) investigated students' notions of mathematics while learning in a self-directed course through an interactive textbook via CD with the assistance of Mathematica, a computer algebra system (CAS) that performs needed mathematical computations on the students' behalves.

Experiential Learning

Studies have aspired to shift college students' views and beliefs about mathematics via experiential learning (Collins & Winnington, 2010; Crocco et al., 2016; Dewar et al., 2011; Henrich et al., 2016). Experiential learning is essentially learning that takes place "by doing" (Lewis & Williams, 1994, 5) where the development of knowledge directly occurs through experience (Kolb & Kolb, 2017; Lewis & Williams, 1994). Collins and Winnington (2010) study included hands-on activities so that students could experience phenomena for themselves as opposed to using rule-based approach for instruction. For instance, in order for students to learn about mixture problems, students were given coins and placed into groups of two where they explored and considered various alternatives for satisfying specified conditions. Groups further explained their approaches to the class so that their peers could see that there may be multiple solutions to fit the indicated conditions. Crocco et al. (2016) implemented GBL pedagogy with experiential conditions such as team-based competition using authentic coins. Dewar et al. (2011) employed a project-based approach that offers civic engagement learning experiences in phases where students must investigate contextual information, strategize, evaluate according to conditions, synthesize, and present findings. Henrich et al. (2016) engaged students in community service activities where students worked in the local community to enrich learning experiences while gaining an improved awareness of civic matters.

Social Cognitive and Coping Strategies

According to social cognitive theory, an individual's action is influenced and reciprocated by contextual and environmental stimuli, and therefore focuses on evolving collaborative action between the individual and events taking place around them (Bandura, 1989). Huang and Mayer (2019) conducted an experimental study where approximately 51% of the participants were undergraduate students in a lab setting within an individual university whereas the remaining participants were recruited from an online recruiting platform (66% U.S.;

25% Europe; Mean Age 21.47; highest level of education – secondary diploma/certificate or undergraduate degree). All participants completed a self-paced online statistics lesson on Chebyshev's Theorem and the Empirical Rule (Huang & Mayer, 2019). However, Huang and Mayer's (2019) treatment group was given four strategies based on the four sources of self-efficacy from social cognitive theory, which was incorporated into a self-paced online statistics lesson with the aim of raising self-efficacy, lowering test anxiety, and thus improving students' learning outcomes. The strategies incorporated were as follows: example modeling for vicarious experience; mental practice for mastery experience; attributional feedback for social persuasion (effort-based as opposed to ability-based); math anxiety coping strategy for affective states (math anxiety coping messages). In contrast, the control group received no social cognitive or coping strategies (Huang & Mayer, 2019). Zimmerman et al.'s (2011) intervention involved the modeling of coping strategies to educate students on detection of errors and adjusting strategies while solving problems.

Self-Regulated Learning Instruction

Self-regulation is the mechanism through which one's ideas, emotions, and behaviors are intentionally monitored, reflected upon, and changed as appropriate for one's learning goals (Baumeister, Tice, & Vohs, 2018). It takes conscious effort, persistence, and resilience. Self-regulated learning is learning by way of self-regulatory practices such as establishing goals, developing plans, applying strategies, monitoring one's self, analyzing personal tasks, and controlling one's actions (Karaali, 2015; Schunk, 1990; Zimmerman et al., 2011). Karaali (2015) and Zimmerman et al. (2011) sought to influence college students' views and beliefs surrounding mathematics through self-regulated learning instruction. Students in Karaali's (2015) study completed metacognitive activities through which self-regulatory tasks were incorporated into their weekly routines (also noted as weekly recaps) where the goal was for the students to be mindful of what they learned, how they learned, and ways in which their learning could be strengthened. Zimmerman et al.'s (2011) treatment group received self-regulated learning instruction emphasizing detection of errors, adjustment of approach, correction from feedback, and additional self-reflection.

Inquiry Learning

Inquiry learning is an instructional methodology where students create their own knowledge through investigation and exploration. It is a method of seeking information for the purpose of obtaining additional information (Camenga, 2017). Butler and Butler (2011) and Ward et al. (2010) attempted to shift college students' views and beliefs related to mathematics via inquiry learning. Butler and Butler's (2011) treatment section participated in groups completing computer lab activities where students learned mathematical information with limited instructor guidance and were never given answers by instructors/graduate assistants during these activities. The students jointly developed, evaluated, and amended their own premises and conclusions (Butler & Butler, 2011). Ward et al.'s (2010) participants were enrolled in a course specifically designed with inquiry as its core attribute and focuses on student resourcefulness and investigation.

Constructs of Focus and Their Measures

Studies focused on ***math attitudes*** (Butler & Butler, 2011; Collins & Winnington, 2010; Crocco et al., 2016; Dewar et al., 2011; Hagerty et al., 2010; Hekimoglu & Kittrell, 2010; Henrich et al., 2016; Karaali, 2015; Meagher, 2012; Van Dyke et al., 2015; Ward et al., 2010), ***math confidence*** (Collins & Winnington, 2010; Crocco et al., 2016; Dewar et al., 2011; Hekimoglu & Kittrell, 2010; Henrich et al., 2016; Wang et al., 2011), ***self-efficacy*** (Hagerty et al., 2010; Hekimoglu & Kittrell, 2010; Henrich et al., 2016; Huang & Mayer, 2019; Meagher, 2012; Zimmerman et al., 2011), ***implicit theories of intelligence*** (Crocco et al., 2016; Hekimoglu & Kittrell, 2010; Mills & Mills, 2018), ***math anxiety*** (Crocco et al., 2016; Hekimoglu & Kittrell, 2010; Huang & Mayer, 2019; Karaali, 2015), ***math enjoyment*** (Butler & Butler, 2011; Crocco et al., 2016; Cunningham, 2010), ***math appreciation*** (Cunningham, 2010), ***conceptual understanding*** (Cunningham, 2010), ***engagement*** (Dewar et al., 2011; Hagerty et al., 2010; Karaali, 2015), ***metacognition*** (Karaali, 2015), ***self-evaluation*** (Zimmerman et al., 2011), ***performance*** (Dewar et al., 2011), and ***achievement*** (Wang et al., 2011). In this section, the measurement of constructs related to students' motivation (e.g., attitude, beliefs) are summarized.

The majority of studies measured the constructs using surveys. Specifically, math enjoyment and appreciation were measured solely using surveys (Butler & Butler, 2011; Crocco et al., 2016; Cunningham, 2010). However, other constructs (i.e., general and/or specific attitudes relative to mathematics, math confidence, self-efficacy, implicit theories of intelligence, math anxiety) were also commonly assessed using survey measures (Butler & Butler, 2011; Collins & Winnington, 2010; Crocco et al., 2016; Dewar et al., 2011; Hagerty et al., 2010; Henrich et al., 2016; Huang & Mayer, 2019; Mills & Mills, 2018; Van Dyke et al., 2015; Wang et al., 2011; Ward et al., 2010; Zimmerman et al., 2011). Notably, the majority of constructs in the literature were measured using a broad range of instruments that included quantitative or qualitative school/course evaluations (Collins & Winnington, 2010; Hekimoglu & Kittrell, 2010) and a host of qualitative measures including focus groups (Dewar et al., 2011; Henrich et al., 2016), interviews (Meagher, 2012), observations (Hagerty et al., 2010; Hekimoglu & Kittrell, 2010; Karaali, 2015; Meagher, 2012), interdisciplinary departmental discussions (Hagerty et al., 2010), semi-structured reflections (Hekimoglu & Kittrell, 2010), recaps and personal narratives (Karaali, 2015), and class discussions (Hekimoglu & Kittrell, 2010). See Table 4 for study identified construct definitions and further measure details.

Major Themes and Conclusions

Findings from this systematic literature review demonstrate some promising practices; major themes are discussed next.

Evidence for Making Mathematics Relevant to Students' Lives. Attempting to deepen students' views and beliefs about what math truly entails and cultivating quantitative problem-solving skills has been shown to positively influence enjoyment of mathematics and perceived relevance/value of mathematics with problem solving in other areas (Butler & Butler, 2011). Allowing students the opportunity to observe what mathematics truly entails coupled with real life exemplars of how mathematicians do and process mathematics can challenge negatively held notions about math to motivate students to learn and improve student's self-efficacy beliefs in mathematics (Hekimoglu & Kittrell, 2010). From this, students are able to observe that mathematicians are dedicated, passionate, patient, persistent, and resilient. Students are also able to realize that mathematics could be seen as an enjoyable, although challenging, task that can be even more gratifying with collaboration (Hekimoglu & Kittrell, 2010). Additionally, teaching with explanation of reasons behind rules, both verbally and pictorially, support understanding, enjoyment, and student value in subject matter (Cunningham, 2010). Furthermore, the inclusion of historical developments of mathematical concepts alone was shown to improve math attitudes (i.e., math is humanistic, variable with respect to the field and generational understanding, and relevant to the real life), mathematics self-efficacy, and student motivation (Hagerty et al., 2010). Including historical mathematical achievements, modern topics, and inquiry learning was shown to enrich student views and beliefs of math as creative and important in the world, but not necessarily with respect to their daily lives (Ward et al., 2010). However, further showing how an explicit topic relates to economic and social matters was shown to improve student attitudes about math as it relates to their personal lives (Ward et al., 2010). In addition, the inclusion of computer-based mastery learning, class discussions, group work, real-world problems, and highlighting the historical development of mathematical concepts coupled with less class lectures has been shown to increase in self-efficacy (Hagerty et al., 2010). Dewar et al.'s (2011) study on project-based experiential learning showed no difference between project-based and standard course students' awareness of math's usefulness in solving real-world problems, but project-based students were better able to connect their learning to the real world and were more aware of the usefulness of mathematics in general. Project-based students also showed improved confidence in ability to answer math questions or respond to mathematical scenarios (Dewar et al., 2011). Finally, the incorporation of a service learning component has been shown to significantly improve students' attitudes toward success in math, beliefs about math, confidence in their own math abilities, effectance motivation, and their view of the usefulness of math (Henrich et al. 2016). Students showed increased confidence in math skills due to reinforcement of prior knowledge, the discovery of novel approaches to solving problems, their instructor's engaging and enthusiastic teaching style, the course's relevance to their lives outside of school, and their engagement with and reflection on tutoring for service-learning; an intensified awareness of their tutoring efficacy via improved confidence in ability to effectively support K-12 students both academically and emotionally relative to math skills and school success (Henrich et al. 2016).

Mixed Results for the Use of Technology in Mathematics. Use of CAS has mixed results. However, due to the small sample size of the case study (3 participants), the following results should not be generalized. Depending on previous experience and learning disposition, students' math self-efficacy may be weakened with too much focus on CAS with little support from instructors (Meagher, 2012). Care should be taken with CAS use and training may help to alleviate unnecessary frustration (Meagher, 2012). Meagher's (2012) case study showed that one in three students felt more efficacious in understanding concepts while the other two felt less efficacious as their view of success in mathematics was more focused on computation over conceptual understanding. Similarly, in Wang et al.'s (2011) study, animation interactivity improved students' understanding and lower-level application, but did not improve student confidence. However, experiential learning and enhanced communication (i.e. math discourse; verbal and written descriptions of problem solving with pictures and manipulatives) was shown to produce positive changes in attitude toward mathematics with respect to interest, confidence, awareness of math relevance to school and life, regard for interdisciplinary learning, and notion of math as a subject as well as mathematics instruction (Collins & Winnington, 2010). Moreover, the use of game-based learning has been shown to yield greater enjoyment in a mathematics course and, in turn, significantly decreases anxiety for students low in confidence and high in anxiety (Crocco et al., 2016). The authors found that the more students enjoy lessons, the better they perform on corresponding assessment in deep learning (e.g., application, analysis, and evaluation; Crocco et al., 2016).

Generally Positive Results for Reflective Activities. Weekly metacognitive activities influence students' realization of potential deep-seated negative beliefs and may stimulate attempts to resolve them while also allowing for the acknowledgement of individual differences in viewing and learning mathematics (Karaali, 2015). The activities were shown to yield positive changes in student's attitude toward mathematics, higher value of mathematics, and greater recognition of its relevance to the real world. Additionally, the integration of social cognitive and anxiety coping strategies was shown to produce higher self-efficacy and lower task anxiety (Huang & Mayer, 2019). Further, self-efficacy strategies utilized in lessons improve learning outcomes by way of reducing task anxiety and elevating self-efficacy (Huang & Mayer, 2019). SRL instruction was not shown to influence students' self-efficacy and self-evaluation in terms of confidence in their ability to accurately solve math problems (Zimmerman et al., 2011). However, SRL instructed students were more calibrated with their task-specific self-efficacy beliefs prior to solving problems as well as their self-evaluative judgments after solving problems (Zimmerman et al., 2011).

Further, the integration of tutoring, class discussions, and written reflections induced the improvement of some students' perspectives into how previous unpleasant experiences with math influenced their existing math attitudes and additionally started an attempt to shift their preconceived notions about math in an effort to improve their attitude toward mathematics and serve as a more effective math tutor (Henrich et al. 2016). Nevertheless, a few students indicated their displeasure surrounding the need and resultant challenge of learning new problem solving techniques relative to math in order to efficiently tutor K-12 students (Henrich et al. 2016). Finally, professors can gain awareness of students' misconceptions regarding mathematics from reading student reflections (Van Dyke et al., 2015). Regular writing about mathematical concepts was not shown to have an influence on students' attitudes toward mathematics communication or mathematics in general, but was shown to negatively influence student attitudes toward assessment. Students who were the least diligent in writing showed a more negative attitude toward communicating in math than writers who were somewhat more diligent.

The most diligent writers had more negative attitudes about their ability to do math than least diligent writers and thus regular writing did not improve ability beliefs. Students generally felt that writing in math was inappropriate (Van Dyke et al., 2015).

Limitations and Gaps in the Literature

Many of the studies reviewed did not exclusively focus on the improvement of mathematical views or beliefs (Butler & Butler, 2011; Crocco et al., 2016; Cunningham, 2010; Dewar et al., 2011; Hagerty et al., 2010; Karaali, 2015; Meagher, 2012; Van Dyke et al., 2015; Wang et al., 2011; Zimmerman et al., 2011). Thus, less attention seems to be placed on understanding results pertaining explicitly to those views and beliefs. Studies focused solely on improving mathematical views and beliefs makes way for gaining more knowledge related to the aim. These studies would be better able to pinpoint more explicit evidence related to the techniques used and study outcomes.

Lack of pre-assessments and/or measure alignment to constructs. Some studies only measured math attitudes post intervention and compared the results of the experimental group versus the control group (Butler & Butler, 2011; Dewar et al., 2011; Hagerty et al., 2010). Dewar et al. (2011) did, however, measure pre- and post-confidence in ability to answer specific math problems as an indication of course content mastery. Crocco et al. (2016) claimed to generally assess 'at-risk' students. However, the initial 7-item survey used in the study tapped into a range of motivation constructs including attitudes, confidence, theories of intelligence, math anxiety, and enjoyment while the post-lesson survey were stated to measure students' enjoyment of the lesson (Crocco et al., 2016). Cunningham (2010) did not appear to have directly set out to measure students' mathematical views or beliefs as the authors only distributed an open-ended questionnaire asking if students found the study methods to be helpful and "why or why not."

Although Mills and Mills' (2018) mindset intervention centered on the promotion of growth mindset, change in students' implicit beliefs or attitudes relative to mathematics were not measured. The authors' attitude measure addressed students' overall attitudes or mindsets concerning intelligence as opposed to specific attitudes with respect to mathematics (Mills & Mills, 2018). Furthermore, the authors' only outcome assessment regarded students' grades with respect to their general implicit belief scores (Mills & Mills, 2018). While Collins and Winnington (2010) also measured change in students' attitudes, all study participants were pre-service elementary school teachers who may have been more easily influenced due to their reverence for education. Additionally, Hekimoglu and Kittrell (2010), Henrich et al. (2016), Karaali (2015), Meagher (2012), and Ward et al. (2010) assessed change in students' views and beliefs relative to mathematics. However, the magnitude of that change due to study approach used was not quantitatively measured as there was no control group used for comparison (Hekimoglu & Kittrell, 2010; Henrich et al., 2016; Karaali, 2015; Meagher, 2012; Ward et al., 2010). In particular, Hekimoglu and Kittrell (2010), Karaali (2015), and Meagher (2012) exclusively employed self-report qualitative measures. Huang & Mayer (2019) was successful in measuring change in students' self-efficacy beliefs, but was not able to determine which strategy or strategies were most effective as all strategies were delivered simultaneously. Consequently, evidence supporting the use of specific practices to influence students' mathematical views/beliefs is not strong in contemporary literature.

To address these gaps, future research is needed where positive views and beliefs with respect to mathematics coupled with a befitting work ethic can potentially aid in students achieving at their maximum level of ability. Future research involving college students should center on improving their mathematical views and beliefs. More attention should be placed on meticulously analyzing outcomes that are directly related to specific view and belief constructs relative to mathematics. These constructs should be measured both pre and post study approach in studies involving both treatment and non-treatment comparison groups to better identify changes due to the specific approach used. The studies should employ quantitative approaches to statistically determine the magnitude of that change.

Importance of conducting studies in classroom and community college settings. Wang et al. (2011) was able to measure change in student confidence. However, the intervention was carried out in a laboratory instead of a mathematics classroom (Wang et al., 2011). Huang & Mayer (2019) is the only other study included in this review conducted with students outside of the classroom setting. Future studies measuring change in students' mathematical views and beliefs should be conducted within a classroom setting so that practitioners are better able to adapt evidence-based practices according to their individual classroom needs. Studies conducted in classroom settings with students enrolled in mathematics classes are closer exemplifications of what practitioners can expect than non-traditional settings. It is also important to note the importance of student population. Although, a good number of the included studies were conducted in the community college setting, more studies should continue to explore this diverse population. Community colleges serve students from all walks of life who may or may not be interested in earning a four-year degree. Most are open-admission colleges and do not require competitive previous academic outcomes for acceptance. Thus, a higher number of students tend to enroll without apposite college-level mathematics skills and may have many negative views of and beliefs about mathematics, which can be a deterrent to academic success in the domain of mathematics.

Affordances of using quantitative, qualitative, and mixed methods approaches. As noted in the "Study Design" section, the studies reviewed used a range of methods. There are advantages to using quantitative methods for studies. Quantitative measures present objective results with very little subjective interpretation by study authors. The statistical information collected has the potential to be extremely accurate and generalizable depending on population and context. More studies should measure change in attitude due to study approach in order to establish greater evidence that particular practices do indeed influence student attitudes, in terms of views and beliefs, relative to mathematics. However, there are disadvantages to solely using quantitative methods. Large sample sizes are typically necessary to achieve reliable results. Moreover, surveys utilized in quantitative research have predefined responses, which limit participants' response options.

There are also advantages to using qualitative methods to explore views and beliefs relative to mathematics. It requires a relatively small sample size to reach saturation (i.e., the stage at which sufficient data has been gathered prior to redundancy). Additionally, the use of qualitative methods allows for researchers to get a deep understanding of views and beliefs through: probing with open-ended questioning techniques; observing behaviors and reactions; being flexible and resourceful as new information is provided. Furthermore, it permits participants to be open and honest about their feelings while offering them the opportunity to expand upon their thoughts with much needed information that may not have first occurred to the researcher. On the other hand, qualitative methods alone are not able to offer statistical data and may result in biased reporting of results depending on the researcher's subjective stance or interpretation of information. Future research should utilize qualitative methodologies specifically to gain an understanding of participants' thoughts relative to study approach in support of objective quantitative results and further efforts to improve student views and beliefs in relation to mathematics.

The use of both qualitative and quantitative methodologies provides a more comprehensive picture of students' views and beliefs relative to mathematics. However, mixed methods studies may present challenges to researchers as they are more time-consuming and thus prevent practitioners from getting a head start on putting findings into practice. Therefore, future research should conduct studies attempting to influence students' views and beliefs with respect to mathematics using both quantitative and qualitative methods in a timely fashion where ample emphasis can be placed on each method. This can be done by intentionally focusing on one method (quantitative or qualitative), collecting the data, finding results, and reporting them in one study. Once completed, the researcher should then follow-up using the alternate method to further explain, support, or counter claims from the first study to further enhance the literature available to practitioners.

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Appendix

Figure 1

PRISMA Diagram

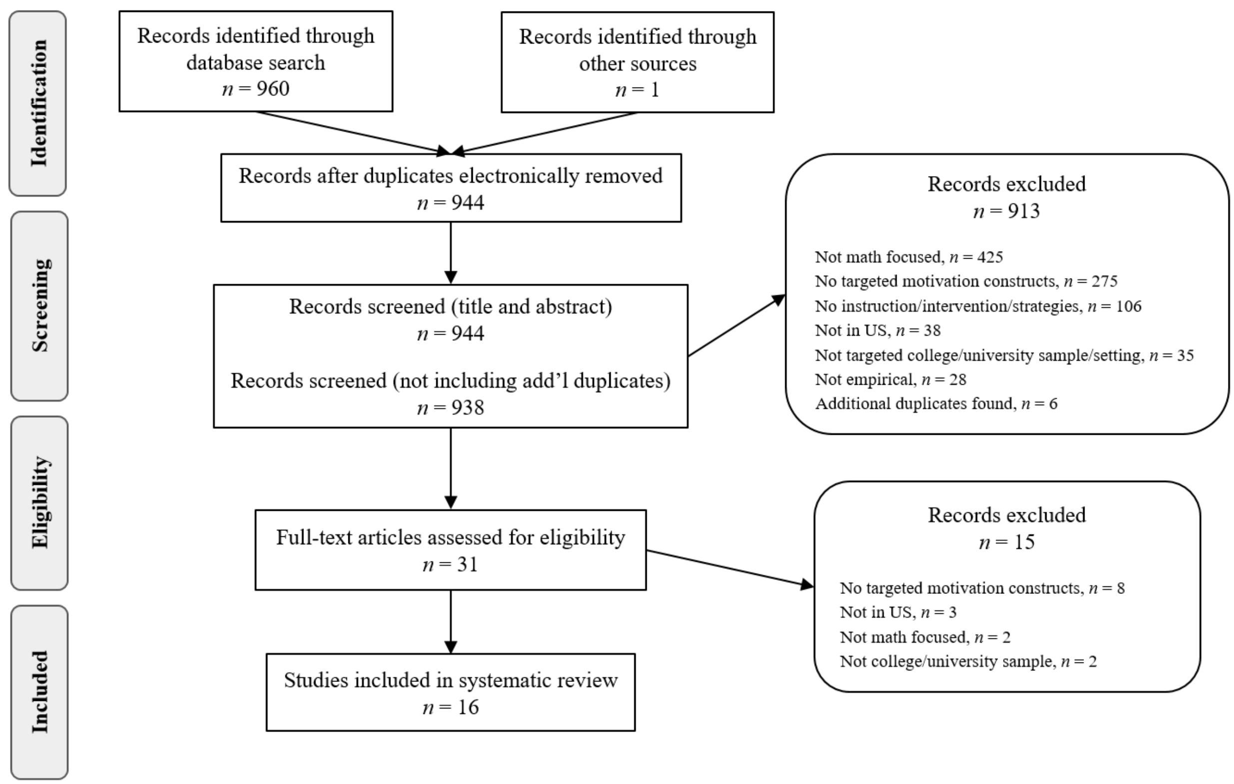


Table 1

Study Characteristics

Study	Student *N*	Student Population [a]	Study Components	Pedagogical/ Theoretical Framework [b]	Motivation Construct Examined	Method [c]	Instruments (related to data collection and/or study approach)	Analysis
Butler & Butler (2011)	84	Pub U	Math Support, Humanizing Math, Discourse, Technology	CT	Attitudes, Performance	Quan	LMS and reflection; Pre- and post test; mean scores from Application Recitation, homework, quizzes, exams, participation, and overall course; exam questions specific to Application Recitation material; Attitudes Toward Mathematics Inventory (ATMI)	Paired samples t-test and ANCOVA; One-way ANOVA
Collins & Winnington (2010)	156	CC	Math Support, Humanizing Math, Discourse, Experiential Learning	A	Anxiety, Attitudes, Confidence	Quan	30-item Student Attitudinal Survey	Factor analysis
Crocco, Offenholley, & Hernandez (2016)	440 [1]	CC	Discourse, Experiential Learning	GBL	Anxiety, Confidence, Enjoyment	Quan	Pre-attitude survey; Post-lesson survey and post-lesson quiz	Correlation analysis
Cunningham (2010)	19	CC	Math Support, Humanizing Math	A	Appreciation, Conceptual Understanding, Enjoyment	Qual	Questionnaire	Quotes/Themes
Dewar, Larson, & Zachariah (2011)	91	Priv U	Math Support, Humanizing Math, Discourse, Experiential Learning	CLT	Awareness/ Attitude (Confidence, Relevance, Usefulness), Engagement, Performance	M	Focus groups; Likert surveys; 9-problem multiple-choice test (pre and post); Knowledge survey (pre and post)	Not explicitly mentioned

Hagerty, Smith, & Goodwin (2010)	n/a [2]	Pub U	Math Support, Humanizing Math, Discourse, Technology	BT, DM, SCT, STLT, VCDT	Attitudes, Engagement, Self-Efficacy	M	Survey; Observation; Discussion with other departments; Grades; Standardized test scores; Attendance rates	Not explicitly mentioned – "Cyclical approach to dynamic change"
Hekimoglu & Kittrell (2010)	295	CC	Humanizing Math, Discourse	AT, CDT, EM, GPFP, SCT	Anxiety, Attitudes, Confidence, Implicit Belief, Self-Efficacy	Qual	Documentary and reflection paper; Semi-structured reflections with prompts; Class discussions; End-of-course evaluations; Classroom observations	Grounded Theory
Henrich, Sloughter, Anderson, & Bahuaud (2016)	78	Priv U	Humanizing Math, Discourse, Experiential Learning	AL, SL	Attitudes (Beliefs, Confidence, Effectance Motivation, Success, Usefulness), Self-Efficacy	M	60-item five-point Likert scale adapted from the Fennema–Sherman scales (pre and post); Audio-recorded semi-structured focus group interviews	Differences between pre- and post-survey combined scores obtained; Significance and magnitude of improvements assessed: 95% confidence intervals constructed for mean improvement per scale; Two-tailed t-tests; Independent transcriptionist transcribed audio tapes verbatim; Transcript analysis using a constant-comparison method
Huang & Mayer (2019)	142	U and ORP	Social Cognitive and Coping Strategies	SCCT	Anxiety, Self-Efficacy	Quan	Practice activity; Posttests (6-item retention, 11-item transfer); 100-point self-efficacy rating scale (pre and post); 1-item, 9-point Likert task anxiety scale; Demographic survey	Chi-square test and independent samples t-tests; Three-way 2 by 2 by 2 ANOVA; Pearson product-moment bivariate correlations; Multiple-group path analysis; Serial multiple mediator

								model analysis
Karaali (2015)	n/a	Priv C	Discourse, Self-Regulated Learning Instruction	ARCS, MCT, MT	Anxiety, Attitude (Interest, Relevance, Usefulness, Value), Engagement, Metacognition	Qual	Observations; Feedback forms	Not explicitly mentioned
Meagher (2012)	3	U	Math Support, Discourse, Technology	DT	Attitude, Self-Efficacy	Qual	Observations; Audio tapes; Video captures of computer screens; Interviews; Module responses	Interviews, Field-notes; Observations; Document analysis; Coding; Transcription
Mills & Mills (2018)	155	C	Humanizing Math	ITI	Implicit Theories	Quan	Theories of Intelligence Scale - mindset questionnaire; Final grades; Retention (Following semester enrollment)	Correlation analysis; Independent-samples t-tests
Van Dyke, Malloy, & Stallings (2015)	97	Priv U	Math Support, Discourse	VCDT	Attitude (Ability, Assessment, Communication)	M	Graded writing assignments (an initial intuitive piece and a subsequent theme); Visual skills assessment (pre and post); Attitude surveys (closed and open-ended)	Writing rubrics; Mixed-model (mixed-effects) regression; Qualitative process of analysis not explicitly described
Wang, Vaughn, & Liu (2011)	123	U	Math Support, Technology	IT, AKCT, GRM	Achievement, Confidence	M	20-item achievement and confidence tests (pre and post; multiple-choice with confidence rating for each item); 5-point scale program perception survey: Survey for Student Learning and Assessment (post); Web log	Multivariate analysis of variance (MANOVA); Univariate analyses of variance (ANOVA); Post hoc tests for group comparisons
Ward, Campbell, Goodloe, Miller, Kleja, Kombe, & Torres (2010)	72	Priv U	Math Support, Humanizing Math, Discourse,	A	Attitudes (Attitude, Creativeness, Usefulness)	M	Grades (Pre- and post-course tests); Pre- and post-course survey (Likert-type portion: adaptation of Indicators of Quality in Undergraduate Mathematics;	Factor analysis and paired difference tests; Theme analysis and coding; Frequency analysis of codes (two-

			Inquiry Learning				Open-ended portion)	sample tests for proportions) to compare pre and post; Nonparametric Friedman rank test for paired data
Zimmerman, Moylan, Hudesman, White, & Flugman (2011)	496	Pub TC	Discourse, Self-Regulated Learning Instruction	SCT, SRL	Self-Efficacy, Self-Evaluation	M	Computer Adaptive Placement Assessment and Support System - (COMPASS) Mathematics Test (ACT); Math periodic examinations (3 cumulative) with Math exam self-efficacy scale (confidence rated prior to each item) and Math exam self-evaluation scale (confidence rated after each solution); Math final examinations; COMPASS posttest exams; Self-reflection form	Cronbach's alpha for both the self-efficacy and the self-evaluation scale reliability; Calibration analyses for both self-efficacy bias and self-evaluation bias; Single factor ANOVAs; Two group multivariate analyses of covariance (MANCOVA); Univariate F-tests

Key: [a] C = College, CC = Community College, ORP = Online Recruiting Platform, Priv C = Private College, Priv U = Private University, Pub TC = Public Technical University, Pub U = Public University, U = University; [b] A = Atheoretical, AKCT = Anderson and Krathwohl's Cognitive Taxonomy, AL = Active Learning, ARCS = The ARCS Model of Motivation, AT = Attribution Theory, BT = Bloom's Taxonomy, CDT = Cognitive Dissonance Theory, CLT = Collaborative Learning Theory, CT = Constructivist Theory, DM = Driscoll's Model of Systematic and Recursive Change, DT = The Didactic Triangle, EM = Theory of Episodic Memory, GBL = Theory of Game-Based Learning, GPFP = George Polya's First Principle of Teaching Mathematics, GRM = Garfield's Reasoning Model, IT = Interactivity Theory, ITI = Implicit Theories of Intelligence, MCT = Metacognitive Theory, MT = Motivation Theory, SCCT = Social Cognitive Career Theory, SCT = Social Cognitive Theory, SL = Service Learning, SRL = Theory of Self-Regulated Learning, STLT = Silver's Teaching and Learning Theory, VCDT = Vygotsky's Cognitive Development Theories; [c] Qual = Qualitative, Quan = Quantitative, M = Mixed

Notes.
[1] Includes English, Math, and Science participants. Subsample sizes not indicated.
[2] Sample size available in previous article as N = 251 (Hagerty & Smith, 2005).

Table 2

Theoretical Frameworks

Category	Pedagogical/ Theoretical Framework	Study
Motivation Theories	Attribution Theory	Hekimoglu & Kittrell (2010)
	Implicit Theories of Intelligence	Huang & Mayer (2019) Mills & Mills (2018)
	Motivation Theory	Karaali (2015)
	Self-Regulated Learning Theory	Zimmerman, Moylan, Hudesman, White, & Flugman (2011)
	The ARCS Model of Motivation	Karaali (2015)
Cognitive Theories	Anderson and Krathwohl's Cognitive Taxonomy	Wang, Vaughn, & Liu (2011)
	Cognitive Dissonance Theory	Hekimoglu & Kittrell (2010)
	Garfield's Reasoning Model	Wang, Vaughn, & Liu (2011)
	Metacognitive Theory	Karaali (2015)
	Social Cognitive Theory	Hagerty, Smith, & Goodwin (2010) Hekimoglu & Kittrell (2010) Zimmerman, Moylan, Hudesman, White, & Flugman (2011)
	Social Cognitive Career Theory	Huang & Mayer (2019)
	Theory of Episodic Memory	Hekimoglu & Kittrell (2010)
	Vygotsky's Cognitive Development Theories	Hagerty, Smith, & Goodwin (2010) Van Dyke, Malloy, & Stallings (2015)
Teaching and Learning Models/Theories	Active Learning	Henrich, Sloughter, Anderson, & Bahuaud (2016)
	Bloom's Taxonomy	Hagerty, Smith, & Goodwin (2010)

	Collaborative Learning Theory	Dewar, Larson, & Zachariah (2011)
	Constructivist Theory	Butler & Butler (2011)
	Driscoll's Model of Systematic and Recursive Change	Hagerty, Smith, & Goodwin (2010)
	Game-Based Learning	Crocco, Offenholley, & Hernandez (2016)
	George Polya's First Principle of Teaching Mathematics	Hekimoglu & Kittrell (2010)
	Interactivity Theory	Wang, Vaughn, & Liu (2011)
	Service Learning	Henrich, Sloughter, Anderson, & Bahuaud (2016)
	Silver's Teaching and Learning Theory	Hagerty, Smith, & Goodwin (2010)
	The Didactic Triangle	Meagher (2012)
Atheoretical	n/a	Collins & Winnington (2010) Cunningham (2010) Ward, Campbell, Goodloe, Miller, Kleja, Kombe, & Torres (2010)

Table 3

Major Components of Study Approaches

Study	Math Support for Conceptual Understanding and Skill Development	Humanizing Math	Discourse	Technology	Experiential Learning	Social Cognitive and Coping Strategies	Self-Regulated Learning Instruction	Inquiry Learning
Butler & Butler (2011)	X	X	X	X				X
Collins & Winnington (2010)	X	X	X		X			
Crocco, Offenholley, & Hernandez (2016)			X		X			
Cunningham (2010)	X							
Dewar, Larson, & Zachariah (2011)	X	X	X		X			
Hagerty, Smith, & Goodwin (2010)	X	X	X	X				
Hekimoglu & Kittrell (2010)		X	X					
Henrich, Sloughter, Anderson, & Bahuaud (2016)	X	X	X		X			X
Huang & Mayer (2019)						X		
Karaali (2015)			X				X	
Meagher (2012)	X		X	X				
Mills & Mills (2018)		X	X					
Van Dyke, Malloy, & Stallings (2015)	X		X					
Wang, Vaughn, & Liu (2011)	X			X				
Ward, Campbell, Goodloe, Miller, Kleja, Kombe, & Torres (2010)	X	X	X					X
Zimmerman, Moylan, Hudesman, White, & Flugman (2011)			X			X	X	

Table 4

Definitions and Measures of Views, Beliefs, and Related Emotions

Study	**Math Attitudes** Definition: "a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activity, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless" (Neale, 1969, p. 632)	**Math Confidence** (domain general) Definition: "a student's perception of their ability to attain good results and their assurance that they can handle difficulties in mathematics" (Pierce et al., 2007, p. 290)	**Self-Efficacy** (domain- or task-specific) Definition: "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391; Pajares & Miller, 1994, p. 193)	**Implicit Theory of Intelligence** Definition: "the belief that intelligence can or cannot be developed through one's efforts" (Dweck, 2002, p. 71)	**Math Anxiety** Definition: "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p.551)	**Enjoyment** Definition: "a positive affective state that occurs when a person engages in an experience or activity that satisfies a desire, goal, or need, including but not limited to the need for pleasure, meaning, security, safety, sustenance, esteem, belongingness, or love" (Smith et al., 2014) Enjoyment is a positive emotion "directly linked to achievement activities or achievement outcomes." (Pekrun et al., 2011, p. 37)	**Appreciation/Value** Definition: Appreciation – "cognitive processes (and may include emotional processes as well) whereby one recognizes the value or importance of a stimulus or event, construes, appraises, or perceives the stimulus or event as positive or meaningful, and possibly feels grateful or thankful in response to perceived benefits" (Tucker, 2007, p. 794) "The perceived value of mathematics may lead students to develop their mathematical skills and abilities, or students may come to value those skills and tasks they

							perform well." (Meece et al., 1990, p. 68)
Butler & Butler (2011)	**Definition:** n/a **Measure:** Attitudes Toward Mathematics Inventory (ATMI; Tapia & Marsh 2002; e.g., *"Mathematics is a very worthwhile and necessary subject" and "Mathematics is one of my most dreaded subjects."*)					**Definition:** n/a **Measure:** Embedded within the ATMI (e.g., *"I have usually enjoyed studying mathematics in school."*)	
Collins & Winnington (2010)	**Definition:** n/a **Measure:** Pre- and post-Mathematics Across the Community College Curriculum (MAC^3) Evaluator/Survey (interest, confidence, awareness of mathematics' connection to other areas of school and life, appreciation for interdisciplinary learning, and concept of math - understanding of mathematics as an intellectual	**Definition:** n/a **Measure:** Embedded within the MAC^3 and regular evaluation surveys					

	structure); "Regular school evaluations" (p. 49)						
Crocco, Offenholley, & Hernandez (2016)	**Definition:** n/a **Survey Item(s):** Initial survey (difficulty, grades, value, enjoyment, ability to do the material, learning preference; e.g., *"I have always found math class difficult."*)	**Definition:** n/a **Measure:** Embedded within the initial survey (confidence in ability to complete subject matter tasks)		**Definition:** n/a **Survey Item(s):** Embedded within the initial survey (e.g., *"People are either good at math or they're not; practice doesn't make a lot of difference."*)	**Definition:** n/a **Survey Item(s):** Embedded within the initial survey (e.g., *"I am worried about how well I am going to do in this math class."*)	**Definition:** n/a **Survey Item(s):** Initial survey (e.g., *"I enjoy math classes."*); Post-lesson survey (e.g., *"I enjoyed this math class."*)	
Cunningham (2010)						**Definition:** n/a **Measure:** Open-ended, end-of-semester questionnaire (Given worked-out examples, students replied to the following: *"Did you find this kind of explanation helpful? Why or why not?"*)	**Definition:** n/a **Measure:** Open-ended, end-of-semester questionnaire (Given worked-out examples, students replied to the following: *"Did you find this type of explanation helpful? Why or why not?"*)
Dewar, Larson, & Zachariah (2011)	**Definition:** Awareness/Attitude – "Students will be aware of the usefulness of mathematics in addressing real world problems, and will have	**Definition:** n/a **Measure:** Pre- and Post-Knowledge survey (confidence rating of ability to solve specified mathematics					

	greater confidence in using mathematics." (p. 608) **Measure:** Focus groups; Self-report Likert survey (e.g., *"The project helped me connect my classroom learning to the real world."*)	problems; Nuhfer & Knipp, 2003)					
Hagerty, Smith, & Goodwin (2010)	**Definition:** (e.g., *''I don't understand why math is required, as I will never need math!''*, p. 425) **Measure:** Survey; Observation; Faculty discussion with other departments		**Definition:** students' "belief in their ability to accomplish a task" (p. 425) **Measure:** Surveys				
Hekimoglu & Kittrell (2010)	**Definition:** n/a **Measure:** Semi-structured reflections with prompts; Class discussions; End-of-course evaluations; Classroom observations	**Definition:** students' belief in themselves to learn mathematics (p. 317) **Measure:** Semi-structured reflections with prompts; Class discussions; End-of-course evaluations;	**Definition:** "students' attitudes and conceptions about their capabilities and skills that are believed to be true" (p. 299) **Measure:** Semi-structured reflections with prompts; Class discussions; End-of-	**Definition:** students' conception "of their mathematical ability as amenable to change or augmentation through effort" vs. the belief "that their mathematical ability is fixed" (p. 316)	**Definition:** "a state commonly described as approaching mathematics with trepidation due to related feelings of weakness, dependency, and frustration" (p. 301) **Measure:** Semi-structured		

		Classroom observations	course evaluations; Classroom observations	**Measure:** Semi-structured reflections with prompts; Class discussions; End-of-course evaluations; Classroom observations	reflections with prompts; Class discussions; End-of-course evaluations; Classroom observations		
Henrich, Sloughter, Anderson, & Bahuaud (2016)	**Definition:** "attitudes toward success in math, beliefs about math, confidence in one's mathematical abilities, effectance motivation, and usefulness of math" (p. 792) **Measure:** Pre- and post-surveys (adaptation of the Fennema-Sherman scales; Fennema & Sherman, 1976; e.g., *"Students who understand the math they have studied will be able to solve any assigned problem in five minutes or less."*, p. 793); Focus group interviews	**Definition:** n/a **Measure:** Embedded within attitudes measure (confidence in one's mathematical abilities; e.g., *"I can get good grades in mathematics."*, p. 793)	**Definition:** n/a **Measure:** Focus group interviews				
Huang & Mayer (2019)			**Definition:** students' confidence		**Definition:** two-dimensional – "the affective dimension (unpleasant feelings such as		

			performing tasks (p. 1020) **Measure:** Pre- and post-self-efficacy rating scale (Bandura, 2006; Pajares et al., 2001)		fear and apprehension) and the cognitive dimension (worry concerning performance)" (p. 1010) **Measure:** Likert task anxiety scale		
Karaali (2015)	**Definition:** n/a **Measure:** Weekly recaps and end-of-semester personal narrative (e.g., *"What are your thoughts and feelings about math today?"*, p. 445)				**Definition:** n/a **Measure:** Observation; Weekly recaps and end-of-semester personal narrative (e.g., *"What are your anxieties associated with this course?"*, p. 444)		
Meagher (2012)	**Definition:** students' "perceptions of the role of technology in their learning" and their "conceptions of mathematics as a subject" as well as their "beliefs about the nature of mathematics" (p. 3) **Measure:** Observations; Field-		**Definition:** "belief in oneself of competence and capability in a given domain" (p. 9) **Measure:** Observations; Field-notes; Interviews; Document analysis				

	notes; Interviews; Document analysis						
Mills & Mills (2018)				**Definition:** fixed mindset – students' belief that "intelligence is innate. You are either smart or not smart." (p. 1046); growth mindset – students' belief that "intelligence can be developed, nurtured and cultivated. They believe that anyone can improve his or her skills and abilities. **Measure:** Theories of Intelligence Scale – mindset questionnaire (general attitude regarding academic effort; Dweck, 2000)			
Van Dyke, Malloy, & Stallings (2015)	**Definition:** students' "attitudes about mathematics as a discipline, … communication in the mathematics classroom, … assessment, … and mathematical ability" (pp. 228-229)						

	Measure: Pre- and Post-attitude survey (Tascione, 1995) with additional item: *“I enjoy doing math”*						
Wang, Vaughn, & Liu (2011)		**Definition:** n/a **Measure:** achievement and confidence tests (pre and post; multiple-choice with confidence rating for each item)					
Ward, Campbell, Goodloe, Miller, Kleja, Kombe, & Torres (2010)	**Definition:** students’ “opinion of mathematics as it relates to them personally” (p. 186; e.g., *“The ability to succeed in mathematics is primarily an inherited trait. You are either gifted for it or not. Most people aren’t. I’m not.”*, p. 184) **Measure:** Pre- and post-course survey (Likert-type portion: adaptation of Indicators of Quality in						

	undergraduate Mathematics - Travers et al., 2003; e.g., *"Mathematics is harder for me than for most people."*, p. 200; Open-ended portion)						
Zimmerman, Moylan, Hudesman, White, & Flugman (2011)		**Definition:** Self-evaluative judgments: *"comparing one's performance to a standard"* (p. 143) **Measure:** Math exam self-evaluation scale (periodic cumulative examinations with confidence rated after each solution; e.g., *"How confident are you that you solved this math problem correctly?"*, p. 148)	**Definition:** "one's capabilities to organize and implement actions necessary to attain designated performance of skill" (p. 142) **Measure:** Math exam self-efficacy scale (periodic cumulative examinations with confidence rated prior to each item; e.g., *"How confident are you about solving this math problem correctly?"*, p. 147)				

Mixed Method Study

A Multiple Case Mixed Methods Exploration of the Experiences That Underpin Community College Students' Attitudes, Self-Efficacy, and Values in Mathematics

Abstract

Mathematics is a subject that is particularly important due to its relevance to our daily lives. It is a general requirement throughout schooling from preschool to the postsecondary level. Unfortunately, many students openly declare negative attitudes and beliefs toward math, as well as low valuing of math in their personal and academic lives. These in turn, negatively influence students' achievement related behaviors and outcomes, such as lack of students' willingness to put forth effort toward learning information. This research project further explored and sought to explain college students' attitudes, self-efficacy beliefs, and values relative to mathematics. A multiple case study mixed-method explanatory sequential design was employed in which community college students' attitudes, self-efficacy, and values in mathematics were quantitatively measured and followed by qualitative exploration. Quantitative survey data was collected and analyzed to identify patterns in student's attitudes, self-efficacy, and values with respect to mathematics across gender and race. Qualitative interviews were then conducted as a follow-up to the survey with a purposefully sampled subset of community college students that represent membership in the groups identified according to the patterns in the quantitative results. These interviews provided in-depth descriptions of community college students' current math attitudes, beliefs, and values, including detailed information of past and current experiences they perceive to influence their attitudes, beliefs, and values toward mathematics. Students' beliefs about how educators can support and improve their attitudes, beliefs, and values surrounding mathematics were also provided.

Keywords: attitude, belief, community college, integrative approach, math, mixed method, motivation, self-efficacy, value, view

A Multiple Case Mixed Methods Exploration of the Experiences That Underpin Community College Students' Attitudes, Self-Efficacy, and Values in Mathematics

Mathematics is a universally vital topic that is used in almost every aspect of life. Calculating the area or perimeter to position household objects, searching for discounts while shopping, measuring while cooking, managing money and spending, estimating the possibility of profit or loss, and much more all require mathematics. Regardless of one's place of origin, language, culture, learning methodologies, or problem-solving strategies, there is usually only one set of resultant facts when it comes to mathematics. More broadly, math helps to teach the mind to think logically and identify patterns in order to make wise choices. Accordingly, it is a main criterion subject emphasized from pre-kindergarten to grade 12 (National Council of Teachers of Mathematics, 2020). It is also a common general undergraduate curriculum requirement (Burdman, 2015; Hart Research Associates, 2016). That is, many students (inclusive of non-math majors) must be able to satisfy a specific level of degree-related math requirements in order to attain their desired degree. Taking these factors into account, mathematical skills are essential in both life and education.

Despite the global relevance of mathematics, many Americans openly profess their dislike for it and claim that it is difficult to grasp. For example, according to a poll of 1,000 adults, mathematics was the subject that 37% of the respondents reported they "hated the most" (Ipsos-Public Affairs, 2005). This was more than double the percentage of respondents who reported any other subjects as their most hated. According to a second poll of 1,085 parents and 810 teachers of kindergarten through 12th grade students, 40% of parents and 67% of teachers indicated that mathematics was the subject in which their students needed the greatest help to finish homework (Knowledge Networks, 2006). These percentages were far higher than those for any other subject, nearly triple for parent respondents and roughly six times larger for teachers. In addition, a Gallup poll of 1,028 teenagers in the United States indicated that math was reported as the most difficult subject for the largest percentage of respondents (37%; Saad, 2005). Taken together, these surveys show that mathematics is regarded as a difficult and despised subject for many students at various levels of education.

The abovementioned pronouncements reveal profound unfavorable attitudes, beliefs, and values of mathematics. They are negative declarations that may harm students' motivation and achievement in a mathematics class. In particular, such decrees represent personal competence beliefs that may become apparent in students' mathematics achievement-related behaviors and outcomes. It has been extensively shown in the literature that students' beliefs about their mathematical ability are strong indicators of their performance (Aiken, 1972; Chen & Zimmerman, 2007; Muenks et al., 2018; Wigfield & Cambria, 2010). Hence, developing more positive views about mathematics (i.e., higher confidence in mathematics) is likely to help students reach their maximum level of achievement potential, regardless of their previous dispositions toward the subject.

Considering the aforementioned trends, it is comprehensible that many students enter college unprepared for college-level mathematics courses (Madison et al., 2015; McCormick & Lucas, 2011). Consequently, the need for mathematics remediation in post-secondary education is growing (Abraham et al., 2014). Students identified as not being ready for college mathematics may be placed into remedial courses that do not count toward a college degree or remedial and must pass them before they can enroll into a college mathematics course. Other students deemed underprepared for college mathematics may be mandated to take co-requisite remedial courses alongside the corresponding college-level mathematics course. Not only can this introduce additional financial strain and delay degree completion, it has the potential to impact students' self-judgments in mathematics. Students who have previously experienced mathematical inadequacy are more likely to be apprehensive about mathematical tasks and question their own math ability (Shodahl & Diers, 1984). Therefore, it is critical to counteract the detrimental influence that prior mathematical experiences may have in shaping undesirable attitudes, beliefs, and values regarding mathematics at the college level.

Cultivating students' belief in themselves relative to confidence in mathematics has numerous benefits inclusive of improved learning behaviors, achievement, and probability that they will persist in school (Aiken, 1972; Wu & Fan, 2017). Healthy competence beliefs, in particular, are vital to student achievement because they have a major influence on whether or not students are willing to put in the effort to learn new things. Research has shown that academic *self-efficacy*, a competence belief focused on an individual's perception of or level of confidence in his or her abilities to carry out a task (Bandura, 1982; Bandura, 1986; Pajares & Miller, 1994; Zimmerman, 2000), is associated with a variety of motivational variables and predicts both achievement and subsequent achievement-related behaviors (Barrows et al., 2013; Davis et al., 2011; Johnson & O'Keeffe, 2016; Larson et al., 2015; Muenks et al., 2018; Muenks et al., 2017; Parks-Stamm et al., 2010; Roick & Ringeisen, 2018; Villavicencio & Bernardo, 2016; Wu & Fan, 2017). As a result, individual differences in student self-efficacy can have a major impact on how well they learn and perform.

Much information is available in the literature regarding college students' individual difference impact on course choice, achievement, and achievement-related behaviors in mathematics. Despite earning higher grades in mathematics on average than males (Douglas & Salzman, 2020), females tend to enroll in fewer math courses during their college career and choose math-related majors at a lower rate than males (Douglas & Salzman, 2020). A meta-analysis conducted by Hyde et al. (1990) concluded that, while the differences are minor, females have a more unfavorable attitude and competence belief regarding math than males. This is assumed to be the case due to math being socially viewed as a male domain (Beasley & Fischer, 2012; Hyde et al., 1990).

Stereotypes are also tied to race, which tend to cause race-gender interaction effects (Beasley & Fischer, 2012). According to the intersectionality framework, originally conceptualized by Black feminist theories proposed that an individuals' experiences of systematic discrimination and oppression are influenced by the interconnection of varying social identities (Crenshaw, 1989). Specifically, Crenshaw (1989) asserts that gender and race-based interactions operate more intricately than they would as separate entities (Hsieh et al., 2021). For example, females are more likely to have lower perceived success expectations than males in Science, Technology, Engineering, and Mathematics (STEM) while Asians are strongly linked to the field and perceived to have higher success outcomes with African Americans having the opposite stereotype (Beasley & Fischer, 2012). Thus, Asian females have varied achievement-related outcomes as academic performance is influenced by the stereotype that is activated while African American or Latinx females are likely to experience more negative effects due to multiple marginalization (Beasley & Fischer, 2012).

Hyde et al. (1990) indicated that, at the time of their research, there were not enough studies to analyze differences in attitudes, beliefs, and values with respect to students' ethnicity and noted the need for this data. However, Hsieh et al. (2021) assert that White males tend to have higher motivational beliefs in math than White females during their youth. The authors note that White and Asian American youth have higher achievement scores on standardized tests in math and have greater expectancies with respect to the subject in comparison to their African American and Latinx counterparts (Hsieh et al., 2021). Very little evidence exists with respect to college students' demographic impact on students' attitudes, self-efficacy, and values with respect to mathematics as a domain at the college level.

Having a deeper understanding of students' attitudes, self-efficacy, and values will enable educators to adjust their pedagogies for the ever-changing student populations for whom we are responsible. Further, acknowledging the varying experiences of students with differing social identities in combination with the components that make up their identity allows for a more profound understanding than examining according to monolithic classifications (Jang, 2018). It is our obligation to engage and embolden all students to realize that mathematics is a meaningful part of their lives as opposed to a "road block" or an unimportant stepping-stone standing in between them and graduation. Very little qualitative research has been conducted on these topics. Therefore, this study was conducted to more deeply understand what math attitudes, self-efficacy beliefs, and values look like for community college students within varying social identity categories. Having students describe their perceptions of mathematics as a subject along with their perceived ability to succeed in it will enable educators to identify possible supports and hindrances to their success. With this knowledge, educators can be more empathetic to student needs and better able to assist in achieving success in mathematics via mindset, support, and encouragement.

Review of Theoretical Frameworks and Empirical Literature

This study drew together key motivation frameworks using an integrative approach (Linnenbrink-Garcia & Wormington, 2019) including social cognitive theory, attitude theories, and expectancy value theory. An integrative approach was used to better understand how complex motivational factors work together to influence students' attitudes, self-efficacy beliefs, and values relative to mathematics.

Attitudes, beliefs, and values are formed according to societal or cultural norms, observation, and/or experience and further inform individuals' situational emotional and behavioral responses. Each construct was represented separately with their own explicit construct theories within educational psychology literature. Student attitudes are reviewed with an emphasis on students' liking or disliking of mathematics. Ability beliefs are reviewed with a focus on self-efficacy using social cognitive theory. Finally, value is reviewed with a focus on students' subjective task values via expectancy value theory. These theories or frameworks were used since they best align with the proposed study's goals.

Student Attitudes

Attitudes embody positive/negative appraisals and predilections according to information obtained from experience and are broken into three components: affective, behavioral, and cognitive (Ajzen, 1993; Ostrom, 1969). The definition of students' attitudes presented by Neale (1969) best represents the construct of interest as "a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activity, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless" (Neale, 1969, p. 632). For the purpose of this study, attitude was defined solely as "a liking or disliking of mathematics" (Neale, 1969).

Although there is not an explicit theoretical framework of students' attitude (i.e., liking or disliking) in school or in mathematics specifically, related frameworks have acknowledged this aspect of students' learning. An individual's experience of fascination or curiosity toward something, which causes feelings of enjoyment and desire to engage more is conceptualized as interest in the realm of motivation (Harackiewicz et al., 2016). Specifically, according to person-object theory of interest (POI), interests emerge as a result of continuous interaction between an individual and a particular object or entity, which can evolve into a more long-term situational interest specific to a domain and then a more consistent individual interest with high personal significance (Harackiewicz et al., 2016; Krapp, 2005). Within engagement theory, feelings or attitudes produced throughout the learning process (e.g., interest, boredom, enjoyment, sadness, apprehension, frustration) are referred to as emotional or affective engagement (Fredricks et al., 2004; Xie et al., 2019). As with interest, engagement is a product of an individual's interactions with environmental and contextual factors (Fredricks et al., 2004). Additionally, expectancy value theory includes intrinsic/interest value, which is the enjoyment or pleasure one feels from performing a task (Wigfield & Eccles, 2002). This value gives an individual the incentive to act, behave, or react in a particular manner with regard to varying situational variables. In this study, the broader construct termed 'attitude' was used because a systematic review of literature on "Improving College Students' Views and Beliefs Relative to Mathematics," showed that its use was relatively standard in representing students' views/beliefs in terms of affect (e.g., emotions, feelings, disposition) toward math.

Ability Beliefs

Ability beliefs associated with student theories of mathematics ability and expectancies of success correlate with student perceptions of self-efficacy (Davis et al., 2011; Wu & Fan, 2017). Student notions of mathematics ability can have an effect on how they perceive and react to the experiences they have in educational settings (Davis et al., 2011; Dweck, 2002). Those who believe ability is fixed may develop a defeatist attitude and give up on a task when they assume they are not doing well. Whereas, students who believe that ability is malleable may persevere when faced with adversity (Dweck, 2002). Student theories of mathematics ability along with relative comparisons of academic status (underdog versus top dog) interact with self-efficacy beliefs in the subject (Davis et al., 2011). In a quantitative study with liberal art university students, Davis et al. (2011) showed that implicit theories of mathematical ability interact with competition status as a positive and statistically significant predictor of perceived helplessness with regard to the competition as well as a negative and statistically significant predictor of mathematics self-efficacy. Furthermore, the authors showed that feelings of helplessness mediate the interaction of implicit theory with competition status predicting self-efficacy and the interaction of implicit theory and competition status predict both self-efficacy and helplessness. The current study was conducted to gain a better understanding of these beliefs, the causal attributions students attach to them, and student's perceived support needs for improved beliefs of mathematics.

Social Cognitive Theory: Self-Efficacy. Social cognitive theory posits that an individual's behaviors are dependent upon and reciprocal with contextual and environmental factors and thus focuses on "emergent interactive agency" (Bandura, 1989). According to Bandura (1989), human action is a consequence of self-efficacy beliefs, goal representations, and expected outcomes. Beliefs guide individual thought patterns, performance motivation, emotional status, and personal choice. Accordingly, self-efficacy has an effect on cognitive, motivational, affective, and selection processes (Bandura, 1989). The construction of self-efficacy beliefs is based on students' personal perceptions of information obtained from mastery experiences, vicarious experiences, verbal and social persuasions, and emotional and physiological states (Bandura, 1989; Usher & Pajares, 2008). Mastery experience fosters perceived competence, vicarious experience encourages prospective ambitions, verbal and social persuasions facilitate student achievement efforts, and emotional and physiological states influence student dispositions, which affect success (Usher & Pajares, 2008). Since self-efficacy develops from prior experiences and affective states, an individual's openness to hearing or willingness to accept new views on mathematics are likely dependent upon it (Usher & Pajares, 2008, 2009). Students with low self-efficacy relative to a task tend to avoid contexts related to having to complete those tasks (Wu & Fan, 2017). Shodahl and Diers (1984) declare that negative self-beliefs in mathematics stimulate a "self-defeating cycle" that must be immobilized (p. 34).

Expectancy Value Theory: The role of expectancies for success and task values

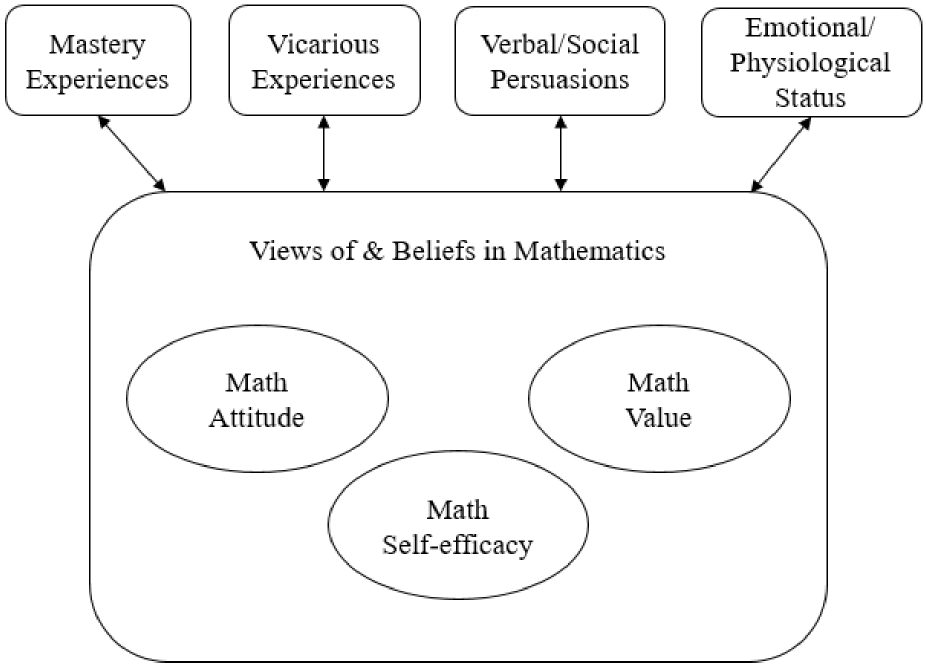
According to expectancy value theory, student expectancies of success and the values they hold about academic tasks determine their achievement-related perceptions and behaviors as well (Wigfield & Eccles, 2002; Wu & Fan, 2017). Like Bandura (1989) along with Usher and Pajares (2008), Wigfield and Eccles (2002) posit that previous experiences are important in determining student views, beliefs, and actions. If an individual does not expect to succeed at an activity and, more importantly, does not believe that the act will be beneficial, it is unlikely that they will be inspired to put much time and effort into the activity. Task-specific beliefs, including ability beliefs, difficulty appraisals, personal objectives, self-judgments, and affective memories, also have an impact on an individual's expectancies and values (Wigfield & Eccles, 2000). The stimulus to engage in a particular task based on how the task meets one's individual needs is labeled as subjective task value (Wigfield & Eccles, 2002). Based on Wigfield and Eccles (2002), subjective task values are theoretically divided into four components: attainment value (i.e., significance of performing well on a task based on one's perception that the activity is important to one's own identity); intrinsic value (i.e., enjoyment obtained from completing a task); utility value (i.e., perception of the role a task plays in one's long-term goals); and cost (i.e., one's belief surrounding the sacrifice needed in addition to the one's expected effort required to fulfill that task). Shodahl and Diers (1984) assert that students' success expectancies act as "self-fulfilling prophecy" (p. 34). The authors indicate studies that show success in mathematics is more dependent upon an individual's views, beliefs, or perceptions of math than any type of inherent ability.

Conceptual Framework

As noted above, social cognitive theory proposes that mastery experiences; vicarious experiences; verbal and social persuasions; and emotional and physiological states influence an individual's judgment of their ability to successfully complete a task (i.e., self-efficacy). Further, various theories surrounding attitude along with expectancy value theory support the notion that experiences inclusive of social influences and feelings guide one's attitude and value relative to a domain. Since the domain of focus is mathematics, the conceptual framework for this study asserts that students' attitudes, self-efficacy beliefs, and values relative to mathematics are reciprocally influenced by experiences, persuasions, and emotional/physiological states. See Figure 1.

Figure 1

Conceptual Framework Visual: Integrated Motivation Theory



Taken together, the current study was conducted to explain and further explore student attitudes, self-efficacy, and values relative to mathematics.

Inquiry Worldview

Education is a diverse field with no “one size fits all” approach. The current study was conducted from a semi-universalist ontology such that it proposes the possibility of having underlying “truths” that universally apply to many cases while also being cognizant that these “truths” are dependent upon contextual factors (DeCuir-Gunby & Schutz, 2017; Schutz et al., 2016). This perspective takes the approach of allowing context to guide investigation and finding solutions for the future improvement of students’ attitude, self-efficacy, and value as they relate to mathematics while accounting for the unique features of community college contexts. Students’ attitudes, self-efficacy beliefs, and values have been widely studied and there is a large body of evidence that indicates consistent, positive associations between these constructs and desirable academic outcomes (Aiken, 1972; Ajzen, 1993; Barrows et al., 2013; Davis et al., 2011; Johnson & O’Keeffe, 2016; Larson et al., 2015; Muenks et al., 2018; Muenks et al., 2017;

Neale, 1969; Parks-Stamm et al., 2010; Roick & Ringeisen, 2018; Villavicencio & Bernardo, 2016; Wigfield & Cambria, 2010; Wigfield & Eccles, 2002; Wu & Fan, 2017).

Be that as it may, contextual factors and individual differences allow for extended possibilities such that there may be multiple realities. Although the proposed correlations between constructs and academic outcomes may be universal, how they manifest is often influenced by gender, culture, social statuses, and other individual differences or contextual factors (Kumar et al., 2018). For instance, an effective instructional method used when teaching African American students may not function as effectively while teaching in culturally diverse classrooms with students from different ethnic groups and, further, may not even function efficiently across all African American student populations (Kumar et al., 2018). With this in mind, methods must be informed by the nature of inquiry according to corresponding practicality with respect to context. Thus, within a universalist ontology cognizant of context, a pragmatist-pluralist worldview will be taken where both single and multiple realities as they interact with human processes are acknowledged will take precedence through use of mixed methods (DeCuir-Gunby & Schutz, 2017). The pragmatist sees the practical significance of human action in education and asserts that questions of “how” are inextricable from those about “why” and “what for” (Biesta & Burbules, 2003, p. 22). The pragmatist-pluralist then further seeks to blend various views in an effort to solve problems of practice according to context (DeCuir-Gunby & Schutz, 2017).

Subjectivity Statement

Working with colleagues and students to increase their knowledge in mathematics for nearly 19 years (15 years at the community college level) has brought me joy and has given me much personal experience as a mathematics educator. My interest in students’ attitudes, beliefs, and values in mathematics, and how to support them, stem from my experience with college students entering my classes, seemingly, without the appropriate prerequisite knowledge and the almost immediate defeat I see on many of their faces when they are not grasping information. Remedial efforts via developmental courses and tutoring centers are helpful, but may not be enough for all students. Some may need more encouragement on the front end to help them be more resilient in the presence of challenges. Having personally taught all levels of mathematics, including remedial classes, from high school to undergraduate math and offering additional help during office hours to students at varying levels of mathematics has given me a chance to observe students' views toward math and recognize the added barriers (e.g., mental strain) caused by student attitudes, self-efficacy beliefs, and values. Students have directly indicated their negative attitudes regarding mathematics and their belief that the subject adds no value to their lives. Pre-assertions that the math is too difficult before even attempting to work through problems seems to prevent an openness to learning the information. In my professional experience, once I am able to convince students of the relevance of mathematics in their lives and that it takes people (including myself as a mathematics educator) time and effort, students tend to believe more in themselves and perform better. The current study aimed to extend our understanding of 1) patterns associated with students' math attitudes, self-efficacy beliefs, and values by subgroups (i.e., gender and race) at a moderately large community college; 2) how schooling experiences and other contextual factors influenced these attitudes, self-efficacy beliefs, and values; and 3) what community college students perceive they need as supports that will inform efforts to advance positive views of and learning behaviors in math.

Purpose Statement

Given the importance of mathematical proficiency in school and in the real world, coupled with the unfortunate evidence that many individuals find mathematics challenging and outwardly communicate their aversion for the subject, my ultimate goal in this research is to better understand how to improve students' attitudes, beliefs, and values surrounding mathematics as a subject including their self-efficacy beliefs in the domain.

Summary of Systematic Literature Review

In order to better understand what researchers have already done in an attempt to improve college students' views and beliefs regarding mathematics, a systematic literature review titled "Improving College Students' Views and Beliefs Relative to Mathematics: A Systematic Literature Review" was conducted in the spring of 2021 (see Supplementary Document for full literature review document). The following research questions guided this review:

1) What are the foundational features (i.e., frameworks, study design, sample context) of intervention studies that have been conducted with college students in an attempt to improve students' views and beliefs relative to mathematics?
2) What are the major components of existing approaches (e.g., interventions, curriculum, and/or instruction) that have been examined with college students seeking to improve students' views and beliefs in mathematics? How are these component features applied and/or measured?
3) What evidence has been established for these approaches for supporting college students' views and self-beliefs related to mathematics?

A review of the extant literature showed that the majority of studies did not exclusively focus on the improvement of students' mathematical views or beliefs (Butler & Butler, 2011; Crocco et al., 2016; Cunningham, 2010; Dewar et al., 2011; Hagerty et al., 2010; Karaali, 2015; Meagher, 2012; Van Dyke et al., 2015; Wang et al., 2011; Zimmerman et al., 2011). Although a small number of the included studies (4 of 16) were indicated to have been conducted in the community college setting, more studies are needed to better understand this diverse and unique population.

Community colleges serve students from all walks of life who may or may not be interested in earning a four-year degree as many opportunities for gaining an early start on a career and job opportunities in various fields are offered that may not be offered by traditional 4-years colleges or universities. For example, community colleges offer programs and certificates (e.g., vocational programs and career studies certificates) that can take less than one year to earn with full-time enrollment at a much cheaper cost than most 4-year institutions of learning. Further, programs are offered where students can choose to earn a 2-year associate's degree and/or transfer two years of general or foundational studies credits to 4-year institutions to later earn a bachelor's degree. Consequently, a high percentage of non-traditional undergraduate-aged students tend to enroll in community college classes (outside of 18-24). Students under 18 enroll to earn early college credits and associate degrees through dual enrollment programs. Similarly, a large number of adult learners who have already entered the job world tend to enroll when they are in need of a career-switch or job/opportunity advancement. Most community colleges are open-admission and do not require competitive previous academic outcomes for acceptance. This allows for much needed equity and inclusion within academia. However, as a result, a higher number of students tend to enroll without apposite college-level mathematics skills and may have many negative views of and beliefs about mathematics, which can be a deterrent to academic success in the domain of mathematics as noted earlier.

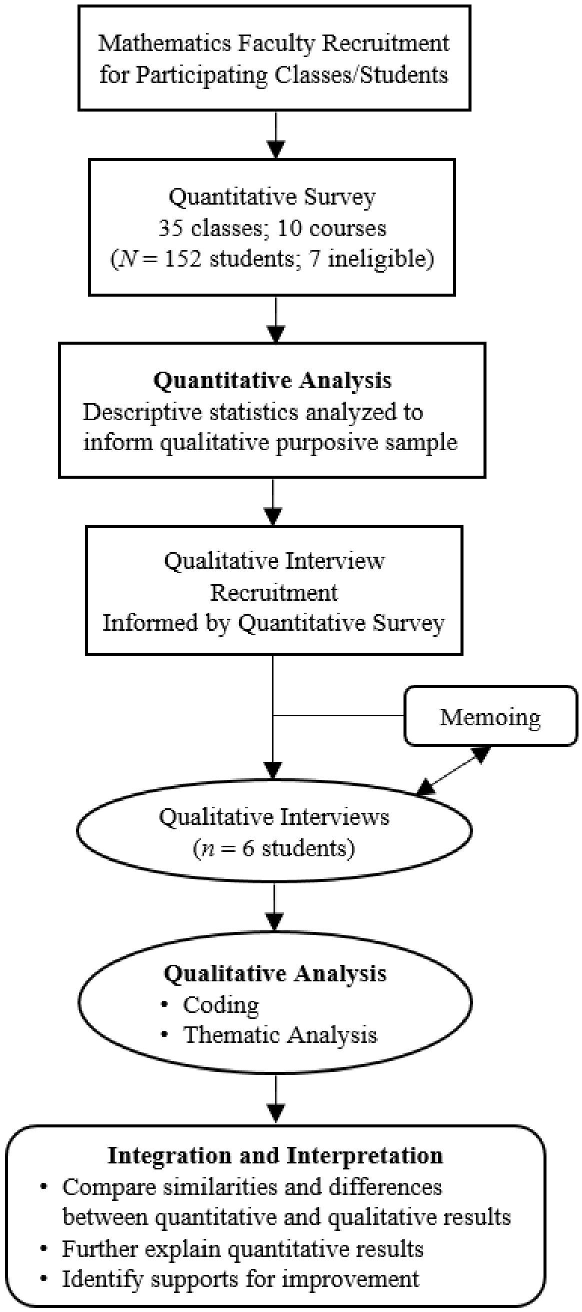
Before implementing interventions aiming to improve students' views and beliefs related to mathematics, one must first understand the individual differences and experiences corresponding to the intended populations' held views and beliefs as well as identify the underlying causes of these views and beliefs with regard to the subject.

The Current Study

The current study focused on 1) gaining insight on the distribution of student views and beliefs in terms of attitudes, self-efficacy beliefs, and values regarding mathematics within subgroups (i.e., gender and racial/ethnic groups) of a moderately large urban community college population (quantitative), 2) understanding the experiences associated with these attitudes, self-efficacy beliefs, and values from students' perspectives (qualitative), 3) obtaining knowledge about how diverse identity markers and mathematics learning experiences are associated with students' math attitudes, self-efficacy, and values (qualitative), and 4) inquiring on students' perceived support needs directly related to these attitudes, self-efficacy beliefs, and values (qualitative). See Diagram 1 for study flow.

Diagram 1

Diagram of Sequential Explanatory Mixed Methods Study



Rationale for Mixed Method Design

There are advantages to using quantitative methods for studies. Quantitative measures present objective results with very little subjective interpretation by study authors (Creswell & Plano Clark, 2018). The statistical information collected has the potential to be extremely accurate and generalizable depending on population and context. However, there are disadvantages to solely using quantitative methods. Large sample sizes are typically necessary to achieve reliable results. Moreover, surveys utilized in quantitative research have predefined responses, which limit participants' response options (Creswell & Plano Clark, 2018).

There are also advantages to using qualitative methods to explore attitudes, self-efficacy, and values relative to mathematics. It requires a smaller sample size to reach saturation (i.e., the stage at which sufficient data has been gathered prior to redundancy; Creswell & Plano Clark, 2018; Merriam & Tisdell, 2016). Additionally, the use of qualitative methods allows for researchers to obtain a deep understanding of attitudes, self-efficacy, and values through: probing with open-ended questioning techniques; observing behaviors and reactions; being flexible and resourceful as new information is provided (Creswell & Plano Clark, 2018; Maxwell, 2013; Merriam & Tisdell, 2016). Furthermore, it permits participants to be open and honest about their feelings while offering them the opportunity to expand upon their thoughts with pertinent information that may not have first occurred to the researcher. On the other hand, qualitative methods alone are not able to offer statistical data and may result in biased reporting of results depending on the researcher's subjective stance or interpretation of information (Creswell & Plano Clark, 2018; Merriam & Tisdell, 2016).

Mixed method research allows for the inclusion of both quantitative and qualitative approaches for answering research questions in a single study on a continuum so that each approach can be used to the enhance the findings of the other (Creswell & Plano Clark, 2018; DeCuir-Gunby & Schutz, 2017; Ercikan & Roth, 2006; Onwuegbuzie et al., 2009; Teddlie & Yu, 2007). The proposed study acknowledges the combined definition of mixed method research offered by Johnson et al. (2007) as follows:

> Mixed methods research is the type of research in which a researcher or team of

> researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration (p. 123).

A case-selection variant (Creswell & Plano Clark, 2018) of the sequential explanatory mixed-method design in the form quan → QUAL was used for the current study in order to gain a more comprehensive picture (Creswell & Plano Clark, 2018; Maxwell, 2013; Merriam & Tisdell, 2016) of students' attitudes, self-efficacy, and values relative to mathematics. A descriptive quantitative strand was conducted using a Likert survey to estimate the distribution of students' self-reported attitudes, self-efficacy, and values in college mathematics, as well as in terms of gender, race, and course level at a moderately large urban community college in the South Atlantic Region of the United States. Results from the quantitative strand was used to provide more generalizable findings regarding patterns of students' attitudes, self-efficacy beliefs, and values in mathematics.

A multiple-case follow-up qualitative strand was conducted by way of one-on-one interviews to explore the nature of community college students' attitudes, self-efficacy, and values related to mathematics as well as their perceived support needs for improving their math attitudes, self-efficacy beliefs, and values. Qualitative findings provided more in-depth understandings of how prior schooling experiences and students' in-and-out of school identities relate to their attitudes, self-efficacy beliefs, and values in mathematics, as well as crucial information about what supports students need to improve their math attitudes, self-efficacy beliefs, and values in community college settings. The integration of both quantitative and qualitative methods add to the literature by allowing for a more complete picture of these community college students' attitudes, self-efficacy beliefs, and values in mathematics.

Research Questions

Given the importance of mathematics in the lives of college students, the current study quantitatively determined the distribution of community college students' attitudes, self-efficacy, and values toward mathematics with regard to specific individual differences. A follow-up qualitative multiple case study (Stake, 2013) inquired into the nature of students' math attitudes, self-efficacy, and values (e.g., prior math learning experiences that influence current views/beliefs, reasons for liking or disliking mathematics) and explored students' perceived support needs to improve these attitudes, self-efficacy, and values. The following research questions guided this study:

RQ1) What is the distribution (i.e., *M*, *SD*, minimum, maximum, skew, kurtosis, correlation) of students' self-reported attitudes, self-efficacy, and values in college mathematics, as well as in terms of self-identified gender, racial/ethnic group, and course level at a moderately large urban community college in the South Atlantic Region of the United States? [Quantitative]

RQ2) What is the nature of community college students' attitudes, self-efficacy, and values related to mathematics for students who report high or low views and beliefs in mathematics? [Qualitative]

RQ3) How do students' various identity markers (e.g., gender, race/ethnicity) and mathematics learning experiences relate to their attitudes, self-efficacy, and values in mathematics? [Qualitative]

RQ4) What do community college students report about what supports would improve/increase their attitudes, self-efficacy, and values? [Qualitative]

Based on the information available, it was hypothesized that females would report slightly more negative attitudes, self-efficacy, and values relative to mathematics. It was also hypothesized that racial minority participants would report more negative attitudes, self-efficacy, and values regarding mathematics due to prior inequitable educational opportunities and experiences (Bae et al., 2021; Beasley & Fischer, 2012; Darling-Hammond, 2004). It was further hypothesized that participants with intersecting identity markers relative to multiple marginalization according to gender and race would also report more negative math attitudes, self-efficacy, and values according to single and multiple marginalization (Beasley & Fischer, 2012).

Participants

The population of focus were students in higher education enrolled in mathematics courses at the community college level. The sample was chosen from all students enrolled in a college credit-level mathematics course at an urban community college located in the southeast of the United States. The particular college of interest is a moderately large community college with three campuses that serve the entire city in which it is located (population 230,436) and its surrounding counties ("United States Census Bureau," 2019; "Participating Community College - PCC," 2020). Based on 2018-2019 data, 78% of the college's student enrollment comes from the service area ("PCC," 2021). The remaining enrollment percentage consists of students from other parts of the country, as well as students from foreign countries.

The students served are demographically diverse. The community college's total Fall 2021 enrollment consisted of 2,696 male, 4,511 female, and 79 gender "Not Reported" students. This count of 7,286 students comprised approximately 51% White students, 28% Black or African American students, 7% Asian, 6% Hispanic students, 5% Multiracial students, less than 1% American Indian/Alaska Native or Native Hawaiian/Other Pacific Islander, and 3% "Other-race or race Not Reported" students with the following population age range percentages: younger than 18 (28.4%), from 18 to 24 (36.5%), from 25 to 40 (26.7%), and older than 40 (8.4%). Approximately 24% of these students were enrolled in a college credit-level mathematics course while 14% were enrolled in a 12-15 week session course and less than 6% were enrolled in a fully synchronous credit-level math course (approximately 3% during the hours of 8am and 5pm; n = 212).

The participants comprised of students enrolled in a 2021 fall semester or 2022 spring semester (12-15 week session), college credit-level mathematics course held fully on campus or virtually (fully synchronous live-online) during the hours of 8am and 5pm at PCC (11 fall classes; 24 spring classes). Including students from all possible credit-level mathematics courses offered allows for rich data from student experiences based on diverse teacher pedagogies, differing levels of student mathematical study, and varying levels of math attitudes, self-efficacy, and values. Course level was also included in analyses. See course levels and additional detail in Table A1. Enrollment in the courses within the specified inclusion criteria included 212 students in the fall semester due to a higher offering of asynchronous distance learning classes for pandemic convenience. Student enrollment in eligible spring semester classes comprised of 445 students. Students enrolled in partially or fully asynchronous online courses were excluded from this study due to the courses' substantive dissimilar teaching and learning platform. Further, students under the age of 18 were excluded as they are likely to be dual enrollment students (i.e., high school students taking college classes).

Recruitment and Sampling Procedures

The sample was recruited via convenience sampling (Creswell & Plano Clark, 2018; Maxwell, 2013; McMillan & Schumacher, 1997; Merriam & Tisdell, 2016) so that the study was open to all possible students taking a fully live, standard-paced mathematics class for college credit at PCC. An email was sent to all full-time and adjunct mathematics faculty teaching a college credit-level mathematics course that met inclusion criteria at PCC notifying them of project plans and requesting their participation in the study. Additional emails were sent to those who had not yet replied within one week of the first email as a friendly reminder of the study requesting their participation. Included within this email was notification that their only responsibilities were to forward or post a student participation email to their eligible class(es) via email or Learning Management System (LMS) class announcement. Strong previously developed relationships with mathematics faculty at PCC permitted cost efficient, timely, and convenient access to willing participants. In addition, survey participation emails were sent directly to fall students who had not yet completed the survey approximately two weeks prior to the fall semester end and to spring students who had not yet replied as of approximately six weeks after semester start (week 7 of 15-week classes; week 3 of 12-week classes). See Appendix C for the participation email to faculty. See also Appendix D for the survey participation request email.

A nested sample (Creswell & Plano Clark, 2018; DeCuir-Gunby & Schutz, 2017) was used for the qualitative strand. Students who completed the quantitative survey, supplied their email address, and selected the option in the survey establishing that they are willing to be contacted for future study participation were considered for follow-up interview. From this pool of potential participants, a maximum variation purposive/purposeful sampling approach was used (Creswell & Plano Clark, 2018; Maxwell, 2013; McMillan & Schumacher, 1997; Merriam & Tisdell, 2016) to represent participants from a range of genders and race subgroups with high or low mathematics attitude, self-efficacy belief, and value outcomes. Interview participation was requested of all 10 students with low (1 to 2.49 range) and 8 of 13 students with the highest (4.33 to 5 range) overall scores (i.e., mean of attitude, self-efficacy, and value scores) who opted in for future research contact. Emails were sent to the befitting students. This email requested voluntary participation in one-on-one interviews and detailed the purpose of the interviews. See Appendix E for the interview participation request email. Phone calls were also made to students who listed phone numbers for contact. In addition, all 12 students in the low-neutral (2.5 to 2.99) who opted in for future research contact were sent participation request emails after over a month of no success in low-scoring student recruitments.

Data Collection

Quantitative Strand

Students' attitudes, self-efficacy, and values relative to mathematics were rated on a 16-item, 5-point Likert survey where students were asked to indicate their level of agreement on a scale ranging from 1 (*Strongly disagree*) to 5 (*Strongly agree*). The constructs measured centered on students' attitudes (5 items), self-efficacy (5 items), and values (6 items) in mathematics. Since three separate constructs were measured, abbreviated forms of pre-established and reliable scales were used to minimize item redundancy, response fatigue or frustration, and dropout attrition or early-exits from the survey allowing for more thoughtful, reliable, and valid assessment (Gogol, 2014). It has been shown that shortened scales using 3-items per construct is efficient in measuring motivational constructs both general and specific to a domain (Gogol, 2014; Heindl, 2020; Kjell & Diener, 2021; Liu, 2020). See Table 1.

Table 1

Math Attitude, Self-Efficacy, and Value Items

Construct	**Survey Items**

Math Attitude	I get a great deal of satisfaction out of solving a mathematics problem. I have usually enjoyed studying mathematics in school. I like to solve new problems in mathematics. I really like mathematics. Mathematics is a very interesting subject.
Math Self-efficacy	I believe I will receive an excellent grade in my math class. I'm confident I can understand the basic concepts taught in my math course. I'm confident I can do an excellent job on the assignments and tests in my math course. I expect to do well in my math class. I'm certain I can master the skills being taught in my math class.
Math Value	Being someone who is good at math is important to me. It is important for me to be someone who is good at solving problems that involve math. It is important for me to be a person who reasons mathematically. Math will be useful for me later in life. Math concepts are valuable because they will help me in the future. Being good at math will be important for future employment.

Math Attitudes. The five items for the attitudes subscale were drawn from Tapia's (1996) enjoyment scale items embedded within the Attitudes Toward Mathematics Inventory (ATMI). According to Tapia and Marsh (2004), the enjoyment subscale of the ATMI has high reliability with α = .89 and a test-retest reliability of r = .84. Students were asked to indicate their level of agreement/disagreement with statements representative of attitudes toward mathematics with respect to the liking or enjoyment of the subject.

Math Self-efficacy. The five items for the self-efficacy subscale were drawn from the 8-item Expectancy Component: Self-Efficacy for Learning and Performance subscale of the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991). This particular portion of the scale is commonly used and has a reported reliability α = .93 (Pintrich et al., 1991). According to Pintrich et al. (1993), all MSLQ subscales were determined to be reliable and valid with respect to measuring college students' motivation and employment of learning strategies. Students were asked to rate their perceived mathematics self-efficacy as it relates to their current mathematics course.

Math Value. The six items for the value subscale were drawn from Conley's (2012) utility value (α = .80) and attainment value (α = .85) scale items. Students were asked to indicate their level of agreement/disagreement to statements representative of perceptions related to the importance or usefulness of mathematics. Intrinsic value items were not included as they overlap with the study's running definition of attitude. In addition, cost items were not included as they are more related to one's perceptions of the unfavorable ramifications of exerting effort into engaging in a task as opposed to the value seen in expending such effort.

Demographic Items. The survey also included demographic items to account for participant gender and race. See Table 2.

Table 2

Demographic Survey Items

Gender Identity	Race
Cisgender Male	Asian
Cisgender Female	Black or African American
Transgender Male	Hispanic/Latinx
Transgender Female	Indigenous American
Non-Binary/Non-Conforming	White
Prefer not to answer	Other*
Other*	

Qualitative Strand

One-hour follow-up interviews were conducted with six individual participants. A semi-structured interview protocol (Appendix G) was used, with pre-established questions to align with the study aims, while also providing flexibility for emergent probes based on participants' responses. The interviews were semi-structured to ensure that much of the focus was on 1) the participants' descriptions of their views associated with mathematics and mathematics ability as well as 2) gaining as much information as possible relative to understanding the participants' perceived influences to these attitudes, self-efficacy, and values. Please see Appendix G for the interview protocol. Participants were encouraged to speak openly and honestly about their attitudes, self-efficacy, and values (both positive and negative) without being restricted to particular questions and answers to select.

The interview sessions ranged from 48 to 80 minutes each, including an unrecorded review of the information sheet (Appendix F) and the protocol introduction (Appendix G). The official query portion of the interview sessions ranged from approximately 35 minutes to 65 minutes and lasted 46 minutes, on average. This particular portion of the interview sessions was audio-recorded to ensure that student responses were noted in a complete and accurate form. Zoom, a software program used for video teleconferencing that offers live transcription, was utilized by means of a password protected laptop computer in order to record and transcribe interviews in real time. These recordings were stored on Zoom Cloud under a password protected Zoom account. Following each interview session, research questions were reviewed in order to memo and make short reflections relating to the interview (Creswell & Plano Clark, 2018; Maxwell, 2013).

Data Analysis

Quantitative Strand

Quantitative survey served to empirically assess RQ1, "What is the distribution (i.e., M, SD, minimum, maximum, skew, kurtosis, correlation) of students' self-reported attitudes, self-efficacy, and values in college mathematics, as well as in terms of self-identified gender, racial/ethnic group, and course level at a moderately large urban community college in the South Atlantic Region of the United States?" Descriptive analyses were conducted on all observed variables using Statistical Package for the Social Sciences (SPSS) to determine the spread of data and descriptive statistics (mean, standard deviation, minimum and maximum values, skew, and kurtosis, correlation). The descriptive statistics were calculated for the entire sample, as well as disaggregated by gender, race/ethnicity, and course level. Results from this strand were also used to identify the most suitable participants for diversified qualitative strand findings. Survey scores were categorized as low for strongly disagree/disagree response averages (score range 1 to 2.49), neutral for neutral response averages (score range 2.5 to 3.49), and high for agree/strongly agree response averages (score range 3.5 to 5).

Qualitative Strand

The qualitative strand served to further explain quantitative survey results relative to RQ1 and, in turn, provided answers for RQ2, "What is the nature of community college students' attitudes, self-efficacy, and values related to mathematics for students who report high or low views and beliefs in mathematics?," RQ3, "How do students' various identity markers (e.g., gender, race/ethnicity) and mathematics learning experiences relate to their attitudes, self-efficacy, and values in mathematics?," and RQ4, "What do community college students report about what supports would improve/increase their attitudes, self-efficacy, and values." The core objective of this strand was to learn more about the experiences that underlie community college students' mathematics attitudes, self-efficacy beliefs, and values as well as to gain insight on student-perceived support needs relative to these attitudes, self-efficacy beliefs, and values.

Interview data was analyzed in the order in which the interview sessions were completed using a constant comparative approach to both inductively and comparatively generate results (Creswell & Plano Clark, 2018; Maxwell, 2013; McMillan & Schumacher, 1997; Merriam & Tisdell, 2016). In order to analyze interview data, the transcribed sessions were copied from Zoom Cloud, where they were directly recorded and stored. Each transcription was then pasted into separate Microsoft Word documents for thorough transcription. While comprehensively listening to the recording of each interview session, corresponding Zoom transcriptions were examined and modified to identify speakers with anonymous student number identifiers (e.g., Student 1, Student 2), separate statements to differentiate between the student participants and myself, and make many necessary corrections to improperly transcribed statements. All finished products were then uploaded to the online computer program, Dedoose, which is a cross-platform tool for assessing qualitative and mixed methods research.

Preliminary codes based on the conceptual frameworks (Bandura, 1989; Neale, 1969; Usher & Pajares, 2008; Wigfield & Eccles, 2002) reviewed above and protocol questions were created and added as initial codes for analysis (Merriam & Tisdell, 2016) on Dedoose. See Table 3 for preliminary codes.

Table 3

Preliminary Interview Codes

Variables	CODE	DESCRIPTION
Attitude	Attitude_Negative	The student expresses a general dislike for math.
	Attitude_Positive	The student expresses a general like for math.
Self-efficacy	Self_Efficacy_Negative	The student is not confident in their ability to complete a mathematical task.
	Self_Efficacy_Positive	The student is confident in their ability to complete a mathematical task.
Value	AttainmentValue_No	The student indicates that mathematics is not important to them.
	AttainmentValue_Yes	The student indicates that mathematics is important to them.
	Cost	The student feels that mathematical tasks require too much time and/or effort.
	IntrinsicValue_No	The student identifies a mathematical task they do not enjoy.
	IntrinsicValue_Yes	The student identifies a mathematical task they enjoy.
	UtilityValue_No	The student does not believe that mathematics is useful.
	UtilityValue_Yes	The student finds mathematics to be useful.
Experience	EmotionalState	The student identifies an emotional state that they believe had an impact on learning.
	Mastery	The student identifies a mastery experience that they believe had an impact on learning.
	Persuasion	The student identifies a verbal or social persuasion that impacted their perception of math.
	PhysiologicalState	The student identifies a physiological state that they believe had an impact on learning.
	Vicarious	The student indicates that a person or people had an influence on their perception of math.
Support	Support	The student identifies specific supports that can or have been employ(ed).

As the sessions were analyzed, additional emergent codes were added as appropriate (Maxwell, 2013; McMillan & Schumacher, 1997; Merriam & Tisdell, 2016). Preliminary common themes were documented by way of coding the first interview session's data on Dedoose in comparison with my reflections on other interview sessions that had previously taken place (Maxwell, 2013; Merriam & Tisdell, 2016). To develop the preliminary themes, repeated codes were identified in Dedoose relative to particular question responses within all other interview sessions according to the first sessions' data coding. Additional codes were established as more interview session data was coded. All interview data files were read and each quote that seemed significant was coded. After moving forward and finding parallel replies to previous sessions, a code was created and previous interview files were revisited to find comparable quotes using key words from the associated protocol questions. Table 4 lists all codes along with the descriptions used to identify and tag quotes.

Table 4

Finalized Interview Codes

Variables	CODE	DESCRIPTION
Attitude	Attitude_Negative	The student expresses a general dislike for math.
	Attitude_Positive	The student expresses a general like for math.
Self-efficacy	Self_Efficacy_Negative	The student is not confident in their ability to complete a mathematical task.
	Self_Efficacy_Positive	The student is confident in their ability to complete a mathematical task.
Value	AttainmentValue_No	The student indicates that mathematics is not important to them.
	AttainmentValue_Yes	The student indicates that mathematics is important to them.
	Cost	The student feels that mathematical tasks require too much time and/or effort.
	IntrinsicValue_No	The student identifies a mathematical task they do not enjoy.
	IntrinsicValue_Yes	The student identifies a mathematical task they enjoy.
	UtilityValue_No	The student does not believe that mathematics is useful.
	UtilityValue_Yes	The student finds mathematics to be useful.
Experience	EmotionalState	The student identifies an emotional state that they believe had an impact on a math task/outcome.
	Mastery	The student identifies a mastery experience that impacted their perception of math.
	Persuasion	The student identifies a verbal or social persuasion that impacted their perception of math.
	PhysiologicalState	The student identifies a physiological state that they believe had an impact on a math task/outcome.
	Vicarious	The student indicates that a person or people had an influence on their perception of math.
Support	Support	The student identifies specific supports that can or have been employ(ed).
Emergent Codes	Ability_Fixed	The student indicates that mathematics ability is fixed.
	Ability_Malleable	The student indicates that mathematics ability is malleable.
	Ability_Natural	The student indicates that mathematics comes naturally to some people.
	Achievement	The student refers to passing an assessment or course, good grades, and/or successful task completion.
	Avoidance	The student refers to avoiding tasks related to mathematics.
	Challenge_Positive	The student expresses a positive reaction to challenge.
	CourseLevel	The student expresses a view/belief based on course level or math type.
	Difficulty	The student indicates having an experience with difficulty in mathematics.
	Effort	The student believes that mathematics requires time, effort, and/or focus.
	EmpatheticView	The student speaks from the view of others.
	Failure	The student identifies an experience with failing a task.
	Gender	The student referred to gender-related experience.
	Influence_Family	The student refers to influence from or support from family.
	Influence_Peers	The student refers to influence from or support from peers.
	Influence_Society	The student refers to influence or support from society.
	Influence_Teacher	The student believes that teachers have an influence on student perceptions of math.
	Online_Negative	The student expresses a negative view/belief of learning or completing a mathematical task online.
	Race_Ethnicity	The student referred to race- or ethnicity-related experience.
	SuccessBelief	The student's generalized definition of success in mathematics.
	TypeAssumption	The student's assumption of "math person" type.

Data Integration

A table was made to showcase demographics and survey results. For strand convergence, a joint display was then constructed according to survey results (Creswell & Plano Clark, 2018). This was done to heighten understanding of students' views and beliefs in terms of attitudes, self-efficacy, and values with respect to mathematics while also observing student's individual differences. Further, notable differences in code counts for students with high overall survey scores versus those with low overall survey scores were observed and described.

Results

Quantitative Strand

During the fall semester, 37 students completed the quantitative survey. Of these, 5 were excluded due to students being enrolled in an ineligible hybrid class (4 students) or being under 18 and still having attempted to take the survey (1 student). During the spring semester, 115 students completed the quantitative survey. However, 2 were excluded due to the student being enrolled in an ineligible hybrid class. Thus, of 152 students surveyed, 145 were loaded into SPSS and evaluated for study purposes.

The 145 included survey participant sample comprised of approximately 56.55% cisgender females, 40.69% cisgender males, 0.69% transgender females, and 2.07% preferred not to specify their gender. These participants were categorized as approximately 15.2% Asian, 19.3% Black or African American, 4.1% Hispanic/Latinx, 52.4% White, and 9.0% Multiracial or Other. One of students classified as Asian self-identified as Asian and Pakistani while another self-identified as Persian. In addition, one of the students classified as White self-identified as "caucasian." The "Multiracial or Other" category consisted of students who identified as Asian and White (1), Black or African American and Hispanic/Latinx (2), Black or African American and White (3), Hispanic/Latinx and White (4), Indigenous American and White (1), "mixed" (1), and "egyptian" (1). See Table A2 for sample sizes by course level.

RQ1) *What is the distribution (i.e., M, SD, minimum, maximum, skew, kurtosis, correlation) of students' self-reported attitudes, self-efficacy, and values in college mathematics, as well as in terms of self-identified gender, racial/ethnic group, and course level at a moderately large urban community college in the South Atlantic Region of the United States?*

To answer the first research question, descriptive statistics were run in SPSS to find the mean, standard deviation, minimum, maximum, skew, kurtosis, and correlation of students' self-reported attitudes, self-efficacy, and values in college mathematics overall. These results were also disaggregated in terms of individual construct (i.e. attitude, self-efficacy, value).

For the whole sample of students, patterns in descriptive statistics showed that students generally hold neutral attitudes (*M* = 3.27, *SD* = .96) with higher self-efficacy (*M* = 3.60, *SD* = .89) and values (*M* = 3.63, *SD* = .77). Please see Table 5.

Table 5

Descriptive Statistics of Students' Math Attitudes, Self-efficacy, Value, and Overall Ratings

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Attitude Score	145	1.00	5.00	3.27	.96	-.30	.20	-.41	.40
Self-efficacy Score	145	1.00	5.00	3.60	.89	-.61	.20	.21	.40
Value Score	145	1.17	5.00	3.63	.77	-.31	.20	-.11	.40
Overall Score	145	1.12	5.00	3.50	.73	-.47	.20	.60	.40
Valid N (listwise)	145								

Additionally, mean comparisons were run to find the mean, standard deviation, minimum, maximum, skew, kurtosis, and correlation of students' self-reported attitudes, self-efficacy, and values in college mathematics overall by gender (Table 6), by race (Table 7), and by course (Table 8). The descriptive statistics showed that, on average, females reported having lower overall math views and beliefs (*M* = 3.44, *SD* = .70) in comparison to males (*M* = 3.60, *SD* = .77). Additionally, Asian participants reported the highest overall math views and beliefs (*M* = 3.72, *SD* = .54) while Hispanic/Latinx participants reported the second highest (*M* = 3.71, *SD* = .32), Black participants reported the third highest (*M* = 3.61, *SD* = .66), White participants reported the fourth highest or second lowest (*M* = 3.44, *SD* = .81), and Multiracial/Other participants reported the lowest (*M* = 3.18, *SD* = .70). With respect to course level, students in courses with all or majority Science majors (STEM concentrations) scored within the high range, on average. Participants taking Statistics and Pre-Calculus I also scored in the high range, on average. Students in MTH 167 – Pre-Calculus with Trigonometry reported the highest overall math views and beliefs (*M* = 3.95, *SD* = .48), followed by MTH 264 – Calculus II (M = 3.80, *SD* = .87), MTH 263 – Calculus I (*M* = 3.68, *SD* = .97), MTH 245 – Statistics I (*M* = 3.63, *SD* = .73), MTH 162 – Pre-Calculus II (*M* = 3.58, *SD* = .78), and MTH 161 – Pre-Calculus I (*M* = 3.54, *SD* = .64). The remaining course level students scored in the neutral range, on average. Only one student in MTH 130 – Fundamentals of Reasoning took the survey. That singular score positioned MTH 130 as having the lowest reported overall math views and beliefs (2.71), followed by MTH 154 – Quantitative Reasoning (*M* = 3.18, *SD* = .67) with the second lowest, MTH 261 – Applied Calculus I (*M* = 3.23, *SD* = .80) with the third lowest, and MTH 111 – Basic Technical Mathematics (*M* = 3.36, *SD* = .65) with the fourth lowest. Please see Tables 6, 7, and 8.[1]

Table 6

Overall Score Distribution by Gender

Gender Identity	Mean	N	Std. Deviation	Minimum	Maximum	Kurtosis	Skewness
Cisgender Female	3.44	82	.70	1.39	5.00	.24	-.18
Cisgender Male	3.60	59	.77	1.12	4.93	1.43	-.92
Prefer not to answer/Other	3.30	4	.43	2.79	3.83	.59	.11
Total	3.50	145	.73	1.12	5.00	.60	-.47

[1] Results from Analyses of Variance (ANOVAs) showed that differences by gender and race were not significant. Contrarily, results of a one-way ANOVA suggest that there was a significant difference in participants' overall math views and beliefs by course level, $F(9,135) = 1.99$, $p < .05$, $\eta^2 = .18$. This is a large effect size according to Cohen's (1988) guidelines.

Table 7

Overall Score Distribution by Race

Race	Mean	N	Std. Deviation	Minimum	Maximum	Kurtosis	Skewness
Asian	3.72	22	.54	2.79	5.00	.00	.45
Black or African American	3.61	28	.66	2.26	4.93	-.36	.15
Hispanic/Latinx	3.71	6	.32	3.26	4.06	-1.23	-.43
Multiracial or Other	3.18	13	.70	2.30	4.19	-1.45	.17
White	3.44	76	.81	1.12	5.00	.52	-.57
Total	3.50	145	.73	1.12	5.00	.60	-.47

Table 8

Overall Score Distribution by Course

Course	Mean	N	Std. Deviation	Minimum	Maximum	Kurtosis	Skewness
MTH 111 - Basic Technical Mathematics	3.36	6	.65	2.48	4.18	-1.58	-.09
MTH 130 - Fundamentals of Reasoning	2.71	1	.	2.71	2.71	.	.
MTH 154 - Quantitative Reasoning	3.18	34	.67	1.39	4.11	.20	-.87
MTH 161 - Pre-Calculus I	3.54	33	.64	2.43	5.00	-.54	.16
MTH 162 - Pre-Calculus II	3.58	10	.78	2.73	4.74	-1.70	.44
MTH 167 - Pre-Calculus with Trigonometry	3.95	14	.48	3.22	4.69	-.82	.03
MTH 245 - Statistics I	3.63	21	.73	2.40	5.00	-.35	.13
MTH 261 - Applied Calculus I	3.23	9	.80	1.36	3.97	3.78	-1.82
MTH 263 - Calculus I	3.68	12	.97	1.12	4.93	4.28	-1.64
MTH 264 - Calculus II	3.80	5	.87	2.37	4.67	2.77	-1.45
Total	3.50	145	.73	1.12	5.00	.60	-.47

These results were also disaggregated in terms of individual construct. On average, both females and males reported having neutral attitudes, high self-efficacy, and high value with respect to mathematics. Females reported lower attitudes (M = 3.13, SD = .98) and self-efficacy (M = 3.57, SD = .89) than males (M = 3.49, SD = .91; M = 3.70, SD = .89). Whereas, females reported similar math values (M = 3.62, SD = .72), on average, with a smaller dispersion than males (M = 3.62, SD = .85).

With respect to race, Asian and Hispanic/Latinx participants reported high math attitudes, self-efficacy, and values. Black and White participants reported neutral math attitudes with high self-efficacy and values. Whereas, Multiracial/Other participants reported neutral math attitudes, self-efficacy, and values. Multiracial/Other participants reported the lowest math attitudes (*M* = 2.82, *SD* = 1.03), self-efficacy (*M* = 3.38, *SD* = 1.06), and values (*M* = 3.35, *SD* = .66). Hispanic/Latinx participants reported the highest math attitudes (*M* = 3.83, *SD* = .61), followed by Asian participants (*M* = 3.57, *SD* = .75), White participants (*M* = 3.24, *SD* = 1.00), Black participants (*M* = 3.24, *SD* = .94). Asian participants reported the highest math self-efficacy (*M* = 3.85, *SD* = .65), followed by Black participants (*M* = 3.74, *SD* = .75), Hispanic/Latinx participants (*M* = 3.60, *SD* = .64), and White participants (*M* = 3.52, *SD* = .97). Black participants reported the highest math value (*M* = 3.85, *SD* = .76) followed by Asian participants (*M* = 3.73, *SD* = .53), Hispanic/Latinx participants (*M* = 3.69, *SD* = .37), and White participants (*M* = 3.55, *SD* = .85).

On average, MTH 167 – Pre-Calculus with Trigonometry students and MTH 263 – Calculus I students scored in the high range for all three constructs (i.e., attitude, self-efficacy, value) while MTH 261 – Applied Calculus I students typically scored in the neutral range for all three constructs. In reference to attitude, on average, MTH 264 – Calculus II students scored the highest (*M* = 3.88, *SD* = .56) followed by MTH 167 students (*M* = 3.86, *SD* = .59) and MTH 263 students (*M* = 3.72, *SD* = 1.13). Courses with students who generally scored within the neutral range for attitude were MTH 162 – Pre-Calculus II (*M* = 3.44, *SD* = 1.02), MTH 161 – Pre-Calculus I (*M* = 3.38, *SD* = .90), MTH 245 – Statistics I (*M* = 3.37, *SD* = .98), MTH 111 - Basic Technical Mathematics (*M* = 3.07, *SD* = .90), MTH 261 – Applied Calculus I (*M* = 3.04, *SD* = .71), and MTH 154 – Quantitative Reasoning (*M* = 2.71, *SD* = .89). The one student in MTH 130 - Fundamentals of Reasoning scored within the low range (2.00) for attitude. No other mean scores fell within the low range. In reference to high range self-efficacy, MTH 245 – Statistics I students tended to report the highest (*M* = 4.05, *SD* = .87) followed by MTH 167 – Pre-Calculus with Trigonometry (*M* = 3.89, *SD* = .64), MTH 161 – Pre-Calculus I (*M* = 3.64, *SD* = .77), MTH 162 – Pre-Calculus II (*M* = 3.62, *SD* = .97), MTH 111 – Basic Technical Mathematics (*M* = 3.60, *SD* = .75), and MTH 263 – Calculus I (*M* = 3.60, *SD* = .96). Courses where students typically reported having neutral self-efficacy were MTH 264 – Calculus II (*M* = 3.40, *SD* = 1.23), MTH 261 – Applied Calculus I (*M* = 3.36, *SD* = 1.15), MTH 154 – Quantitative Reasoning (*M* = 3.28, *SD* = .89), and MTH 130 – Fundamentals of Reasoning (2.80). Courses where students generally reported high value were MTH 264 – Calculus II (*M* = 4.13, *SD* = 1.02), MTH 167 – Pre-Calculus with Trigonometry (*M* = 4.10, *SD* = .62), MTH 263 – Calculus I (*M* = 3.72, *SD* = 1.07), MTH 162 – Pre-Calculus II (*M* = 3.68, *SD* = .76), MTH 161 – Pre-Calculus I (*M* = 3.60, *SD* = .61), and MTH 154 – Quantitative Reasoning (*M* = 3.56, *SD* = .68). Courses where students tended to report neutral value were MTH 245 – Statistics I (*M* = 3.48, *SD* = .85), MTH 111 – Basic Technical Mathematics (*M* = 3.42, *SD* = .82), MTH 130 – Fundamentals of Reasoning (3.33), and MTH 261 – Applied Calculus I (*M* = 3.28, *SD* = .93). See Tables A3, A4, and A5 in Appendix A.

Overall score frequencies were then run to determine individual participants' score spread for qualitative interview sampling. Based on the distribution of overall scores, approximately 10% of the participants scored in the low range, 36% scored in the neutral range, and 54% scored in the high range. A frequency histogram (Figure 2) was created to model this data. Further, a clustered bar chart (Figure 3) was created to model the participants' overall score by gender and race.

Figure 2

Overall Score Distribution Histogram for Qualitative Sampling

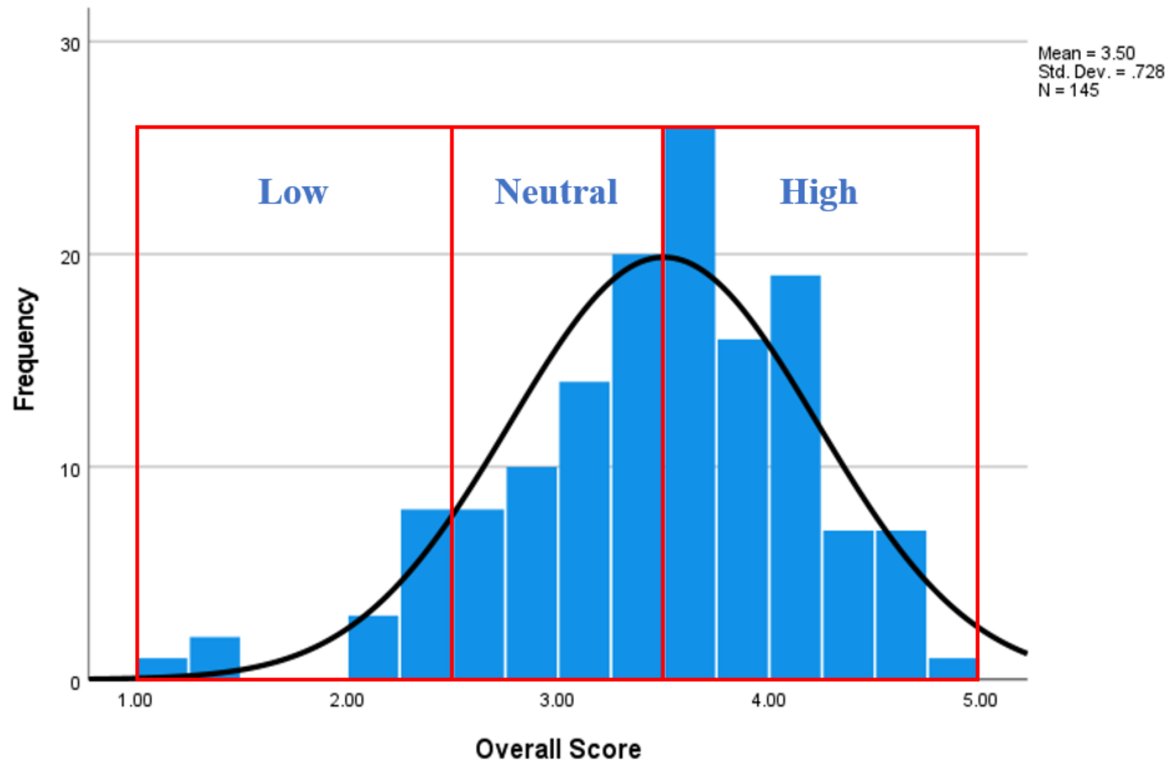
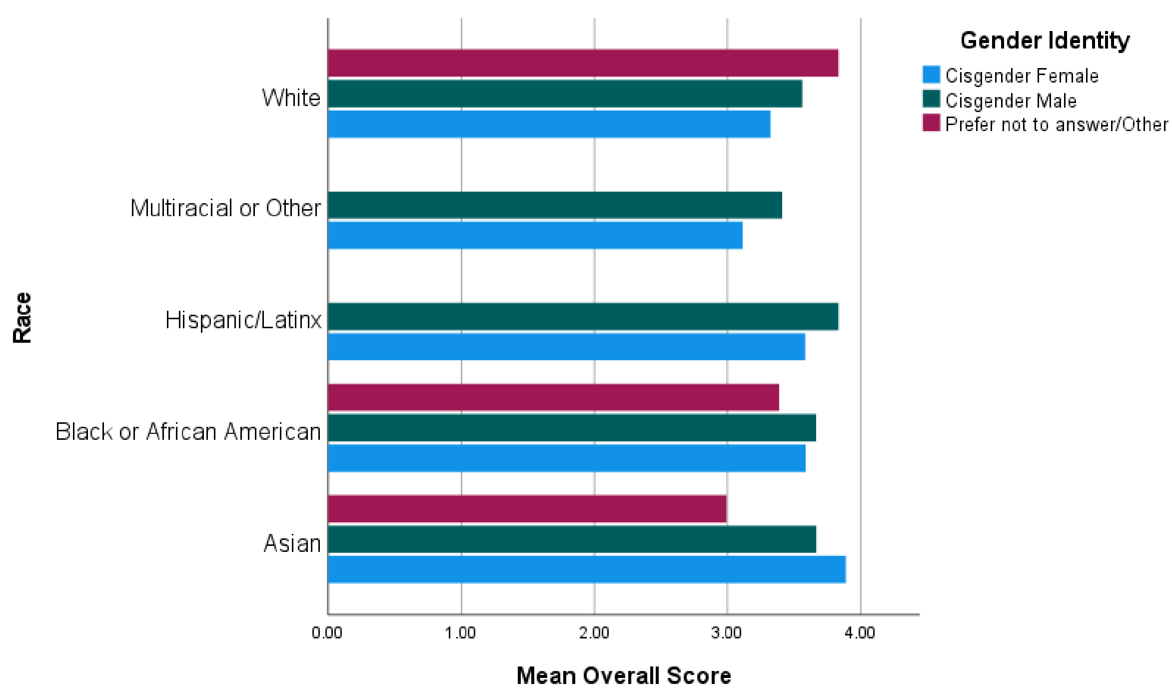


Figure 3

Overall Score by Gender and Race Clustered Bar Chart



Frequencies were also disaggregated by score range (i.e., low, neutral, high) according to gender, race, and course. According to these values, approximately 11% of female participants scored in the low range, 39% scored in the neutral range, and 50% scored in the high range while 8% of male participants scored in the low range, 29% scored in the neutral range, and 63% scored in the high range. No Asian or Hispanic/Latinx participants scored in the low range. Approximately 41% of Asian participants scored in the neutral range while 59% scored in the high range. Approximately 33% of Hispanic/Latinx participants scored in the neutral range while 67% scored in the high range. Approximately, 4% of Black participants scored in the low range while 39% scored in the neutral range and 57% scored in the high range. Approximately 13% of White participants scored in the low range while 33% scored in the neutral range and 54% scored in the high range. Approximately 23% of Multiracial/Other participants scored in the low range while 38.5% scored in both the neutral and high range. Approximately 17% of MTH 111 – Basic Technical Mathematics participants scored in the low range while 33% scored in the neutral range and 50% scored in the high range. The one MTH 130 – Fundamentals of Reasoning student who completed the survey scored in the neutral range. Approximately 21% of the MTH 154 – Quantitative Reasoning participants scored in the low range while 41% scored in the neutral range and 38% scored in the high range. Approximately 3% of the MTH 161 – Pre-Calculus I participants scored in the low range while 42% scored in the neutral range and 55% scored in the high range. None of the MTH 162 – Pre-Calculus II or MTH 167 – Pre-Calculus with Trigonometry participants scored in the low range. However, approximately 60% of the MTH 162 participants scored in the neutral range and 40% scored in the high range while approximately 21% of the MTH 167 participants scored in the neutral range with 79% scoring in the high range. Approximately 9.5% of the MTH 245 – Statistics I scored in the low range while

28.6% scored in the neutral range and 61.9% scored in the high range. Approximately 11% of the MTH 261 – Applied Calculus I participants scored in the low range while 33% scored in the neutral range and 56% scored in the high range. Approximately 8% of the MTH 263 – Calculus I scored in the low range while 25% scored in the neutral range and 67% scored in the high range. No participants in MTH 264 – Calculus II scored within the neutral range. However, 20% scored in the low range with the remaining 80% scoring in the high range. Please see Table 9 for counts.

Table 9

Overall Score Range Counts by Gender, Race, and Course

		Overall Score Range		
		Low	Neutral	High
		Count	Count	Count
Gender Identity	Cisgender Female	9	32	41
	Cisgender Male	5	17	37
	Prefer not to answer/Other	0	3	1
Race	Asian	0	9	13
	Black or African American	1	11	16
	Hispanic/Latinx	0	2	4
	Multiracial or Other	3	5	5
	White	10	25	41
Course	MTH 111 - Basic Technical Mathematics	1	2	3
	MTH 130 - Fundamentals of Reasoning	0	1	0
	MTH 154 - Quantitative Reasoning	7	14	13
	MTH 161 - Pre-Calculus I	1	14	18
	MTH 162 - Pre-Calculus II	0	6	4
	MTH 167 - Pre-Calculus with Trigonometry	0	3	11
	MTH 245 - Statistics I	2	6	13
	MTH 261 - Applied Calculus I	1	3	5
	MTH 263 - Calculus I	1	3	8
	MTH 264 - Calculus II	1	0	4

A bivariate correlation analysis was conducted to examine the associations between students' course level, gender, race, math attitude, math self-efficacy, math value, and overall math view/belief (i.e., average of attitude, self-efficacy, and value scores). See Table 10.

Table 10

Correlations

		Course	Gender Identity	Race	Attitude Score	Self-efficacy Score	Value Score	Overall Score
Course	Pearson Correlation	1	.08	-.04	.27***	.12	.08	.19*
	Sig. (2-tailed)		.36	.66	.00	.17	.35	.02
	N	145	145	145	145	145	145	145
Gender Identity	Pearson Correlation	.08	1	-.05	.15	-.01	.04	.08
	Sig. (2-tailed)	.36		.58	.07	.92	.67	.36
	N	145	145	145	145	145	145	145
Race	Pearson Correlation	-.04	-.05	1	-.11	-.15	-.14	-.16
	Sig. (2-tailed)	.66	.58		.20	.08	.09	.06
	N	145	145	145	145	145	145	145
Attitude Score	Pearson Correlation	.27***	.15	-.11	1	.58***	.60***	.88***
	Sig. (2-tailed)	.00	.07	.20		.00	.00	.00
	N	145	145	145	145	145	145	145
Self-efficacy Score	Pearson Correlation	.12	-.01	-.15	.58***	1	.45***	.82***
	Sig. (2-tailed)	.17	.92	.08	.00		.00	.00
	N	145	145	145	145	145	145	145
Value Score	Pearson Correlation	.08	.04	-.14	.60***	.45***	1	.79***
	Sig. (2-tailed)	.35	.67	.09	.00	.00		.00
	N	145	145	145	145	145	145	145
Overall Score	Pearson Correlation	.19*	.08	-.16	.88***	.82***	.79***	1
	Sig. (2-tailed)	.02	.36	.06	.00	.00	.00	
	N	145	145	145	145	145	145	145

***. Correlation is significant at the 0.001 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Course level was significantly correlated with math attitude ($r = .27$, $p < .001$) and overall math view/belief ($r = .19$, $p < .05$). Math attitude was also significantly correlated with math self-efficacy ($r = .58$, $p < .001$), math value ($r = .60$, $p < .001$), and overall math view/belief ($r = .88$, $p < .001$). Additionally, math self-efficacy was significantly correlated with math value

($r = .45$, $p < .001$) and overall math view/belief ($r = .82$, $p < .001$). Further, math value was significantly correlated with overall math view/belief ($r = .79$, $p < .001$).

Qualitative Strand

A total of 108 (10 low, 35 neutral, 63 high) from a total of 145 students indicated that they were willing to participate in future research. From this group, 8 students who fell in the high, 10 students who fell in the low, and 12 students who fell in the low-neutral groups from the Fall 2021 or Spring 2022 survey were contacted. Interviews were conducted with the total of six community college students (three high, three low overall scores) who responded to the email to schedule an interview. This sample of students included 4 males (1 Asian male with high overall score; 2 White males with high overall score; 1 White male with low overall score) and 2 females (1 Multiracial female with low overall score; 1 White female with low overall score) who were enrolled in Quantitative Reasoning (MTH 154), Pre-calculus I (MTH 161), Pre-calculus with Trigonometry (MTH 167), Statistics I (MTH 245), or Calculus II (MTH 264) at the time of their quantitative survey completion. I first present participant bios to describe each student in my case study, focusing on their unique characteristics, math learning experiences, and math views and beliefs. Research questions then follow along with rich descriptions of resultant themes and supporting sample quotes.

Student 1. Student 1 is a self-identified Asian male who completed both the quantitative survey and interview during the spring semester while being enrolled in an in-person MTH 245 – Statistics I course. His overall Math Attitude, Self-Efficacy, & Value survey score (4.46) was in the high range (i.e., 3.5 to 5). His disaggregated scores were 4.20 (attitude), 5.00 (self-efficacy), and 4.17 (value).

Student 1 is from Vietnam and had a much different experience there than here in the

U.S. Prior to interview start, he stated that he was not really interested in math, but that he believes the subject is the best instrument to help him achieve his goals more quickly. He also mentioned that he was pleased to know that someone was examining math views and beliefs and asserted that his friends dislike math and avoid discussing the subject at all costs. Once the interview began, he spoke a lot about the belief that there are a set number of intelligences and his belief is that these intelligences are innate, but can also be heightened with practice. However, he believes that only a certain level of expertise can be reached according to an individual's natural-born intelligence. He believes that math is important, gratifying, useful, and worth the time/effort expended. He doubted his math ability in Vietnam, but has an increased sense of confidence in the U.S. due to the feeling of mathematics being more of a refresher here. He does not have a set belief about people that are mathematicians or people who are good at math outside of them specializing in math-related fields due to personal choice based on innate intelligence. He related experiences of failure, challenge, and being reprimanded to feelings of low ability/confidence. He believes in gender disparities when it comes to treatment in Vietnam, but does not believe the same for the U.S. He believes that caring, friendly, encouraging, and supportive teachers can change student views.

Student 2. Student 2 is a self-identified White male who completed both the quantitative survey and interview during the spring semester while being enrolled in a live-online MTH 167 – Pre-calculus with Trigonometry course. His overall Math Attitude, Self-Efficacy, & Value survey score (4.69) was in the high range (i.e., 3.5 to 5). His disaggregated scores were 4.40 (attitude), 5.00 (self-efficacy), and 4.67 (value).

Student 2 has an extraordinary passion for mathematics, but indicated that was not always the case. He expressed that maturity level and observance of life-relevant application had a lot to do with the change in his math views and beliefs. Having attended college earlier in life with no interest in taking math courses and later returning to specialize in mathematics, he believes that mathematics ability is an acquired skill that can be developed with effort and time, given the appropriate context of space, stimulus, individual circumstance, and support. He believes that math is important and useful for everyone, to a certain degree. He, personally, enjoys engaging with mathematics and attempts to relate it to much of what he observes in life, both inside and outside of school. He does not attach a specific characteristic to his idea of a typical mathematician outside of them being intrigued by numbers. However, he believes that an individual's gender and race plays a role in their experiences with mathematics. He related an experience of having a low grade and subsequent disparaging remarks from his teacher to feelings of low ability/confidence earlier in life. He expressed that society has a general negative connotation regarding math that promotes a lack of interest in the subject very early on in life. He suggested that teachers who consistently show their love for mathematics, relate math to relevant real life applications, reach out to their students, and offer positive affirmations have the potential to impact students' perceptions of math.

Student 3. Student 3 is a self-identified White male who completed the quantitative survey during the fall semester while being enrolled in a live-online MTH 264 – Calculus II course. His overall Math Attitude, Self-Efficacy, & Value survey score (4.67) was in the high range (i.e., 3.5 to 5). His disaggregated scores were 4.40 (attitude), 4.60 (self-efficacy), and 5.00 (value). He completed the interview during the spring semester while being enrolled in an in-person MTH 267 – Differential Equations, which was not a course included in the quantitative study due to its class meeting time of 7:40pm to 9:05pm.

Student 3 declares math as his favorite subject and believes that math ability can be innate, but can also be an acquired skill as he has seen strong examples of both. He personally differentiates his math learning ability based on class mode (i.e., virtual versus in-person) and believes that in-person is best for him. He also distinguishes between school-related tasks and tasks that arise in daily life when it comes to his own confidence level. Experience with difficulty was perceived as a direct relation with ability and more difficulty was observed relative to school-related tasks with unsupportive teachers who did not teach in a manner he thought to be conducive to his preferred learning style. He sees mathematics as exceedingly important and useful, but according to individual interests. He has a view of the typical mathematician based on the standard depiction of them on television and in theaters (e.g., “nerdy” with glasses, enamored with nonstop math tasks all day, every day). However, he indicated that anyone can be “good at math” with practice. He emphasized the high influence that teachers have on students’ views of math. He suggested that approachable teachers who reach out to students, provide greater details while teaching or helping students, and offer alternative methods to problem solving are better able to improve students’ perceptions of mathematics.

Student 4. Student 4 is a self-identified White male who completed the quantitative survey during the fall semester while being enrolled in an in-person MTH 161 – Pre-calculus I course. His overall Math Attitude, Self-Efficacy, & Value survey score (2.43) was in the low range (i.e., 1 to 2.49). His disaggregated scores were 2.40 (attitude), 2.40 (self-efficacy), and 2.50 (value). He completed the interview during the spring semester while being enrolled in another in-person MTH 161 course as well as an in-person MTH 154 – Quantitative Reasoning course, both of which were included in the quantitative study. However, the student did not complete the survey again during the spring semester.

Student 4 was not as verbose and required much more probing than the other interview participants. He did, however, readily assert his dislike for mathematics due to his perspective that the subject is naturally challenging. He shared that he tends to get frustrated and overwhelmed with school-related mathematical tasks often. His view of mathematics is perceived to be directly connected to his self-proclaimed low grasp of mathematical content. Due to his apprehensions with respect to math, he avoids taking mathematics courses in modes that are not taught fully in person. He does acknowledge that there are aspects of basic mathematics that can be easier to understand and valuable with respect to real life. He believes that mathematical knowledge can be developed with effort, but also believes that math ability may be innate for some people, although uncommon. He does not have a specific type in mind with regard to those who are able to be successful with math outside of those who simply have a natural ability to complete tasks related to the subject. He believes that sociable teachers who have positive dispositions, communicate mathematical ideas clearly to students, relate mathematics course objectives to real life, and include a little humor during lecture have the ability to positively influence students' views and beliefs related to mathematics.

Student 5. Student 5 is a self-identified Indigenous American & White female who completed both the quantitative survey and interview during the spring semester while being enrolled in an in-person MTH 154 – Quantitative Reasoning course. Her overall Math Attitude, Self-Efficacy, & Value survey score (2.30) was in the low range (i.e., 1 to 2.49). Her disaggregated scores were 1.40 (attitude), 2.00 (self-efficacy), and 3.50 (value).

Student 5 freely proclaims her dislike for mathematics, but indicates that it is completely due to her not understanding the subject. She made it clear that it was highly probable that she would like math if she had a better understanding of it due to its interesting nature. She believes that mathematics is needed, but asserted that it isn't a current priority of hers despite the fact that she believes it should be. She was sure to differentiate her perceptions from others and stated that she personally feels that completing school-related math tasks takes too much of her time and effort while producing inadequate results. She openly admits that this may not be the same for others and expressed that math ability is both innate and fixed. However, she also believes that spending additional time with the subject may be beneficial if doing so leads to comprehension. She does not believe that her school-related math ability is directly connected to the mathematical tasks she encounters in her daily life. In the real world, she is confident in her capability to perform simple mathematical computations, but believes she will "freeze" if ever presented with situations requiring any mathematics she regards as complex. Her view of those who are particularly successful at mathematical endeavors is solely based on cognitive ability and not based on any physical or social characteristics. She expressed that failure and negative attitudes toward mathematics leads to low interest and lack of confidence in math. She feels that teachers who reach out to their students, teach to varying learning styles, hold study sessions outside of class for extra credit, provide supplementary rewards, and offer uplifting words of encouragement have the ability to improve student views and beliefs with respect to mathematics.

Student 6. Student 6 is a self-identified White female who completed the quantitative survey during the fall semester while being enrolled in an in-person MTH 154 – Quantitative Reasoning course. Her overall Math Attitude, Self-Efficacy, & Value survey score (1.39) was in the low range (i.e., 1 to 2.49). Her disaggregated scores were 1.00 (attitude), 1.00 (self-efficacy), and 2.17 (value). She completed the interview during the spring semester while being enrolled in an in-person MTH 245 – Statistics I course, which was also included in the quantitative study. However, the student did not complete the survey again during the spring semester.

Student 6 is extraordinarily dispirited with respect to mathematics. She views the subject as foreign language that overwhelms her, both physically and emotionally. She is of the belief that math is unidimensional and solely focused on getting an answer. Akin to that, she perceives mathematicians or people who are math experts as people who lack social depth and are fixated on answers as opposed to understanding the reasons behind those solutions. She considers people who are good with math to be rare and born with that ability. She also believes that it is possible for people who may not have a naturally high ability to be successful with mathematical tasks to get better with effort, but she feels that it would be particularly challenging and would necessitate a willingness to put forth a great deal of personal effort. She believes that basic mathematics is useful, but she does not see the relevance of college mathematics in her personal life. She feels that school-related mathematics, at any level, requires too much time and effort with no benefits. She indicated that she seeks support from teachers and tutors, but would appreciate it most from peers so that her feelings can be validated without judgment. She also suggested that student experiences with math vary and may be dependent on gender and/or race. She has had personal experience with judgments perceived to be due to her status as a female. In addition, she communicated her indirect experiences with disparities in the treatment of White versus minority students. She believes that students are mainly responsible for their own motivation and perceptions of math, but she expressed that teachers who give additional detail without assuming foundational knowledge, show that they care about their students, acknowledge students' effort, and give positive reinforcements could possibly encourage student efforts to be successful with mathematical tasks.

RQ2) *What is the nature of community college students' attitudes, self-efficacy, and values related to mathematics for students who report high or low views and beliefs in* *mathematics?*

A total of 6 themes emerged regarding the nature of community college students' math attitudes, self-efficacy, and values. These themes, described in more detail below demonstrated that a host of individual (e.g., perceived level of math understanding, cost and benefits of math, beliefs about nature of math ability) and math learning experiences (e.g., emotions experienced during math classes, social comparison) influenced the positive attitudes, high self-efficacy, and positive values among the students in the high group, and the inverse (negative attitudes, low self-efficacy, negative values) for the students in the low group. These are described in more detail below.

Perceived level of math understanding is associated with students' math attitude as well their self-efficacy, which may vary from course to course.

Students tend to hold positive attitudes toward mathematics at levels for which they understand. Students shared that when they are confused or feel like they are not able to comprehend the information in their math class, this experience was associated with negative feelings. Students from both the high and low view/belief range spoke to their liking of mathematics when they understand it and their displeasure or discomfort with levels they perceive as complex and beyond their capabilities. For example, Student 1 (high view/belief) expressed his imbalance of thought with respect to his own personal liking of mathematics. He stated, "I might like it, and I might not like it." He was very clear in explaining that he generally likes math, but not the higher level or more science-based mathematics. He further spoke on behalf of his peers and indicated that they don't like math because they find it hard to understand. For example:

"I have to study Calculus, Pre-calculus, and Applied Calculus I, and Statistics in order to transfer to a four year institution and because I'm familiar with those math levels. So, um I can do it easily and it's not a problem to me. So, I think I like it, but for those people that are not familiar with it, like my friends, because a lot of my classmates, they don't like math because they are not familiar with or because they find it so hard for them to understand and also the teacher, because they do the old school way, or maybe they go so fast during the lecture. So, I think that might be the biggest reason that they don't like math. … I like math, but just like not so scientific level… just like 100, 200 levels. That's it. Don't go further (Student 1)."

Student 5 (low view/belief) specifically stated that she would like math more if she understood it. For example:

"It's not my favorite subject, but mainly just because I'm not very good at it. … I feel like if I did understand math, I would like it so much more, but I know that when I do start to understand something, I'm like, oh, this is really like cool or, like, I like it. So, I feel like if I did understand it, I would like it more (Student 5)."

Similarly, she states:

"I've always, like, had a harder time understanding math. Like, there were certain things that I'd be fine with. Like, I did really well in geometry, but algebra and, you know, like even the class that I'm in now, it's just so difficult for me to understand. And I, like, feel like as soon as I start to understand it, I immediately forget it. So, I just, I don't know, because of that, I just never preferred it (Student 5)."

Students with lower or more negative views and beliefs with respect to mathematics tend to feel that the subject is more challenging than other subjects. All of the students with low views/beliefs described math as more complex and harder to achieve high grades in than other disciplines. For example, Student 4 pointed out the need to understand and apply in mathematics as opposed to simply memorizing answers:

> "I can understand basic mathematics, like you know, the kind we learned in elementary school, addition, subtraction, multiplication, division, but, you know, when I'm getting to stuff like algebra and things like that, it kind of gets more complicated. It's not like subjects, like history, where you just have to memorize certain things and where most of the questions on your test will be multiple choice or true or false. It's kind of where you have to understand how to solve problems, and then, you know, apply them (Student 4)."

Student 6 constantly spoke about her math grades in comparison with all other subjects. She mentioned that she dropped out of college years prior due to not being able to pass a developmental math class, but decided to try again. She, unfortunately, sees math as an academic gatekeeper preventing her from being able to earn an associate's degree as it is currently the only degree requirement she identified as holding her back from graduating. For example:

> "I just really think that math will be the sole reason that I possibly don't finish college. Because, like, I've got B's, A's, then you look at my math grade, it's a D or an F. Like, things just aren't lining up. I'm good at the rest of the school (Student 6)."

Students with high versus low math views and beliefs vary in the perceived costs and benefits of investing in math.

Students who hold lower or more negative views and beliefs about math also tend to feel that mathematics requires a lot of time and effort, but they believe that time may be too time consuming and not personally worthwhile due to subsequent math outcomes. They use other subjects as a comparison in support of their claims, but they mostly feel that the additional time and effort needed is due to their level of understanding and inability to easily grasp the material. For example, Student 4 stated that the nature of mathematics is that much more is required for understanding than other subjects and also attributed time consumption to the amount of steps needed to solve problems:

> "Well, to say the least, I think it does take more time than most subjects … It might just be the way math itself is all laid out. As I've told you, it's different than most subjects and it kind of takes more time to actually get used to it. … A lot of math problems, they require so many steps. I guess a lot of people just look at the problems and go…*grabs head* (Student 4)."

Students 5 and 6 spoke about the added effort they must expend in an attempt to understand the material, including a constant need for tutoring, and then having the feeling of defeat after their efforts are perceived as unhelpful as evidenced through course grades. For example:

> "For me, I feel like it requires a lot of time just because I find things harder to understand. If maybe I was like better at math, like it wouldn't take up as much of my time. Like, I'd be able to like solve things quicker or understand problems faster, but because it takes me so long to understand something, it just takes me so much time to do work and, you know, make time like to just finish everything. So, again, I think that's something that can be different for everyone, but for me personally, it is a very like time consuming thing … I'm like spending hours trying to understand like, you know, how to solve something and I still don't get it and I'm like, well, that was just, you know, hours wasted on not understanding something (Student 5)."

> "Not in the terms of how much they assign. It's just based off of, like, the tutoring, like, how much extra effort I have to put in. … Way too much. … I don't feel like what I'm gaining from it is equal to the stress and tears that I'm putting into it (Student 6)."

Students who hold higher or more positive views and beliefs about math tend to feel that mathematics requires time and effort, but they believe the time spent is necessary and advantageous. These students acknowledge that learning math and performing novel or unfamiliar mathematical tasks may take more time than other subjects. However, they feel that learning anything requires some effort and time. They find that the time and effort spent shows and improves their understanding. For instance, Student 2 spoke about his teacher's detailed advice on the time allotment needed to be successful in his math course:

> "[S]he told us when we first started the class this latest class that we should make sure to a lot like 15 to 20 hours a week for this class. I think that was including the class time, but I can't remember. Either way, it was like, it was a lot. As soon as she said it, I was like that's a part time job. Is it too much? I don't know the answer to that, in part because, like I so quickly fell in love with it that like, for me, it's not too much. It's my favorite part of my week … It doesn't feel like too much to me and it certainly feels worth it. But it does, it is a lot, it is a lot of time to do math coursework. So, yeah. I could see why others might feel that it was too much. I don't know another way around it. Because I like, you kind of need that much time to truly understand the concepts, to be able to like repeat those results, you know. (Student 2)."

The student likened that time allocation to that of a part-time job, but expressed his joy in spending that time with math. He stated that he didn’t feel it was too much for him and that he believes that much time is required to thoroughly comprehend mathematical concepts. Although, he empathetically conveyed that he could see how it would be too much for others.

Students perceive high-level math ability as innate, but also believe that a certain level of success can be achieved with effort.

While most students feel that mathematics ability can get better with effort, they also believe that math proficiency comes easier to certain people and the level to which “non-math” people excel has a limit. Students were able to give concrete examples of people, such as themselves, family members, or peers who they regard as naturals at math or as people who simply don’t take well to mathematical tasks but excel in other areas. For instance, Student 1 spoke a lot about a set number of intelligences available and implied that people tend to be a certain type of intelligent such that they are not able to perform as well in areas external to their natural intelligence:

> “I mean like, you cannot reach like the high level, but you can reach like mid-level, like or 100 level if you just like practice doing it, you’re eventually familiar with it. … [W]hen you’re born, you have something like, you have skills or something that you were born with it. You were born with like, like people can do painting, but those people cannot do painting. Yeah. Yeah so, like people were failing math classes because they were not that kind of intelligent (Student 1).”

Students 3 and 6 also described fixed beliefs about math, sharing examples of people in their lives who seem to have a natural ability for the subject. As shown in the quotes below, students described math ability as a trait, rather than as a set of knowledge and practices that is developed over time:

> "I feel like it's definitely something that gets better with time, but I also feel like certain people are better with numbers and certain people aren't. Like, it's just kind of a thing that comes to you because, in my family, like, me and my dad are super good with numbers, but my mom is better with words, like English stuff. And so is my sister, but yeah, for some odd reason, that's been how it is. My dad's mom is really good with numbers, though. I will say that. So, I just feel like some people are better with words and some people are better with numbers (Student 3)."

> "I definitely think you're hardwired because my dad can divide weird numbers in his head and he doesn't even have to think about it, but I can barely do the multiplication tables. So, I really think people are born with it. *[Do you feel that it is possible for people to learn math and get better with effort?]* Yeah, definitely. It just will never come easily to them. They'll have to work to be good at it (Student 6)."

According to most of the students, although some people are born with a natural aptitude for mathematics, it is not a prerequisite for success.

Math avoidance behaviors are linked to students with low or negative math views and beliefs.

Students with low or negative views and beliefs of mathematics tend to purposely avoid the subject and often seek knowledge from advisors in an effort to complete the bare minimum quickly. For example, Student 2 indicated that this was his second attempt at attending community college after 10 years. He admitted that he was not fond of mathematics earlier in life, especially during his first try at community college, and stated that he avoided math “like the plague.” At that time, he requested what he deemed to be the easiest math so that he would be “done with math forever.” He now loves math so much that he switched his major to science with a concentration in math:

> “I actually did school, I did college like 10 years ago and now I’m going back to school. My first time through college, like, I tried to avoid math like the plague. And then, just like two weeks ago, I changed my major to mathematics. So, it’s been kind of a full swap … [I]n my first round, I took statistics in an effort to like take what I was told by the counselor was the easy math. I took statistics my very first semester of college back in 2008 or whatever and then just was like, I’m done. No more math. I’m done forever. I never need to touch another number. And then upon returning to college, like I, you know, I literally changed my major to mathematics. Like, there’s never enough math anymore. (Student 2).”

Student 2 attributed his change in math view to age/maturity, life experience, and personal interests. He explained that he was never really interested in or open to math when he was younger. As he matured in age, he realized how much it connected to real life. He acquired a passion for creating spreadsheets for various purposes, primarily to keep track of data (e.g., video game results). He also found that math was closely related to his original choice in major (i.e., art) as well as his job as a computer-aided (CAD) designer:

> “I started working for my dad as a CAD designer and numbers play heavily into that. I got interested because it was like art, which is what my original major was. And then, and then yeah, the more that I, it was like almost just a realization of how much numbers have become important to me. I didn’t even, they snuck up on me, like, I didn’t realize,

you know, how much I kind of enjoyed them. I always had sort of a negative connotation of math as it kind of fit into the educational, my educational timeline, you know (Student 2)."

Student 5 also mentioned that she sought to complete her math requirements immediately as well. However, she confessed that without that advice, she would be avoiding math all together and would not be in her current math class:

> "[M]y first semester, I did not take a math course. It was purposeful because it was my first semester of college and I knew I hadn't taken a math class in a while and I wanted to, like, I don't know, because I didn't know what to expect when starting at PCC. So, I just wanted to, like, ease my way into it and I was like, oh, I'll just take one next semester. And then, when I met with my advisor he suggested this math class, the one I'm currently in. … I don't know if I would have taken one this semester (Student 5)."

Similarly, Student 6 shared that her advisor played a significant role in choosing to take a math class, but was not looking forward to it because of her association between math and failure:

> "I tried to get them all knocked out in the beginning per my advisor's lovely recommendation, which I commend them for and I'm on my last one, statistics. … But, I didn't put them off because I know I wouldn't have been a happy camper. … I just don't want to think about it anymore because I'm associating math with college and failing. So, let's get that out of the way (Student 6)."

Students in the low group only see the relevance of basic mathematics concepts and skills in out-of-school contexts whereas students in the high group cited complex math problems in

the real world.

Students with lower or more negative views and beliefs of mathematics tend to feel that only basic mathematics is needed in their personal lives outside of school and are more confident in their ability to complete those mathematical tasks versus school-related tasks they perceive as more complex. Although, these students did express that they would not be confident in the math ability if something more complex did appear in their lives outside of school. For example, Student 4 indicated that he considers school-related math to be worthless in his personal life, and if the situation ever arose, he would not be confident in his ability to successfully complete those tasks:

> "Sometimes I, how do I put this? How do I feel about the ability to use it outside of school? Well, I think most of the time, I don't really see how useful it is. I've never really been seeing it come up, but if it ever was to, then, I wouldn't say I'd feel very confident about, you know, how to use it (Student 4)."

Student 5 similarly stated that she would not feel confident having to complete complex math tasks outside of school, but doesn't anticipate the need to as she doesn't foresee such tasks coming up:

> "If it's something that's simple, I'm like fine with it, I can do it. But if it's like, you know, a big complicated problem, I'll probably just stare at it and not know what to do. … [T]he most I would get would be like, like at work or something it would be like, oh, how many of these things do we need if, you know, we're taking out like, because I work at Starbucks and, like I don't know, I think there's like just small little instances where you have to do like quick, simple math and that like I'm completely fine with. But, like,

in my day to day life, I don't really have like complex math problems coming up other than like math class, you know. That's about it (Student 5)."

Students with higher or more positive math views and beliefs tend to perceive real-world mathematical tasks as more than surface-level math, which makes them question their ability to be successful in completing mathematical tasks in the real world, broadly. When asked about their ability to complete mathematical tasks outside of school, they typically started talking about complex situations that are either out of the realm of their interest or levels of math for which they have yet obtained knowledge in. For instance, in response, Student 1 noted that his current level of knowledge is not at the highest level possible and how he still has much to learn in order to achieve his goals:

"[N]ot so good, but I can use it. Not use it regularly, I would say yeah, but I'm not so good at it. … [T]here are many more things that I don't know. Like, statistics is specialized in business. Statistics is specialized in accounting a lot more than I have studied and those that I'm not familiar with. So, yeah. Sometimes, I think about it and I'm like, I don't know (Student 1)."

Relatedly, Student 2 explained that he constantly sees math in his daily life and gets excited about learning more so that he will soon be competent in more complex arenas related to math:

"I actually, like I was just complaining about this to my girlfriend, but I feel like I keep having an idea of like, we'll learn something in math class and I'll have an idea for how I want to toy with the numbers in something that I'm working on. But it doesn't quite match the equation that we've learned or the concept we've learned. And so, I start digging around for what equation, like will help me and I'll get to this one where it's like

> I don't even know what half of the symbols on the sheet mean. It's like, I honestly feel like I'm excited for in two or three years when I have way more math under my belt to apply to real, my real life situations and questions. But yeah. In general, math is constant for me. … It's like I'm now becoming aware of all the things that I don't know yet, you know (Student 2)."

Students with higher or more positive math views and beliefs tend to feel that a certain level of mathematics knowledge is important with respect to success and their personal aims. The students expressed that it was pertinent for them to understand and do well in mathematics so that they could earn their degree, understand and apply math to the real world, make more money, and have the ability to make decisions through logical thinking. For example, Students 1 and 2 stated:

> "[M]ath is important to me. I need it to earn more money. … So, the best ways that I have to perform well in my classes to work toward that goal GPA so I can successfully transfer to [local university] or [semi-local university]. So, yeah. That's the reason why I have to perform well in math. Have to. Yeah, it has a lot to do with my future (Student 1)."

Student 2 further acknowledged the general importance of foundational mathematics:

> "I think it's important for everyone. I don't know how important. I'm still learning it. So, I will know this better in the future, but I don't know how important like, after a certain degree, right, after a certain point in mathematics, it's probably not a whole lot of real-world applications for most people. But definitely having a base level understanding of mathematics seems you know, dare I say crucial to success in the world (Student 2)."

Students with lower or more negative math views and beliefs acknowledge the importance of mathematics, but do not attach it directly to their current personal identity. For example, Student 5 consistently emphasized that while she believes some people need mathematics for their careers, she does not find high school and college level mathematics to be personally beneficial:

> "I do think math is really important. Like, I know it's something that most people probably do need, like for you know, careers or just in life. Like, math is something that comes up a lot. For me, right now, I don't know if I'd consider it like my top priority, which I feel like it probably should be. But, right now, it's not super important to me, but I know it probably should be (Student 5)."

Students typically find foundational mathematics to be useful with respect to life and feel that higher levels of mathematics are useful to others depending on their personal interest or chosen career. For instance, Student 1 asserted that lower levels of Calculus are helpful for his future, but that higher levels are not personally necessary. He specifically referred to Calculus I and II as basic mathematics courses, which is not necessarily the same for other students. Especially those with non-STEM interests or backgrounds. He stated the following:

> "[S]o, I mean like for a certain level, like just do basic math, do like Calculus I, Calculus II. I'm fine with that. Just like cuz those are, I think those are helpful for my future, but like upper levels, like Calculus III, those are I don't think are gonna, because those are the, because people using Calculus III and the equivalent level, they are, must be, you must be like, like you, you're a major in math or those people are scientists or, or

physicians because they use math for, for bigger problems but, for me, I just need math to use in maybe accounting, maybe in economics … [M]ath is everywhere in our daily life. (Student 1)."

Further, Student 3 indicated that mathematics, in general, trains students to think rationally and broadens their minds. However, he also stated that most of the necessary life skills are taught in grade school with mostly career-based mathematics being taught at the college level:

> "I do think it's very useful. I mean, everybody might not use every equation that they learned throughout their schooling, but I feel like they'll definitely use some of them. And just learning them is good for them to expand their mind. I guess it depends on what major you're going for. Because, I feel like you learn most of like the regular basic stuff that you need in life through high school, or not just high school, through your, you know, K through 12 years. And then, when you get to the college level, you're learning more career-based kind of things. (Student 3)."

Of note, Student 5 suggested that her current class has no relevance to her current or future life:

> "I feel it is used in a lot of different things, like jobs and stuff like that. So, I do think it is useful and important. I guess it depends on what you're doing because, like, I mean with some of the stuff we learn in our class now, like, I don't see myself using all of that in the future, but like, I do think that some people might. So, I think it depends on what you plan to do career wise, or what you want to know because maybe some people are just taking math classes because they like math, I don't know. I think it just depends on what you're doing (Student 5)."

Student levels of satisfaction and enjoyment from mathematical tasks are associated with

their math views and beliefs.

Students with higher or more positive math views and beliefs tend to enjoy mathematics and reported even greater satisfaction from added mathematical tasks and mathematical challenges with successful outcomes. Both Students 1 and 2 specifically proclaimed their eagerness to tackle mathematical challenges and described the profound joy they feel when they are able to come up with correct solutions:

> "Whenever, the feeling, when you finish or you're doing the math problem well, like you come up with a good result or a good solution for that math problem like, the dopamine just comes into your brain. Yeah, it's kind of like that. It's like feeling, you know, satisfied. Yeah because whenever, I think you know this feeling too, because whenever the math is so hard, and you finally or eventually come up with a solution for it, you can feel that feeling. … [T]he harder the problem is, the better or the more satisfying it is when you come up with a solution for that problem (Student 1)."

> "So, I'd have to look up the right equation to do it and then apply my numbers to it. And the more I kind of did that, the more I felt like there was another one that was slightly more complicated that I wanted to try. … [F]rom day one of this math class, I became so enamored with like doing every math problem that she put in front of us just because, like that's how I want to spend my free time it seems like (Student 2)."

Similarly, Student 3 shared that he enjoys being viewed as the "go-to" person for math help, both in and out of school:

"I use mathematics all the time. So, it's kind of like, [Student 3] is the good one with math. Go ask him the problem because I don't know. I would say I enjoy doing math (Student 3)."

Students with lower or more negative math views and beliefs tend to report more negative responses to being given mathematical tasks that are perceived as challenging. They described several accounts of being overwhelmed with feelings of stress, frustration, anxiety, and defeat. For example, Student 4 shared the following:

"It can be overwhelming at times. Well, it can be frustrating, you know, when I'm working on trying to solve the problems because sometimes I'm wondering, where do they get all these numbers from? (Student 4)."

In particular, Students 5 and 6 indicated that when they see math, their "brain stops working" or they simply freeze and stare at the problems:

"Like, the problems, I can't even remember like specifically, like, what part of math it was, but like, I know there's been certain problems where, like, I've done it and I understand it, and then I enjoyed it, but then when I don't understand it, it kind of just frustrates me (Student 5)."

"Just, it doesn't click in my brain. Like, it looks like another language to me. My brain just gets overwhelmed the moment it sees numbers. … Flustered is probably the best way to put it. My brain just kind of stops working (Student 6)."

Taken together, the qualitative themes presented here provide insight to RQ2 regarding the nature of and differences between the math views and beliefs of students in the high versus low groups.

RQ3) *How do students' various identity markers (e.g., gender, race/ethnicity) and mathematics learning experiences relate to their attitudes, self-efficacy, and values in mathematics?*

A total of 5 themes materialized regarding students' gender, race/ethnicity, and mathematics learning experiences as they relate to their math attitudes, self-efficacy, and values. These themes, which are discussed in greater depth below, showed that while some students do not believe that identity markers are associated with their math views and beliefs, others directly and/or vicariously experience gender and/or racial bias and acknowledge its impact on their own or others' math attitudes, self-efficacy, and values in mathematics. Further, themes revealed that math learning experiences (e.g., mastery, social, emotional) had a reciprocal impact on students' math views and beliefs as they relate to their perception of who is able to be successful in math as well as their own attitude, self-efficacy and value with respect to math.

Half of the students (2 of 4 males; 1 of 2 females) reported that gender had no impact on their views or beliefs with respect to math. However, some of them have had direct and/or indirect (vicarious) experience with gender and/or racial/ethnic bias across different contexts.

Varying beliefs about women in math based on direct and vicarious experiences.

Student 1 referenced a pervasive bias against females in Vietnam with respect to overall aptitude, but he doesn't believe it exists in the United States. He implied that seeing so many female mathematics professors at PCC who are extremely intelligent allows for such judgment:

"Well, talking about gender. I don't think, I might have, but what I think it's, I don't

> have any, gender is not a problem, but those people over there, I think it's a problem. Yeah. Boys are smarter than girls. So, they appreciate boys more than girls. The U.S. don't have that issue. You see, because I have a lot of professors are women. Like, you, you know [current female teacher]? [Current female teacher] is so good. … So, yeah. I might think teachers, if teachers, if they are women, they're better. I think, because the way they, they just like mother, like mom, because they know how to do it softly, to deliver information to students, than men. Because men, when talking about men they like, they're not so what's the word? Let me translate it. I don't know. They're not so subtle (Student 1)."

Student 2 was candid about the conversations he had with a female friend who has a doctor of philosophy (Ph.D.) in mathematics who works for the National Aeronautics and Space Administration (NASA) about her experiences in academia as a student as well as a professor. He described how she communicated the many times she was overlooked, spoken down to, and treated unfairly by her teachers, supervisors, and colleagues solely because of her female status within the field of mathematics. Her perception was that many of her superiors and peers in the field underestimated her mathematics abilities because they view females mathematically inferior to males:

> "I will say that that friend that I mentioned, who got her PhD in math and now works for NASA, told me about like many stories along with, she went to out-of-state university, and so when I knew her well, we were like, that was two years or so that I was living in the same city as her, and she was telling me about all sorts of situations where like teachers or employers that were, like she worked as an Assistant Professor for a while and there were just many situations where she said that like, there would be her and her

three colleagues that were all kind of on the same level, and they were all male and if a project was being given out or whatever, she would just be last. If she was the only one, with nothing to do, she would be given the project. Otherwise, it kind of went to her colleagues and that's, I'm positive, just one of probably a daily occurrence. I'm sure that it does, I feel like math is one of those, is a particularly like a subject where like sexism and racism are probably quite ubiquitous. Being a White man makes it like, I don't, it's not in my line a vision as often, you know what I mean. But I'm positive that even that is like indicative (Student 2)."

Similarly, Student 6 indicated that she had many direct experiences of being looked down upon, talked down to, and facing additional judgment by male teachers or what she calls "math men" partially because of her gender:

"[B]eing a girl, sometimes a man will treat you, like a math person, math men, sort of have a different personality. I'm not trying to be all like women, she-power, that's not what I'm insinuating here. It's just how it is. … They'll definitely, if you don't quite understand something right off the bat, they'll judge you for it or talk down to you for it and I think being a woman plays into that too. But, that could be me making an assumption (Student 6)."

It is notable that the views and beliefs related to gender and math differed by cultural and geographical contexts (student referencing Vietnam gender norms versus students referencing U.S. norms).

Beliefs about racial minorities in math based on direct and vicarious experiences.

Students who identify as White may not have direct experience with racial bias that impacts their math views and beliefs. However, some of them indirectly experienced bias they perceive as connected to race and were empathetic to its reality. For example, Student 2 continuously spoke of the privileges that he perceives as being attached to his identity as a cis-gender White male. He declared that his academic journey has likely been made much easier than that of minorities, or females for that matter. He indicated that his racial identity, coupled with his gender, has shielded him from experiencing many of the challenges and trauma associated with being a minority (e.g., micro-aggressions, macro-aggressions, discrimination):

> "I would just assume that like part of why there has never been an over, sort of like, implication that I don't have the ability is because I am a cis-White male, right. There is a societal assumption that like a Cis-White male should be fine at math, right. So, like, yeah. I think my current path was made much easier than, it was already paved (Student 2)."

Student 6 stated that her racial identity (i.e., White) also made her academic pathway a little easier based on her ability to get the additional support and attention she needed. She spoke empathetically about incidents she has consistently been privy to where she witnessed the favoritism shown toward White students over minority students. She asserted that some teachers demonstrate, through their actions, their internal belief that non-White students do not deserve the same level of support as White students:

> "I sometimes imagine that it was easier for me to get the help that I needed because I'm White. I've felt that on more than one occasion. … There are some teachers, I'm trying to put this as delicately as possible, some teachers who believe that people who aren't White don't deserve as much support as the White children do and, now, they're never going to come out and say that, but it's very clear through their actions. And they're

making assumptions about non-White people and their abilities of life, in general. So, there are certain teachers who were known to, like, only pick on the White kids to answer questions or ask questions or all that stuff. Like, they were specifically known for that, by the students. So, I've never had any like firsthand experience with that, of course, but, like, I know it happened (Student 6)."

Ethnicity may have an influence on students' views and beliefs relative to mathematics. Students from other countries may have varying experiences with mathematics depending on their geographical location, having to do with sociocultural norms. Student 1 indicated that his views and beliefs about mathematics were much different when he was in Vietnam as his experiences with mathematics have been polar opposite:

"I'm a boy. So, those things are not so like traumatic for me, but if it is a girl, that definitely, yeah… because yeah, a lot of my girlfriends, I mean, it's not my like girl. I don't know what to say, girlfriends? Yeah. They are art majors and they got insulted by those people every time. … [M]ost of Asian countries, they think men are better than women. You know, it's what they think. You cannot change the ideology. It's always like that. So, I'm glad I'm here because gender equality, no discrimination (Student 1)."

As mentioned before, he stated that gendered ideas in Asian countries that males are more intelligent than females continue to persist. So, he declared that his experiences with math have been less traumatic because of it. However, he was still able to describe his feelings about the treatment of students based on academic ability and labels of intelligence, including his own. While in Vietnam, his math views and beliefs were extremely negative due to his academic outcomes and intelligence labels, so much so that he dropped out of school. Once he started attending community college in the United States, his math views and beliefs changed drastically. He understood the math content in his classes, began to feel more confident in his math abilities, and started to enjoy completing mathematical tasks. For example, he stated the following:

> "[I]n Vietnam, like, um, we have three majors that you have to be good at, in order to be to be recognized as a good academic student. And the first major is mathematics, second one is literature, and the third one is foreign language, which is English. … [E]very student in Vietnam has to take a test. It is a test you have to take in order to go to university. Yeah, but, if you fail the test, you can't go to university. You have to pass it and it depends on your grade. You can go to this like, a good school or just the normal school or a bad school. And in those tests, they have a lot of like mathematics level from 100 levels to 300 levels and… I mean, because I'm not interested in and I'm not good at math, I can do the best to the 200 levels. So, I did not perform well on that test. Yeah and when, and then I go to that unsuccessful, go to that university and my major was accounting, I studied there for one year and then I dropped out. I moved. Well, I moved with my family to the U.S. and so it's like, when I study over here, like in PCC, like everything is refreshed. It's so cool to me that the education system is so, I mean it's so, democratic (Student 1)."

Assumptions about individuals who are able to be successful with mathematics.

Although seemingly aware of ongoing gender and/or racial/ethnic inequities in the access to and perception of students in mathematics, students reported that they did not personally hold gender or race stereotypes as they relate to their perception of the typical person who can be successful with mathematics. Many students feel that math ability is irrespective of one's demographic characteristics. In response to the question, "What types of people are good at math?," Students 3, 4, and 5 replied:

> "Just like, your everyday person. Um, I don't know. Any size any, any color, any age, any whatever. I just feel like, an everyday person (Student 3)."

> "I just see them as another regular person. They just happen to be really smart at math. … I'd say it kind of all depends on the person (Student 4)."

> "I feel like anyone can be good at math and anyone can NOT be good at math (Student 5)."

Students tend to associate the ability to be exceptionally successful in mathematics with an individual's personal interests, self-efficacy, and aptitude as opposed to physical characteristics. They feel that the person must favorably "identify" in some way with the subject. For example, when asked to describe his view of the typical mathematician, Student 1 implied that it mostly has to do with a person's choice due to their fondness of math along with their confidence level and intellectual ability:

> "So, people, they choose or specialize in something, they must feel that they are good at something so that they can choose it. Like, for those people, they go to math. They just, they feel like they can do this one good, but they can they do this one better. Yeah, so they would choose it as their strong point. Like, they can do the calculus course, but when they go to statistics, they just feel like, this is for me. It's for me. It's not for

everyone else. Yeah, it's kind of like that. They just want to get into that problem and right away, they know the answer. I don't know. It's like something, yeah, again talking about the people that have intelligence in logical thinking (Student 1)."

Students 2 indicated that he had no specific definition, but that his assumption would be that they really enjoy doing math to the point of obsession. He was sure to mention that being good at math doesn't require the same level of passion and was more related to time spent working with math:

"I would have no idea how to, if someone said, like define typical mathematician, I wouldn't even know how to begin to describe that because it all feels so new to me. I will say that, like, that I know, I have two friends who both got their PhDs in mathematics and like one of them now works for NASA and like, if you had asked me what the average NASA employee was like, I wouldn't assume she was representative of that group, but like now, who knows, right. Like, now she is my only NASA representative into my brain. So, yeah. I don't know. The typical mathematician, I guess at this point, I would assume just someone like me, who like gets a little nerdy when it's time to manipulate numbers and like gets kind of excited about that idea, about drawing on a whiteboard. … [P]eople who are good at math, I think it's a much, much broader category. And that's just anybody, I would imagine who, either has an affinity for numbers or more commonly just spends most of their time dealing with numbers (Student 2)."

Student 5 made sure to separate her own personal identity from that of a typical mathematician. Her explanation had mostly to do with her perceptions of her own sense of lack of ability. For example, she stated:

"I consider people who do math as like a career, like really smart because I could never do that and, like I don't know, I just I've always been amazed at people who just like understood math like that well where they like make a whole career out of it and do big stuff (Student 5)."

Some students have an assumption that being extremely good at math is attached to someone highly intellectual and fastidious who may lack social skills. For example, Student 3 gave a very specific description of an individual who deals with math as a profession. He indicated that the person would be "nerdy" with glasses, math-absorbed, and possibly a gamer:

"I guess somebody that's definitely a nerdy person, like they're wearing glasses and everything's really neat about them. I feel like they'd be a very neat person. And maybe scrawny. I don't know. I've watched a lot of movies. So, definitely nerdy looking and glasses and scrawny, but also in their free time, I feel like they're either solving math problems or maybe playing a video game (Student 3)."

Student 6 specifically identifies them with being an anomaly who has no people skills:

"I guess, just like, a freak of nature in the best way possible. … [M]ath people don't have social skills (Student 6)."

These examples show that some students feel that being exceptionally talented with respect to math seems out of their reach or contradictory to the perception they hold of their own identity.

Mastery, social, and emotional experiences also have a bearing on students' math views and beliefs.

Experience with achievement outcomes impacted students' views and beliefs of mathematics. When students performed well, they tended to feel good and it boosts their motivation to repeat related behaviors or actions. This encouraged students to seek more knowledge and put forth efforts needed to feel that way again. When they didn't perform well, they tended to feel bad and avoid repeating the thing that made them feel that way. Student 5 communicated that her definition of achievement or success in mathematics is understanding and consistently indicated that having understanding in math would promote her liking of the subject and her willingness to engage with it more often. For example, she stated:

> "Understanding. Like, I feel like if I was able to understand what I was doing or, you know, the problems, how certain aspects of math work, like, I would feel successful. Like, I don't think it would matter even how long it took me to solve a problem as long as I understood what I was doing. I would consider that a win (Student 5)."

When asked what she believes causes a lack of confidence in math, she replied:

> "Failing. Like, I feel like, for me, it kind of started when I started like taking that one math class and I didn't do good and then I immediately was like, oh I don't like math, like I'm not good at it and I think people who don't have like a positive attitude towards it, probably don't get like a positive reaction from it. They don't put in as much effort (Student 5)."

Socially, students are aware of the negative connotation associated with mathematics. Many of them explained that a large number of the people they know, inclusive of family members, friends, and advisors/counselors, who dislike and/or are uninterested in math. Student 1 specifically stated that many people in Vietnam are not interested in math. For example:

> "[I]n Vietnam, they just think that you have only two kinds of intelligence. One is logical

> thinking and one is art and, I don't know, like critical thinking, yeah. So, there are a lot of people in Vietnam, they are not interested in math (Student 1)."

Others recounted how their friends and household family members avoid math and wince when faced with mathematical tasks. Student 2 explained that even his advisor questioned his request to switch to a math major and found it odd that he was that interested in math:

> "I feel like there's a really, really, people, especially, I think, parents and teachers alike, anyone who's not in math, even when I switched my math major just recently, the counselor I was talking to, like kept asking if I would sure, basically. Like, kept like trying to make sure. And she's like, you know, her background was much more in the social sciences arena, which is what I was changing my major from. And so, I think that, for her, she was just projecting that like she has a negative connotation of her own sort of experience with math and there was this like, she just wanted to make sure that I knew that would be a lot of work and I was like, … Yeah, I know. It's cool. You're good. But I think that that's pervasive in our society, right. I think that if you don't have, if you aren't gifted, that sort of like positive connotation of math, it's far more common to be gifted and then to adopt a negative connotation of math. And it's really easy. If you say like, you know, oh man f*** math, you're going to get a lot more people in the room with you, in any given particular room, who say like, yeah bro, totally, I hear you, which is interesting. I assume that has to start really, really early so that it can be that sort of ingrained that, like, for me, it took until I was in my 30's to even question that belief, right (Student 2)."

The student perceived this as a negative projection of the advisor's own views and beliefs of the subject. In addition, Student 4 asserted his view of math's high difficulty level as common knowledge despite there being people who are good at it. For example, he stated:

> "Well, even though, as I've told you, math can be difficult for me, I've realized that my view on math is not uncommon. Although, I do know that there are some people who are naturally good at it as well (Student 4)."

Students' emotional or physiological responses to mathematical tasks or outcomes are associated with their views and beliefs relative to mathematics. Students have positive emotions when they view or believe something to be enjoyable, interesting, and/or attainable. They tend to like the things associated with those feelings. Students 1 and 2 often expressed the positive sensations felt while working with math and their willingness to continue doing so. For example:

> "When you finish the problem, you come up with a solution, like, the feeling, it feels good. Feels good. But when you don't, you cannot come up with a solution, it feels annoying. Yeah, terrible. … [W]hen they find something hard, they probably don't like that thing (Student 1)."

> "I'm like stoked. Yeah. I find myself, when I like have free time, I find myself like going, well, what's next in math, in the math book, like maybe I can just move ahead, which I don't, I'm sure the shine will eventually wear off or something, but like right now, I'm just so stoked about the sort of like novelty of getting to do this much math, of getting rewarded to play with numbers this much (Student 2)."

On the other hand, students have negative emotions when they view or believe something to be unpleasant, inaccessible, and/or pointless. Some students, even further, experience uncomfortable physiological states with these negative emotions. For instance, Student 6 stated that she gets physically ill with stomach pains when she thinks about math:

> "It, like, literally makes my stomach hurt just thinking about it. … I've always hated it, but then in eighth grade, it became tied in with my self-esteem. … Yeah. It just always took way extra effort for me. But, I was always able to keep up until the eighth grade (Student 6)."

Parents, teachers, and other role models influence students' math views and beliefs.

Teachers, advisors, and tutors have a significant influence on students' views and beliefs with respect to mathematics. For example, Student 1 detailed that many of his teachers in Vietnam were rude and looked down at him for his perceived lack in mathematical thinking ability. He stated that there were times they would embarrass students by calling them "dumb" or similar in front of large classes, full of their peers. This made him dislike math and feel that it was an incomprehensible subject for himself as well as his peers. It did not, however, make him value the subject any less as it was looked upon with high academic regard in his country due to its usefulness in societal progression. Whereas, once circumstances changed due to his move to the United States, improved math outcomes, and better treatment by teachers, his views/beliefs of math also shifted for the better. For example, he declared:

> "[M]y high school have a lot of mean teachers. They are kind of rude. They, I will say, if you, like for example, some people in my class, they like are intelligent, but they cannot do that kind of problems, most people would say, those teachers would say you're dumb in front of like 40 people in the class. Yeah that's, that's what they do. I mean, I

will say it's terrible over there. Students they, I mean you had to look up to those people, to those teachers (Student 1)."

Other students specifically stated that certain teachers actually made them like math, at least while in their class. Students also mentioned how tutors offer additional support and encouragement, which tends to help raise students' self-efficacy as well as their attitudes toward associated topics in math. Student 5 was able to recall specific people who were able to positively influence her view of math at particular moments in her life:

> "I know my geometry teacher, like I said earlier, was a reason that I liked my math class or geometry class so much, like, and I think it may have also contributed to me doing better in the class. In my first algebra class, I will admit that the teacher was not the best. He was like, honestly, he didn't even like show how to solve the problems. It was more just, like, do it yourself, and I remember struggling with that. So, I think it does depend on the teacher (Student 5)."

> "I mean, my tutor that I had. She was very, like, oh you've got this. Like, um, she was very encouraging as well. Um. She'd be like, oh, the next test, like you've got it. We've worked on this. Like, you'll pass it. And I think, I typically, like I didn't, maybe it wasn't like the highest passing score, but, like, I didn't fail. So, I don't know. Her encouraging words were really nice (Student 5)."

When the people who students spend a majority of their time with outside of class have particular interests or disinterests, it is easy to be swayed in the same direction. In addition, comparisons made or time spent with classmates can have an impact on students' perceptions.

Therefore, family members and peers also have a significant influence on students' math views and beliefs. For instance, Student 2 detailed how most of his family were so anti-mathematics that his father, who is a "math person," kept his enthusiasm for the subject hidden while at home. Student 2 stated that a lack of interest in math was encouraged in his household and therefore, he had no other point of view until he was much older and realized that math was truly enjoyable and essential to many areas of his life. For example:

> "I feel like there was more just a general, other than from my dad, and even him, like, I feel like the rest of the family, like had this attitude of like, you know, we're a liberal arts family, and so he sort of kept his love of math sort of like to himself, not like shamed for it or anything. He just like, he knew we weren't interested. So, he just didn't really bother going into that. I don't think there was any time where I doubted my, where I was like taught to sort of doubt my own ability. I feel like it was more just a general sort of negative connotation of math, in general. So, like, an encouragement of the lack of interest as opposed to, you know, a lack of ability. … [M]y surroundings, my community was all, encouraged that lack of interest in math (Student 2)."

Student 6 described the heavy influence her peers have had on her math views/beliefs through achievement comparisons. She confessed that she attempts to talk to her classmates about course assessments to get reassurance that she is not the only one who struggles with the course material. Unfortunately for her, she implied that most times these other students have much higher grades than her, which reinforces or lowers her views and beliefs with respect to math even more. For instance, she stated:

> "Like, we would just be talking about a test and they'd be like C, C, B, or they'd be like, oh that was easy or like, oh it was tough, but I got it. And then, I'd be looking at my 35

like, oh yeah, congrats you guys (Student 6)."

The qualitative themes offered here, taken collectively, give RQ3 insight into how individual identities and learning experiences related to race and/or gender impact students' math views and beliefs.

RQ4) *What do community college students report about what supports would improve/increase their attitudes, self-efficacy, and values?*

A total of 5 themes appeared regarding students' perceived needs of support to improve/increase their math attitudes, self-efficacy, and values. These themes, as detailed below, show that teaching pedagogy (e.g., integration of real-world application, provision of positive reinforcement, in-class and out-of-class outreach, facilitation of opportunities to engage one-on-one with teacher and in peer groups) and teachers' overall moods are helpful in producing favorable student attitudes, self-efficacy, and values toward mathematics.

Students feel that it is their own responsibility to improve their math learning outcomes, inclusive of math views and beliefs, and that one teacher may be unable to take on such a comprehensive feat. They feel that it may take a community of educators, along with society, to do so and that the direct onus also is on the student to improve their own learning outcomes and associated math views or beliefs. All of the students mentioned that reaching out for help when needed is their primary responsibility, which they regard as beneficial in favorably changing their math outcomes and associated views/beliefs. They recognize that teachers are human beings with a large number of students to tend to and that altering deeply held negative views/beliefs is a difficult task. Student 2 specifically emphasized that by the time they reach high school or college, too many students have already decided that they detest math for one teacher to convince them otherwise:

> "I don't want to like cast aspersions on old math teachers that I'm sure were doing their best and were very tired or whatever, but I will say that I think, especially in like high school, there are just too many students who, especially as you go up the grades, have already decided they hate math. Too many students who are going to approach it with a negative connotation for one teacher to make sure to, like you know, lift backup, right. … I am hesitant to like put too much on the teachers because I know they got a lot on their plates (Student 2)."

Student 4 was also reluctant to give suggestions for teachers. Additional questions were posed in order to solicit a response. When asked if there was ever a time he put a little more effort in because of something that a teacher did or said, he replied:

> "I just have to try to motivate myself (Student 4)."

When asked if a teacher could have helped change her view of math, she responded:

> "No, because you have to be the one to reach out. You can't wait for your teacher to do it. They can't read your mind. So, it all has to be, do you want the help? Do you want to put in the effort to get it done? (Student 6)."

Despite this, students still offered several recommendations that could be helpful in improvement attempts.

Use of real-world connections to make sense of mathematical content can improve students' math views and beliefs.

Students believe that teachers who make sense of mathematical content through real-world connections have the ability to positively influence student views and beliefs of mathematics. They believe that teachers who do so have the power to positively influence students' math views and beliefs. Student 2, who was able to reflect on a time where he despised math and had no interest in it, consistently indicated that his views and beliefs relative to mathematics began to shift for the better once he realized how closely the subject was linked to the real world and his own personal interests. For example, he professed:

> "The things that I disliked before, and I guess to an extent now, like in the old days, I always felt like in math classes, the way that math was taught, it felt very difficult to, it felt so abstract from sort of my day to day life and needs that it, I would be told a rule and the rule just sort of existed in space, right. And it was like I couldn't figure out: a) why that rule kind of made sense on the page and part of why that was so difficult to comprehend was because I couldn't figure out why that rule made sense in the world. And I feel like it was often taught as just like you need to memorize this thing and that will make these equations work. But it's like, I couldn't figure out even when those equations would come up, when that trick would work, why that trick should work, and it makes more sense now. Part of it, I don't know if you've ever, I'm sure you know [current instructor], who's my current teacher. She's very good at like putting it into real-world context while she's giving it to you. And so, you have that, you get that immediate sense of where it's relevant and then you can start applying it to other things in your brain. But yeah. I don't remember ever getting anything like that in high school or in my first round through college, through community college. I don't remember getting that sort of real-world application (Student 2)."

He and other students stated that the teachers who related the content they were teaching to the real world helped them gain the understanding of math needed to make sense of the subject and make it less abstract. For example, Student 4 implied that these connections allowed for the observance that math may not be as difficult as he once thought:

> "I remember a lot of my teachers, when, you know, teaching the subject, sometimes I may not have thought they've been explaining things clearly, which can be confusing. I do remember back in 10th grade, my geometry teacher, [previous teacher], who was a good guy by the way. Well, while math could be tricky sometimes, I do remember he tried to explain things as well as he could. Sometimes, he'd even compare certain things to aspects of real life. Yeah, because even if it had a minor effect on, like, how well I can grasp the concept, it still could do something. … As I told you, how one of my teachers would try to compare, like math to like things in real life, it actually made a little more sense and I was thinking maybe this isn't so bad after all (Student 4)."

Teachers' observed emotional states and behaviors have an impact on students' math views and beliefs.

Students believe that teachers' attitudes have a major impact on students' views and beliefs relative to mathematics. Many students noted that some of their teachers had what they perceived to be bad attitudes. This made students feel that those teachers weren't friendly, didn't care about their students, disliked the subject they were teaching, and/or were only present for a paycheck. Consequently, students would feel undervalued, be unopen to learning, and would hesitate to ask questions in times of confusion. Students appreciate teachers who are approachable, caring, and passionate about teaching and learning. For example, Student 1 was adamant about the need for teachers to be friendly so that students won't be afraid to seek help from them when necessary:

> "I would say encourage students to ask questions, become friendlier because, usually, in

those classes that, I think, students have better performance, they have like, their teachers are friendlier. They like encourage students to ask them questions and it makes the students feel comfortable when they ask them (Student 1)."

Student 2 pointed out that he rarely had math teachers who seemed to enjoy teaching and would have benefited from a having an excited math teacher:

"I don't know if there was just like a burnout thing or they enjoyed math but not teaching math or they wish they were teaching at a different level or what, but I don't recall very many of my math teachers sounding excited about those sort of like the things they were, I would have loved to see, if nothing else, I would have just loved to see that sort of like, I would love to hear in their voice that this is a cool thing I'm about to teach you, right. Like, I'm not just throwing crap at you. Like, this one's cool. I like this one. You guys are gonna like this one, right. Even if we didn't, I feel like that makes such a big difference to sort of prime everybody for this like, you know, potentially a cool thing to learn, right (Student 2)."

Student 4 expressly noted that a little humor here and there would stimulate a desire to perform at peak levels:

"Sometimes it all depends on like, you know, the general mood of the teacher when they're teaching things, you know, like, how outgoing they are because a lot of times, you know, when my teachers have positive attitudes and, you know, can be a little humorous at times, somehow, it could kind of make me motivated to do the best I can (Student 4)."

Students feel that teachers should show personal interest in the math being conveyed and teach with care, patience, and empathy while understanding that some students may need to be refreshed on foundational information related to content. They feel that this should be done with care, patience, and empathy in acknowledgement that it may be necessary to refresh student minds on content-related fundamentals or prerequisite information. Teachers who show interest in the math help students feel that the math they are learning may be worthwhile since it means so much to the person teaching. If a teacher seems dispassionate or indifferent about the math they teach, students will may immediately shut down and view the subject as just one more boring thing they are being forced to learn. Many of the students feel that were deprived of having math teachers who were excited about the subject. For example Student 2 shared:

> "Because again, my surroundings, my community was all, encouraged that lack of interest in math, right. So, I think an excited teacher or a teacher that one-on-one was like, you could love this or like this could be really cool, right. I feel like I never really got counterpoint. So, I think like the biggest thing for me, kind of all, this seems to be the theme of all my answers, it's like teach kids why math is cool, which I think is a hard sell sometimes because you're having to go against the sort of societal conversation. (Student 2)."

Student 6 expressed that teachers should care so much about the math they are teaching that they should be responsible and cautious so as to not discourage students from learning by assuming they have equal understandings of the material. She feels they should be ready and willing to show patience and helpfulness. When asked what a teacher in her past experiences could have done to change the way she viewed math, she replied:

> "Probably not assuming that people have a basic understanding of things. You know when, like, you get directions offline and you're, like, wow they must assume these

people are really stupid because they'll tell you how to do, like, the tiniest basic things? Do that with math. Don't assume that I remember how to divide fractions because I'm about to go on YouTube and look it up. … [J]ust being open to questions and being patient. Patience is the big one, and empathy (Student 6)."

She also recounted a cherished experience with a previous teacher:

"My Algebra II teacher, my junior year of high school, because that was the hardest class I've ever taken in terms of, like, effort I've had to put out. But like, he was a great cheerleader. He was genuinely invested in his students' progress. You could tell he was there beyond the paycheck and he was just genuinely invested in how good I was doing. And that made a world of difference to know that someone cared beyond how good their gradebook looked. I'll always remember him (Student 6)."

Positive reinforcement positively influences students' math views and beliefs.

Students' views and beliefs related to math would benefit from positive reinforcements provided by teachers, family members, or peers. All of the students shared instances where they received positive reinforcement from someone, which made them feel better about their ability to learn math or successfully complete a mathematical task. Students claimed that, even if for only a moment, they viewed math as more pleasant and less difficult. Sometimes, an encouraging word is all it takes to boost morale and impact their views/beliefs. For example, Student 2 implied that a word of encouragement from a math teacher, at an early age, might have been enough to change his view of math and related achievement behaviors.

"I feel like positive reinforcement or whatever, too, may have been like all it took, right. It may have been helpful at that age to hear like, listen, like I think you could be really

> good at math, but you have to care at all, right (Student 2)."

Student 3 gave examples of how his current teacher verbally provides positive reinforcements that enhance his confidence:

> "[M]ore recently, my teacher would be like, 'I'm proud of you. You're doing so great.' Yeah. He's super nice. I like him. Just like, people giving you props makes you feel a lot better (Student 3)."

Student 5 shared that a previous teacher offered positive reinforcement through incentives for performing well in on class assignments:

> "My algebra teacher from high school, I remember, like, I mean, I didn't do good in the class and she wasn't the most helpful teacher, but I do remember that like, there would be times where if, like, not as like me as an individual, but like if the class collectively, like got a certain score or average, she kind of would like reward us. Like, oh next class, you know, we will have a movie class or something or, like, we'd do something interesting unrelated, like, to math, I guess. That, like, kind of motivated some people to, I don't know, study, I don't know, do better on the test. So, I don't know, some type of like motivation (Student 5)."

Students' views and beliefs regarding mathematics could benefit from teacher outreach.

Teacher outreach was noted as tremendously beneficial in improving students' views and beliefs relative to math. When teachers show they care by reaching out to students, those students tend to not fall by the wayside. Students want to feel that they matter. When they matter, they typically pay greater attention to the course or subject for which they feel the teacher is attentive to them and their needs. Student 2 indicated that reaching out to students who aren't doing well or working to their full potential could help:

> "[I]t would have helped probably to like if, I don't know how to describe it exactly because I feel like there were many times where I just barely understood a concept, just like, I only put just enough effort in to get over the hurdle, right, and once I understood it enough to get a passing grade on the test, then I just sort of checked out. And I feel like, I would imagine that that was sort of apparent to somebody who really understood the math and was looking at my work that I was showing on my test, right, that like I understood it up to a point and then just sort of gave up, right. So, like it's possible, like again I don't want to put too much on them, but I would say that if there was one thing they could do, maybe to reach out to individuals who are like maybe either like failing or, right on that middle line might even be a more accessible group, right, where I feel like you can get a C math student up to a B fairly easily, maybe easier than you can get an F student up to a D, right. And maybe there could be more sort of, it could have been more outreach, to me to try to like, I'm so close to being on it, right. I feel like maybe there was room for like one-on-one engagement there (Student 2)."

Student 3 associated teacher attitude with their willingness to reach out to students. He indicated that teachers reaching out to offer support with alternate methods to view and work with the content could be helpful. For example, he stated:

> "Yeah, they definitely could have [helped change views]. If they didn't have an attitude when they came in and they reached out to help you rather than just watch your grade fall. … [I]f they notice a student is not doing good in their class or their grades are dropping, maybe try and talk to them and figure out a way to help them out. I know a lot of teachers will do that and have done it, but some teachers just don't. But, that's also

> kind of on the students, you know, responsibilities, because it's our obligation to seek for help too. It's not just, sit there and wait for somebody to come help you. If you have the drive to figure it out and you want to, then you would go seek for help. But, yeah. I would just say try to extend their hand a little bit more. Maybe if a student is not understanding it and there's other ways to do it or maybe try and help them figure out another way to learn it, then that would be a good option (Student 3)."

Students appreciate opportunities to work with their teachers and peers who may be able to provide fresh or enthusiastic outlooks on content, in groups or one-to-one settings.

Many students value opportunities to engage in groups or one-on-one with their teachers and peers. Student 2 expressed his yearning to have had a tutor who modeled the enthusiasm for math that he sought from his teachers:

> "[I]f there was an opportunity for everyone to have a math tutor who really loved math, like I feel like in most of my math classes, I never really got the impression that my math teacher was particularly excited about math, which is like surprising now that I think about it because that's certainly not the case with things like my literature classes (Student 2)."

In response to being asked what a teacher did to make her feel good or better about her math ability, Student 5 described a previous teacher's efforts to motivate students by giving them incentives to attend study halls in order to work one-on-one with her or participate in in group study sessions:

> "[M]y geometry teacher also did stuff like, I feel like she did like a thing, but I can't exactly remember what it was. But, she did like a another type of motivation to like

come, she'd give like extra credit points if we, um, I think it was like, if we came to like, she did these things during like study halls where we would get to basically, like, study for the quiz or the test and if we came to it, she'd give us extra points. So, like, her way of rewarding us was literally like helping us with the test. I feel like that was probably more helpful, but, it was motivating me to come to a study group, while also getting extra points on my test (Student 5)."

Student 6 similarly shared that she perceived tutors and group sessions to likely be helpful in improving her own views and beliefs related to math. She consistently shared her longing for peer interaction with math. For example:

"I just really wish that, like, tutoring and small group, like group study sessions, were more accessible. Like, I have searched far and wide for a tutor that will work with me. Not in the sense of, like, will do work with me, but will work with the way I learn. Like, trying to find a small group of friends to study with. Like, I've tried, like, verbally saying something in my math class. Like, hey, if anyone's interested in getting together for 45 minutes someday, let me know. We can get through the homework. It's just been like pulling teeth trying to get help. … I would love, like, someone who, like, I don't know, is in their senior year and they did really good in statistics and they're passionate about helping other people, yada, yada, and there'd be low pressure (Student 6)."

The qualitative themes provided here for RQ4 contribute to the awareness of community college students' personally perceived support needs to help enhance their attitudes, self-efficacy, and values.

Data Integration

A table was created to show demographics and survey outcome labels (i.e., high, neutral, low) with disaggregated and overall scores, by student (Table 10). This was done to model demographic categories and differentiate between corresponding student scores in preparation of constructing a table to bring the quantitative and qualitative data together. A joint display (Table 11) was then created to show representative quotes with corresponding disaggregated construct results.

Students with high overall math views and beliefs had similarly high disaggregated views and beliefs (i.e., attitude, self-efficacy, value) with respect to math. Students with low overall math views and beliefs also had similarly low disaggregated views and beliefs in terms of attitude and self-efficacy. Students 1 and 2 have maximal math self-efficacy while Student 3 holds maximal math value. Contrarily, two of the students who hold low overall math views and beliefs possess math values that do not necessarily align. Student 4 has similar disaggregated math views and beliefs, but his math attitude and self-efficacy are comparable and lie within the upper low range while his math value is situated at the lowest neutral point. Student 5 has among the lowest math attitude and self-efficacy lying within the low range while her math value is situated at the bottommost position of the high range. Student 6, on the other hand, does hold disaggregated math views and beliefs, all falling within the low range. Her math attitude and self-efficacy are both at the very bottom of the low range. Student interview data matched well with survey items and scores. See Tables 10 and 11.

Table 10

Qualitative Participant Demographics & Survey Scores

	Race	Gender	Course Level	Math Attitude	Math Self-efficacy	Math Value	Overall Views/ Beliefs
Student 1	Asian	Male	MTH 245	*High (4.20)*	*High (5.00)*	*High (4.17)*	High (4.46)

Student 2	White	Male	MTH 167	*High (4.40)*	*High (5.00)*	*High (4.67)*	High (4.69)
Student 3	White	Male	MTH 264	*High (4.40)*	*High (4.60)*	*High (5.00)*	High (4.67)
Student 4	White	Male	MTH 161	*Low (2.40)*	*Low (2.40)*	*Neutral (2.50)*	Low (2.43)
Student 5	Multiracial	Female	MTH 154	*Low (1.40)*	*Low (2.00)*	*High (3.50)*	Low (2.30)
Student 6	White	Female	MTH 245	*Low (1.00)*	*Low (1.00)*	*Low (2.17)*	Low (1.39)

Table 11

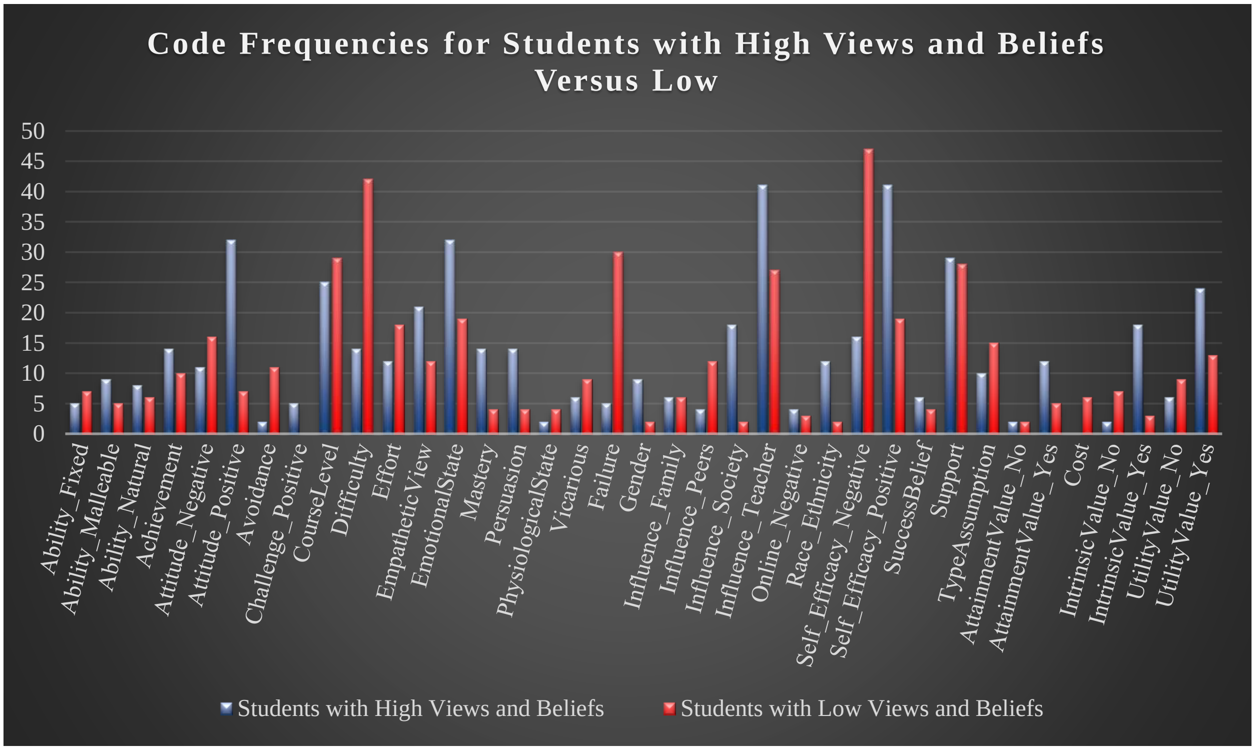
Joint Display of Survey Data with Interview Quotes

Construct	Survey Items	Representative Quotes	
		High Group ($M \geq 3.5$)	Low Group ($M < 2.5$)
Math Attitude	I get a great deal of satisfaction out of solving a mathematics problem. I have usually enjoyed studying mathematics in school. I like to solve new problems in mathematics. I really like mathematics. Mathematics is a very interesting subject.	*High* - "[T]he harder the problem is, the better or the more satisfying it is when you come up with a solution for that problem (Student 1)" *High* - "[F]rom day one of this math class, I became so enamored with like doing every math problem that she put in front of us just because, like that's how I want to spend my free time it seems like. So, I something in those two parallel storylines, feels like that transition just sort of happened and I suddenly was interested in finding the next new way to manipulate numbers (Student 2)." *High* - "[T]hat's probably been my favorite subject since a long time. I really don't know, since, it's just been one of my favorite subjects (Student 3)."	*Low* - "It's not my favorite subject, but mainly just because I'm not very good at it. I don't know. I think it's interesting. It's not my favorite though (Student 4)." *Low* - "I don't like math, like I'm not good at it and I think people who don't have like a positive attitude towards it, probably don't get like a positive reaction from it (Student 5)." *Low* - "I've always hated it, but then in eighth grade, it became tied in with my self-esteem (Student 6)."
Math Self-Efficacy	I believe I will receive an excellent grade in my math class. I'm confident I can understand the basic concepts taught in my math course. I'm confident I can do an	*High* - "I can do it easily and it's not a problem to me (Student 1)." *High* - "I have a better grade in this math class than any other math class I've ever taken (Student 2)." *High* - "I feel pretty confident in it. Yeah. And like I said, especially with this year, because the way the teacher that I have now, he teaches like really descriptively, detailed, and that's how I like to learn (Student 3)."	*Low* - "I can understand basic mathematics, like you know, the kind we learned in elementary school, addition, subtraction, multiplication, division, but, you know, when I'm getting to stuff like algebra and things like that, it kind of gets more complicated (Student 4)." *Low* - "I feel like I'm spending so much time and I'm still not understanding that, like, sometimes it

	excellent job on the assignments and tests in my math course. I expect to do well in my math class. I'm certain I can master the skills being taught in my math class.		really just feels pointless (Student 5)." *Low* - "I just really think that math will be the sole reason that I possibly don't finish college (Student 6)."
Math Value	Being someone who is good at math is important to me. It is important for me to be someone who is good at solving problems that involve math. It is important for me to be a person who reasons mathematically. Math will be useful for me later in life. Math concepts are valuable because they will help me in the future. Being good at math will be important for future employment.	*High* - "That's the reason why I have to perform well in math. Have to. Yeah, it has a lot to do with my future (Student 1)." *High* - "[M]ath is so universal, it shows up in places and you don't even realize really that you're doing math (Student 2)." *High* - "[T]hey help us find a lot of answers to things that we wouldn't, you know, be able to comprehend without numbers and math (Student 3)."	*Neutral* - "In the long run, it could be used, but as of this moment, not so much. … Well, I think most of the time, I don't really see how useful it is (Student 4)." *High* - "I do think math is really important. Like, I know it's something that most people probably do need, like for you know, careers or just in life. Like, math is something that comes up a lot. For me, right now, I don't know if I'd consider it like my top priority, which I feel like it probably should be. But, right now, it's not super important to me, but I know it probably should be (Student 5)." *Low* - "Maybe like the little stuff that I need in my day-to-day, but further than that, no. I'd like to forget about it (Student 6)."

The qualitative findings present a wealth of information regarding the individual, social, and sociocultural factors from students' lived experiences that influence their high and/or low views and beliefs in math. Notable differences in code counts for students with high overall survey scores versus those with low overall survey scores were observed. Figure 4 displays the frequency of code usage, by code name, in terms of students with high views and beliefs versus those with low views and beliefs. Figures B1 and B2 disaggregate this data further, by student, for students with high overall survey scores (Figure B1) and students with low overall survey scores. Notable differences between high and low scoring students (i.e., greater than 36% difference between groups and representative spread within high or low group) in relation to code counts were observed. Students with high views and beliefs referred to having positive math attitude (e.g., liking math, enjoying mathematical tasks), self-efficacy (e.g., feeling confident in their ability to tackle school-related tasks and successfully achieve task goals to a certain level), intrinsic value (e.g., greater satisfaction, joy, and excitement from performing mathematical tasks), mastery experiences (e.g., getting high grades, understanding content, applying math to their lives), and seeing the positive in challenging mathematical tasks notably more often than students with low views and beliefs. Students with low views and beliefs referred to having difficulty (e.g., not understanding course material, having a hard time performing in-school or life-related mathematical tasks, forgetting course material), failure (e.g., receiving low grades, inability to perform well on school-related math tasks), negative self-efficacy (e.g., lack of confidence in their ability to perform mathematical tasks), no intrinsic value (e.g., dissatisfaction with math engagement, having unfavorable emotional or physiological responses to mathematical tasks), high perceived cost (e.g., feeling that math takes too much time and effort with no benefit), and avoidance (e.g., seeking to rid themselves of mathematical requirements) with respect to math notably more often than students with high views and beliefs. Please see Figures 4, B1, and B2.

Figure 4



Discussion

The data surrounding the social stigma concerning individuals' attitudes, self-efficacy, and values with respect to mathematics is clear, showing that math is often the most dreaded and difficult subject among students (Ipsos-Public Affairs, 2005; Knowledge Networks, 2006; Saad, 2005). With mathematics being viewed as a gatekeeper subject in academia, particularly at the college level, it is important to understand the experiences that underpin these students' attitudes, self-efficacy, and values in the domain. Although the literature is rich in studies regarding associations between students' attitudes, self-efficacy, and values as they relate to choice, achievement, and achievement-related behaviors in mathematics, there is limited evidence that serves to inform on the particular experiences that trigger these views and beliefs from student perspectives (Aiken, 1972; Barrows et al., 2013; Beasley & Fischer, 2012; Davis et al., 2011; Douglas & Salzman, 2020; Johnson & O'Keeffe, 2016; Larson et al., 2015; Muenks et al., 2018;

Muenks et al., 2017; Parks-Stamm et al., 2010; Roick & Ringeisen, 2018; Usher & Pajares, 2008; Villavicencio & Bernardo, 2016; Wu & Fan, 2017). Further, it is necessary to observe that individual differences and contextual factors related to gender and race may provide varying perspectives. The current study contributes to the literature as follows:

1) Knowledge was obtained on the complexity of attitudes, self-efficacy, and values in mathematics among community college students currently taking credit-level mathematics courses.
2) Insight was gained on the qualitative nature of present-day community college students' mathematical attitudes, self-efficacy, and values.
3) Light was shed on how identity markers related to gender and race along with learning experiences in mathematics relate to present-day community college students' attitudes, self-efficacy, and values in mathematics
4) Present-day community college students identified supports that may enhance or strengthen their attitudes, self-efficacy, and values in mathematics.

It is important to have this information to nurture student attitudes, self-efficacy, and values in mathematics. Acknowledging these experiences, both personal and vicarious, play a significant role in students' perceptions of mathematics can motivate educators to empathize with their students and offer additional supports to meet the needs of today's students.

Quantitative survey results provided a broad interpretation of the distribution of students' self-reported attitudes, self-efficacy, and values in college mathematics overall, disaggregated, as well as in terms of self-identified gender, racial/ethnic group, and course level at a moderately large urban community college in the South Atlantic Region of the United States. Qualitative interviews with six of the surveyed students allowed for a deeper look into some of the underlying reasons for these views and beliefs. The study's quantitative results are based on a 22% survey response rate, which may lean closer to students who are more willing to participate in tasks or discourse related to mathematics for varying reasons. This notion was supported based on the number of responses received (6 of 30; 20%) with respect to interview requests sent to students in varying overall view and belief ranges. Many students may not want to or do not have the time to devote to discussing mathematics outside of their standard class time.

Next, the quantitative, descriptive results regarding the distribution of students' math views and beliefs are discussed, followed by a discussion of the qualitative findings. Notably, the quantitative trends indicate a lack of statistically significant or substantive difference in math views and beliefs along gender and racial lines. However, when the quantitative data was used to identify a high and low groups of students for follow-up interviews, findings demonstrate complex individual and cultural differences in students' math learning experiences that underlie their math attitudes, self-efficacy, and values.

Distribution of Students' Math Views and Beliefs

Results from the quantitative strand of the study showed that students' math attitudes, self-efficacy, values, and overall math view/belief were shown to be significantly correlated with one another. This aligns with the extant literature that shows that different facets of students' motivation are related and likely operate in a reciprocal fashion (Linnenbrink-Garcia & Wormington, 2019). It was further revealed that community college students typically hold between neutral and high overall views and beliefs relative to mathematics with a majority in the high range and the least in the low range. This is contradictory to the literature that suggests views and beliefs related to mathematics, in general, are often low or negative (Ipsos-Public Affairs, 2005; Knowledge Networks, 2006; Saad, 2005). Disaggregate data showed that students' math attitudes were lowest of all. This points toward a need to raise students' fondness of mathematics in an effort to promote the improvement of associated views and beliefs about the subject (Harackiewicz et al., 2016; Krapp, 2005). The disaggregation of these views and beliefs in terms of gender, race, and course level descriptively demonstrated that gender and race may not play as large a role as course level or math type.

Gender. Math Attitude, Self-Efficacy, and Value survey results indicated that females have lower overall math views and beliefs than males as hypothesized (Beasley & Fischer, 2012; Hyde et al., 1990). A greater percentage of females hold low to neutral views and beliefs in comparison to males while a greater percentage of males hold high views and beliefs than females. In breaking down these differences, females tended to have lower math attitudes and self-efficacy than males, but similar math value as males. This contributes to the literature by demonstrating that, while females may like math a little less and have slightly lower confidence in their ability to successfully complete mathematical tasks than males, both genders perceive math as having approximately the same value in their life. In acknowledgement that these differences were not significant, it appears that there may be a shift in the way people view mathematics as it relates to gender (i.e., male domain; Beasley & Fischer, 2012; Hyde et al., 1990).

Quantitative survey results were somewhat supported by qualitative results with most of the students claiming that gender has no impact on their own personal experiences with mathematics. However, some students do experience gender bias, indirectly or directly, with respect to mathematics in academia or the workforce. Direct experience with gender bias could undermine students' learning processes, make them feel inferior, and/or impede their views and beliefs with respect to mathematics.

Race. Math Attitude, Self-Efficacy, and Value survey results show that there are slight, but statistically insignificant, differences in students' overall math views and beliefs by race. Prior to the survey, it was assumed that White and Asian students would have the highest views and beliefs with respect to mathematics due to the literature on math achievement outcomes (Hsieh et al., 2021), but results showed that Asians and other non-White students actually report higher views and beliefs than White students, whereas, Multiracial students tend to have the lowest. The survey showed that Asian and Hispanic/Latinx students hold neutral to high views and beliefs with the majority in the high range. A higher percentage of Asian students were shown to hold neutral views and beliefs while a higher percentage of Hispanic/Latinx students hold high views and beliefs. A small percentage of Black students were shown to hold low views and beliefs while a majority hold high views and beliefs. That majority was very close to the same percentage as Asian students. A higher percentage of White students were shown to hold low views and beliefs while a majority also hold high views and beliefs. An even higher percentage of Multiracial students were shown to hold low views and beliefs with an equal amount holding neutral versus high views and beliefs.

The breakdown of these differences with respect to attitude, self-efficacy, and value showed further that White community college students have among the lowest attitudes, self-efficacy, and values toward mathematics with Multiracial students having the lowest. The literature is limited in evidence related to college students' demographic impact on students' attitudes, self-efficacy, and values with respect to mathematics as a domain at the college level. This study adds to the literature in that area. Like gender, differences by race were not statistically significant. Still, the descriptive results indicate that future study attempts at the community college level should not be limited to minority students.

Qualitative findings supported quantitative survey results, to some extent, with a majority of students stating that race has no impact on their experiences with math. However, certain students in academia are subjected to racial prejudice in mathematics, either indirectly or directly. Students who identify as White may not have had firsthand encounters with racial bias that has influenced their math views and beliefs, but their indirect experiences with race-related prejudices have made them sympathetic to its existence and empathetic to the impact it may have on those affected by it. As with gender bias, student learning may be harmed by direct exposure to racial prejudice, which may make individuals feel inadequate and/or distort their math views and beliefs (Greer, 2008; Lambert et al., 2009; Seaton, 2010). Further, ethnicity may have an influence on students' views and beliefs relative to mathematics. Students from foreign nations might have different mathematical experiences depending on their physical location and associated sociocultural norms.

Course Level. Course level or math type was shown to be statistically significant in terms of its relationship to students' overall views and beliefs with respect to mathematics. In particular, students' math attitudes were significantly associated with course level. A possible explanation is that this is due to certain classes containing either all or majority STEM students who may be more agreeable to mathematics while other courses house non-STEM students who may not be so agreeable to mathematics. As one would assume, Math Attitude, Self-Efficacy, and Value survey results show that STEM majors tend to have higher overall views and beliefs of mathematics than non-STEM majors. This speaks to their choice of majoring in fields more closely related to math.

Results also showed that introductory level STEM-based mathematics courses (i.e., MTH 162, MTH 167) had no students within the low range of views and beliefs. Therefore, STEM students who are just starting their mathematics career at the community college level typically seem to begin with neutral to high math views and beliefs. A majority of those who place lower (MTH 162) tend to begin with neutral views and beliefs while an even larger majority of those who place higher/advanced (MTH 167) begin their community college math career with high views and beliefs. Trends differ with respect to higher level STEM-based math courses (i.e., MTH 263, MTH 264). A small percentage of MTH 263 students hold low math views and beliefs with a higher percentage holding neutral views/beliefs and a majority holding high views/beliefs. A higher percentage of MTH 264 students hold low math views/beliefs, none neutral, but the highest majority hold high views and beliefs. These trends show that, within the STEM-based courses, a greater percentage of students hold high views and beliefs while in lower level courses than those in higher level STEM-based courses. Taken together, one interpretation of these trends is that at higher levels of mathematics, students tend to hold a "hate or love" relationship with math. This contributes to the literature on students' math motivation that currently does not account for these seemingly contradictory views and beliefs. Non-STEM courses have a larger percentage of students with low math views and beliefs, by course, than STEM-based math courses with the exception of MTH 264 holding a large percentage of students with low views/beliefs.

Intersection of Identities in Math

Through both interpersonal encounters and structural oppression, members of historically disadvantaged groups regularly face demeaning messages about their identity groups (Nadal et al., 2021). However, holding a historically marginalized gender and/or racial identity marker may not be a robust predictor of math views and beliefs in and of itself. As previously mentioned, the quantitative data show that the White community college student participants actually have lower attitudes, self-efficacy, and values in math than all other monoracial students with the exception of having similar attitudes as Black or African American students. With most of the interview participants identifying as White, qualitative data show that their perceptions and experiences are extremely diverse. One implication of this finding is that general trends should not always be applied to individual students. Moreover, with 12 of 145 students identifying as Multiracial having the lowest attitudes, self-efficacy, and values, future research should focus on understanding the intricacies of multiple racial identities with respect to mathematics. This is a growing student population that may experience the role of race uniquely. It has been shown that Multiracial individuals are less convinced that race influences ability and, in response to being hyper aware of race in certain situations, they exhibit stereotype inhibition as opposed to stereotype activation in comparison with monoracial individuals (Shih et al., 2007).

Additionally, qualitative data showed that students attempted to detach math ability from racial or gender identity while understanding the possibility of its influence on teachers' and students' mindsets. When asked directly about what a mathematician looks like, students said it is possible for anyone to be a "math person" or be good at math. However, when speaking of their learning experiences (direct or vicarious), half of the students shared a clear awareness of systemic and/or cultural barriers for women and/or racial minorities with an imbalance in opportunities, respect, and acceptance within the field of mathematics. Taken together, they believe that anyone may have the ability to perform well, but the hurdles placed before individuals according to gender (i.e., females) and/or race (i.e., non-White, non-Asian) may impede their progress and in turn have an impact on their views and beliefs.

As previously mentioned, course level emerged as a statistically significant differentiator of students' math attitude, self-efficacy, and value. Data from interviews revealed that students tend to have higher views and beliefs relative to mathematics at levels for which they understand and, thus, identify with. Students choose to major or concentrate in areas they are more interested in and are able to align with their personal identity. This is reflected in the quantitative evidence with students in STEM programs having more positive math attitudes, self-efficacy, and values. Furthermore, students spoke of math ability as it relates to certain levels of mathematics. They seem to have a growth mindset with respect to math, but only for the levels of math that they believe are essential in their life. Their mindset becomes more fixed with anything they perceive as beyond their own personal reach. Thus, it is still possible that students from historically marginalized groups have views and beliefs influenced by messages that displace them from the field of mathematics.

Nature of Students' Math Views and Beliefs

Interview data showed that math views and beliefs are not static within racial/gender groups but rather, are influenced by a host of individual (e.g., degree of math comprehension, perceived cost of exerting effort in math, growth mindset beliefs) and math learning experiences (e.g., emotional responses to math, social appraisals).

Based on interview data accounts, students with high math views and beliefs do tend to like mathematics much more than students with low math views and beliefs. They feel much more confident in their ability to complete their current school-related mathematical tasks and gain more enjoyment from doing so. They also experience mastery much more often and tend to get more motivated when faced with challenges in math. This is consistent with research that links greater math beliefs to more positive learning and achievement behaviors (Aiken, 1972;

Chen & Zimmerman, 2007; Muenks et al., 2018; Wigfield & Cambria, 2010; Wu & Fan, 2017). In comparison with students who hold high math views and beliefs, students with low math views and beliefs tend to have many more experiences with difficulty and failure in mathematics, doubt their ability to complete school-related math tasks, rarely find joy in doing mathematics and typically find that it takes up too much of their time and/or effort, and tend to avoid math more often. This aligns with prior research showing that negative achievement-related behaviors and outcomes are linked to negative views and beliefs (Shodahl & Diers, 1984). This also speaks to motivation literature as a precursor to low motivation and achievement-related behaviors since students are more likely to excel in subjects that interest them and give high confidence (Aiken, 1972; Barrows et al., 2013; Davis et al., 2011; Johnson & O'Keeffe, 2016; Larson et al., 2015; Muenks et al., 2018; Muenks et al., 2017; Parks-Stamm et al., 2010; Roick & Ringeisen, 2018; Villavicencio & Bernardo, 2016; Wu & Fan, 2017).

The findings from this study contribute to these broader established trends by providing more nuance. For example, findings showed that students' math attitude and self-efficacy are linked to their perceived degree of math comprehension, which might vary from course to course. They tend to have more of a favorable attitude toward mathematics at levels for which they comprehend. This finding is backed up by research, which reveals that feelings of inadequacy versus mastery are linked to negative views and beliefs about math (Bandura, 1989; Shodahl & Diers, 1984; Usher & Pajares, 2008). Additionally, with respect to value, the perceived costs and advantages of investing in math differ across students with high and low math views and beliefs. According to student testimonies, mathematics requires much time and effort. However, students who hold higher or more positive views and beliefs feel that the time invested is imperative and beneficial. Whereas, the students who hold lower or more negative views and beliefs about math tend to declare it is too demanding and not personally rewarding based on resultant outcomes. These findings are supported by research that shows task-specific views and beliefs have an influence on an individual's expectations and values (Wigfield & Eccles, 2000). As a result, mathematics is perceived to be more difficult than other disciplines by students who have lower views and beliefs about the subject.

Findings also shed light on how ability beliefs are more nuanced, in that students can simultaneously hold both fixed and growth mindsets towards mathematics. Several students stated that math ability can be improved with effort, but they also feel that some people are born with a natural aptitude for math and there is a limit to how far "non-math" individuals are able to perform. This underlying fixed view of math ability may challenge the degree of effort students are willing to put forth. Students who are on the lower spectrum of math view/belief are more likely to engage in math avoidance practices (Wu & Fan, 2017). They tend to solicit guidance from advisors that will best help them complete their math requirements as quickly as possible in order to avoid having to deal with math in the future. This aligns with the literature showing that students who have low beliefs in relation to a task prefer to avoid situations that require them to execute such activities (Wu & Fan, 2017).

Math is regarded as important to students' lives, identities, and ambitions to varying degrees, but findings demonstrated a notable difference between the high and low student groups. Students with lower or more negative math views and beliefs feel that basic math is all they need in their lives outside of school and are more confident in their ability to perform such tasks than they are in their ability to complete school-related tasks, which they believe to be more difficult. A possible explanation for this finding is that students with low or negative math views and beliefs may not make the connections between mathematics and the real world, and this may be inhibited by their negative views and beliefs about math. They also recognize the value in mathematics in general, but they do not associate it with their current identity. Contrarily, students with higher or more positive math views and beliefs generally think of real-world mathematical tasks in a less simplistic manner than students with low views/beliefs, and as a result, they question their ability to successfully complete real-world mathematical tasks outside of school. They are more likely to believe that a certain level of understanding in math is crucial for success because it is applicable to their own particular objectives such as generating income, earning higher educational degrees (e.g., transferring to a four-year university for a bachelor's degree), choice in career (e.g., CAD design), leisure-time interests (e.g., tracking, manipulating, and understanding data), and understanding the real world (e.g., "find answers to things that we wouldn't … be able to comprehend without numbers and math"; Student 3). By and large, both high and low math view/belief students often find fundamental mathematics useful in their daily lives (e.g., counting, adding, subtracting) and higher levels of mathematics beneficial to either themselves (high math view/belief) or others (low math view/belief) depending on their own interests or chosen vocation.

Mathematical task satisfaction and enjoyment are based on students' math views and beliefs. Students with higher or more positive math views and beliefs have a tendency to enjoy mathematics and gain satisfaction from being given additional mathematical tasks, even more so when challenges are met with successful outcomes. On the other hand, students with lower or more negative math views and beliefs are more likely to have negative reactions when given mathematical tasks they consider difficult or challenging. They are also more likely to see limited value of math in their lives, beyond connections to simple tasks.

Student Assumptions of "Math-Able" Individuals. Students have wide-ranging beliefs about those who are capable of excelling in mathematics. When asked directly, a number of students say that they do not attach a gender or race stereotype to their belief of who can succeed in mathematics. Many of them believe that any individual, regardless of gender or race, can be "good at math." They more so associate one's ability to succeed in mathematics with personal interests, self-efficacy, and aptitude rather than physical traits or categories. To them, mathematics ability comes naturally to some, but it is not a requirement for success. Some students believe that being exceptionally gifted in math equates to being a highly intelligent and meticulous person who may not interact well with others. Future research should look further into these views and how students situate themselves in the realm of mathematics with respect to their own characteristics and traits.

The Role of Other Influences. Students' math views and beliefs are influenced by other social, emotional, and physiological experiences. Students are well aware of the negative connotation that mathematics has in society. Students, themselves, admit that this is hard to combat. However, students expressed that teachers, advisors, tutors, family members, and peers have a considerable impact on students' math views and beliefs. It is well-established across various frameworks that students' motivation and circumstances change over time, and the direction of these changes is reciprocally influenced by one's social environment (e.g., Eccles & Wigfield, 2020; Ryan & Deci, 2000, 2020). The students also conveyed that their views and beliefs of mathematics are shaped by their experiences with achievement outcomes as well as their emotional and/or physiological responses when faced with mathematical tasks or outcomes. These qualitative findings are in line with research that shows how mastery experiences, vicarious experiences, verbal and social persuasions, as well as emotional and physiological factors, shape students' views and beliefs (Bandura, 1989; Usher & Pajares, 2008). This study contributes to the largely quantitative, self-report nature of motivation research by highlighting the stories of students' math learning experiences in relation to their attitudes, self-efficacy beliefs, and values.

Suggestions for Educators

Although educators can and should offer students' support, many students believe that teachers, alone, cannot be charged with improving student views or beliefs. Students do feel that teachers play a major role in influencing their math views and beliefs and thus gave recommendations based on previous and current experiences. Students feel that teachers should use real-world examples to explain mathematical concepts. According to research, demonstrating the relevance, utility, and value of mathematics through real-world applications enhances students' math views and beliefs (Butler & Butler, 2011; Collins & Winnington, 2010; Dewar et al., 2011; Hagerty et al., 2010; Henrich et al., 2016; Ward et al., 2010).

Positive emotions were also frequently mentioned by students. It was established that emotions or "moods," particularly in the classroom, can be contagious. This aligns with the large body of literature regarding the role of emotions in how students think and feel about a subject, which in turn influences their achievement (Pekrun, 2006). Relatedly, students believe that teachers should exhibit their own genuine interest in the math being taught. Students further suggest that teachers offer positive reinforcements as well as reach out and acknowledge students' individual existence so that they feel valued and, in turn, put forth the necessary engagement efforts to be successful.

For additional support, it was suggested that teachers provide students with opportunities to meet individually with them as well as with their peers in one-on-one or group settings. These findings contribute to the literature by providing an added understanding of how students' views and beliefs are influenced by their teachers and other members of society. Working one-on-one with teachers allows for the teacher to better understand gaps in individual student's understanding. The teacher is then able to go more in-depth, targeting student knowledge gaps and offering alternative methods for learning and execution. Collaboration with peers allows the opportunity to work with others who could potentially offer innovative or stimulating viewpoints on course topics. These suggestions align with literature showing that structured opportunities for building a sense of community is important, and especially so for students from historically marginalized groups (Xu et al., 2018).

Limitations and Areas for Future Research

There were several limitations to this study. The study was conducted during the coronavirus pandemic (COVID-19) pandemic. During this time, students had numerous added stressors external to academics on top of the normal pressures of being a community college student. Also, because of the pandemic, fall semester classes were mostly online. Although, the population of focus was students taking in-person or live-online (virtual via Zoom) classes where they would have weekly contact with their professors and classmates either, the pandemic still made it so that classes were constantly being canceled or students had to miss class. During the first two weeks of the spring semester, all classes were taught online. However, those that were slated to be in person, migrated to that mode after that. More classes were held in person during the spring semester as well, but the challenges of the pandemic still plagued education and students' lives. Many students had to play catch up for various reasons (e.g., COVID illness, childcare issues, family or friend death, higher demands at work, civil unrest). All things considered, it was more challenging to get student survey responses and interview participants. It is likely that many students had more vital things to take care of over checking emails, completing surveys, and engaging in interviews, especially when there were no course grade benefits. Therefore, quantitative results depended on students who checked their emails or teacher announcements, had the time to fill out the survey, and didn't mind answering questions about their math views and beliefs. Furthermore, qualitative results depended on those same students to be available and willing to engage in discourse about a subject that they may or may not be fond of.

The qualitative portion of the study was limited to only six participants. Therefore, the sample was not large enough to make as many claims as desired. In addition, only one interview participant is non-White (Asian). The Multiracial student identified as White and Indigenous American. This was not an intentional effort. The goal was to have a diverse representation of student genders and races/ethnicities. Having a large majority sample of one race (mostly White/non-minority) limits the study in that race could have possibly had more of an impact on some of the quantitative survey students' mathematical experiences both inside and outside of school settings. Moreover, their interpretation and reaction to experiences could vary immensely from those of other racial/ethnic backgrounds. There was also an imbalance with respect to gender and high/low views and beliefs. The two female interview participants held low or negative overall math views and beliefs. The study could have benefited from gaining an awareness of perspectives that females with high or positive overall math views and beliefs hold. In addition, the interview participants' course levels varied, but students on the high/positive extreme were mostly STEM-based students while all of the students on the low/negative extreme were non-STEM students. Thus, there was some diversity in the sample.

Future research should attempt to replicate this study outside of the confines of a health crisis or natural disaster, if at all possible, in order to obtain more participants and gain further knowledge from students of more diverse backgrounds. The information learned should then be put into practice. Students' articulated perceptions, experiences, desires, and suggestions can be used in future studies to enhance students' views and beliefs about mathematics. Future research should aim to test, quantitatively, participant suggestions that have not yet been empirically validated in the literature.

Significance and Implications

Mathematics is a core subject that all students must encounter and successfully complete in academia. The views and beliefs they hold in relation to the subject are important as they manifest in students' achievement behaviors and outcomes. Therefore, it is critical to counteract as many low or negative views and beliefs as possible. Teaching and learning requires a constant awareness of students' views and beliefs with respect to mathematics so that teachers are able to pivot when necessary to reach students who might otherwise fall to the wayside. In particular, being cognizant of the experiences that underpin students' attitudes, self-efficacy, and values with relation to mathematics along with students' prescribed antidotes for improvement, instructors may provide more positive or favorable experiences while preventing the reproduction of more negative or unfavorable experiences.

This study further adds to the literature in that it qualitatively describes and explains the math views and beliefs of students at a large urban community college in the South Atlantic Region of the United States. Findings clearly demonstrate that students' views and beliefs about math develop over time in complex ways. Major themes that emerged from the integrated (quantitative and qualitative) findings showed a confluence of individual (e.g., perceived ability), interpersonal (e.g., experiences with math teachers, stories from family and friends about math), and sociocultural (e.g., whether racial discrimination and/or gender norms are salient in one's country) influences are at play in the math attitudes, beliefs, and values students hold. From this, community college stakeholders in comparable settings will be able to empathize with the ways today's students' grapple with learning math. Knowing how their students experience and feel towards math is the first step to implementing appropriate strategies attempting to improve students' math attitudes, self-efficacy, and values to enhance achievement outcomes in STEM-related courses. Further, with students seemingly placing the burden of improving their math learning, views, and beliefs on themselves, educators should be explicit in encouraging students to seek help from their instructors and tutors so that they don't feel it is solely their responsibility to navigate their math understanding without additional support.

Implications for Theory

This study contributes to the expansion of motivation theories through the integration of theories (i.e., social cognitive theory, expectancy value theory) while also including attitude as its own entity with regard to students' liking or disliking of mathematics. Attitude, self-efficacy, and value were individually assessed through quantitative survey and further explained with qualitative interviews. Through the use of both methods (quantitative and qualitative), context was accounted for while keeping students' viewpoints at the forefront.

With regard to context, the study considers math attitude, self-efficacy, and value as constructs that are shaped by complex sociocultural circumstances (e.g., gender, race, course level) as they relate to math learning experiences. In a majority of educational psychology studies, experiences related to sociocultural identity, and race in particular, are frequently thought to work in a monolithic manner (Davis et al., 2021; Matthews & López, 2020). This study sought to avoid relegating race and gender to mere generalizations in acknowledgement that student experiences vary and may be dependent on students' intersecting individual identities, as well as their interpretations of their learning and cultural contexts (Matthews & López, 2020). Taken together, findings contribute to our understanding of the complexity of community college students' culture, learning experiences, racial, and/or gendered experiences and how these relate to their shared and unique math beliefs and values.

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Appendix A

Appended Tables

Table A1

Study Course Levels

MTH Course Level	Course Title	Course Description	Credits
111	Basic Technical Mathematics	Provides a foundation in mathematics with emphasis in arithmetic, unit conversion, basic algebra, geometry and trigonometry. This course is intended for Career and Technical Education (CTE) programs.	3
130	Fundamentals of Reasoning	Presents elementary concepts of algebra, linear graphing, financial literacy, descriptive statistics, and measurement & geometry. Based on college programs being supported by this course, colleges may opt to add additional topics such as logic or trigonometry. This course is intended for occupational/technical programs.	3
154	Quantitative Reasoning	Presents topics in proportional reasoning, modeling, financial literacy, and validity studies (logic and set theory). Focuses on the process of taking a real-world situation, identifying the mathematical foundation needed to address the problem, solving the problem, and applying what is learned to the original situation. This is a Passport Transfer course.	3
161	Pre-Calculus I	Presents topics in power, polynomial, rational, exponential, and logarithmic functions, and systems of equations and inequalities. Credit will not be awarded for both MTH 161: Pre-calculus I and MTH 167: Pre-calculus with Trigonometry or equivalent. This is a Passport Transfer course.	3
162	Pre-Calculus II	Presents trigonometry, trigonometric applications including Law of Sines and Cosines, and an introduction to conics. Credit will not be awarded for both MTH 162: Pre-calculus II and MTH 167: Pre-calculus with Trigonometry or equivalent. This is a Passport Transfer course.	3
167	Pre-Calculus with Trigonometry	Presents topics in power, polynomial, rational, exponential, and logarithmic functions, systems of equations, trigonometry, and trigonometric applications, including Law of Sines and Cosines, and an introduction to conics. Credit will not be awarded for both MTH 167: Pre-calculus with Trigonometry and MTH 161/MTH 162: Pre-calculus I and II or equivalent. This is a Passport Transfer course.	5
245	Statistics I	Presents an overview of statistics, including descriptive statistics, elementary probability, probability distributions, estimation, hypothesis testing, correlation, and linear regression. Credit will not be	3

		awarded for both MTH 155: Statistical Reasoning and MTH 245: Statistics I or equivalent. This is a Passport Transfer course.	
261	Applied Calculus I	Introduces limits, continuity, differentiation and integration of algebraic, exponential and logarithmic functions, and techniques of integration with an emphasis on applications in business, social sciences, and life sciences. This is a Passport Transfer course.	3
263	Calculus I	Presents concepts of limits, derivatives, differentiation of various types of functions and use of differentiation rules, application of differentiation, antiderivatives, integrals, and applications of integration. This is a Passport Transfer course.	4
264	Calculus II	Continues the study of calculus of algebraic and transcendental functions including rectangular, polar, and parametric graphing, indefinite and definite integrals, methods of integration, and power series along with applications. Features instruction for mathematical, physical and engineering science programs. This is a Passport Transfer course.	4

Note.
Passport Transfer course = Course accepted by all public institutions of higher education in Virginia to fulfill lower-division general education requirements.

Table A2

Course Levels and Corresponding Degrees

Course Level	Course Title	Corresponding Associate Degree(s)	Semester(s) Offered During Study	Survey Sample Size (%)
MTH 111	Basic Technical Mathematics	[1]Horticulture Technology (AAS) Opticianry (AAS)	Spring 2022	6 (4.1%)
MTH 130	Fundamentals of Reasoning	Accounting (AAS) Management (AAS) Human Services (AAS) Culinary Arts (AAS) [1]Horticulture Technology (AAS) Paralegal Studies (AAS) Information Systems Technology (AAS)	Spring 2022	1 (0.7%)
MTH 154	Quantitative Reasoning	Architectural and Engineering Technology (AAS) Early Childhood Development (AAS) [1]Liberal Arts (AA) [1]Social Sciences (AS) [1]General Studies (AS)	Fall 2021 & Spring 2022	34 (23.4%)
MTH 161	Pre-Calculus I	Business Administration (AS) [1]Liberal Arts (AA) [2]Science (AS) [1]Social Sciences (AS) [1]Medical Laboratory Technology (AAS) [1]General Studies (AS)	Fall 2021 & Spring 2022	33 (22.8%)
MTH 162	Pre-Calculus II	[2]Science (AS)	Fall 2021 & Spring 2022	10 (6.9%)
MTH 167	Pre-Calculus with Trigonometry	[2]Science (AS)	Fall 2021 & Spring 2022	14 (9.7%)

MTH 245	Statistics I	[1]Liberal Arts (AA) [3]Science (AS) [1]Social Sciences (AS) [1]General Studies (AS)	Fall 2021 & Spring 2022	21 (14.5%)
MTH 261	Applied Calculus I	Business Administration (AS) [1]Liberal Arts (AA) [1]Social Sciences (AS) [1]General Studies (AS)	Spring 2022	9 (6.2%)
MTH 263	Calculus I	[3]Science (AS) Engineering (AS)	Fall 2021 & Spring 2022	12 (8.3%)
MTH 264	Calculus II	[3]Science (AS) Engineering (AS)	Fall 2021 & Spring 2022	5 (3.4%)

Key: AA = Associate of Arts, AAS = Associate of Applied Science, AS = Associate of Science (AS)

Note.
[1] Course is one of two or more MTH options that can be used to satisfy noted degree.
[2] MTH 161 + MTH 162 = MTH 167; Credit will not be awarded for both MTH 167 and MTH 161 or MTH 162.
[3] Course is a requirement for one or more of the specializations within the degree.

Table A3

Survey Score Distribution by Gender

Gender Identity		Attitude Score	Self-efficacy Score	Value Score	Overall Score
Cisgender Female	Mean	3.13	3.57	3.62	3.44
	N	82	82	82	82
	Std. Deviation	.98	.89	.72	.70
	Minimum	1.00	1.00	2.00	1.39
	Maximum	5.00	5.00	5.00	5.00
	Kurtosis	-.49	.10	-.49	.24
	Skewness	-.15	-.62	.00	-.18
Cisgender Male	Mean	3.49	3.70	3.62	3.60
	N	59	59	59	59
	Std. Deviation	.91	.89	.85	.77
	Minimum	1.00	1.00	1.17	1.12
	Maximum	5.00	5.00	5.00	4.93
	Kurtosis	.03	.85	.09	1.43
	Skewness	-.55	-.80	-.53	-.92
Prefer not to answer/Other	Mean	3.15	2.80	3.96	3.30
	N	4	4	4	4
	Std. Deviation	.75	.16	.57	.43
	Minimum	2.40	2.60	3.17	2.79
	Maximum	4.20	3.00	4.50	3.83
	Kurtosis	2.23	1.50	1.98	.59
	Skewness	1.13	.00	-1.20	.11
Total	Mean	3.27	3.60	3.63	3.50
	N	145	145	145	145
	Std. Deviation	.96	.89	.77	.73
	Minimum	1.00	1.00	1.17	1.12
	Maximum	5.00	5.00	5.00	5.00
	Kurtosis	-.41	.21	-.11	.60
	Skewness	-.30	-.61	-.31	-.47

Table A4

Survey Score Distribution by Race

Race		Attitude Score	Self-efficacy Score	Value Score	Overall Score
Asian	Mean	3.57	3.85	3.73	3.72
	N	22	22	22	22
	Std. Deviation	.75	.65	.53	.54
	Minimum	2.40	2.60	3.00	2.79
	Maximum	5.00	5.00	5.00	5.00
	Kurtosis	-.92	-.24	.33	.00
	Skewness	.30	.04	.55	.45
Black or African American	Mean	3.24	3.74	3.85	3.61
	N	28	28	28	28
	Std. Deviation	.94	.75	.76	.66
	Minimum	1.40	1.80	2.33	2.26
	Maximum	4.80	5.00	5.00	4.93
	Kurtosis	-.57	.65	-.80	-.36
	Skewness	-.01	-.77	-.43	.15
Hispanic/Latinx	Mean	3.83	3.60	3.69	3.71
	N	6	6	6	6
	Std. Deviation	.61	.64	.37	.32
	Minimum	2.60	2.60	3.17	3.26
	Maximum	4.20	4.20	4.17	4.06
	Kurtosis	5.48	-.94	-1.13	-1.23
	Skewness	-2.31	-.97	-.15	-.43
Multiracial or Other	Mean	2.82	3.38	3.35	3.18
	N	13	13	13	13
	Std. Deviation	1.03	1.06	.66	.70
	Minimum	1.40	2.00	2.00	2.30
	Maximum	4.20	5.00	4.17	4.19
	Kurtosis	-1.54	-1.60	-.14	-1.45
	Skewness	.03	.37	-.40	.17
White	Mean	3.24	3.52	3.55	3.44
	N	76	76	76	76
	Std. Deviation	1.00	.97	.85	.81
	Minimum	1.00	1.00	1.17	1.12
	Maximum	5.00	5.00	5.00	5.00
	Kurtosis	-.28	.16	-.31	.52
	Skewness	-.33	-.64	-.26	-.57
Total	Mean	3.27	3.60	3.63	3.50
	N	145	145	145	145
	Std. Deviation	.96	.89	.77	.73
	Minimum	1.00	1.00	1.17	1.12
	Maximum	5.00	5.00	5.00	5.00
	Kurtosis	-.41	.21	-.11	.60
	Skewness	-.30	-.61	-.31	-.47

Table A5

Survey Score Distribution by Course

Course		Attitude Score	Self-efficacy Score	Value Score	Overall Score
MTH 111 Basic Technical Mathematics	Mean	3.07	3.60	3.42	3.36
	N	6	6	6	6
	Std. Deviation	.90	.75	.82	.65
	Minimum	1.80	2.80	2.50	2.48
	Maximum	4.20	5.00	4.50	4.18
	Kurtosis	-.89	3.30	-1.74	-1.58
	Skewness	.05	1.55	.54	-.09
MTH 130 Fundamentals of Reasoning	Mean	2.00	2.80	3.33	2.71
	N	1	1	1	1
	Std. Deviation	.	.	.	.
	Minimum	2.00	2.80	3.33	2.71
	Maximum	2.00	2.80	3.33	2.71
	Kurtosis	.	.	.	.
	Skewness	.	.	.	.
MTH 154 Quantitative Reasoning	Mean	2.71	3.28	3.56	3.18
	N	34	34	34	34
	Std. Deviation	.89	.89	.68	.67
	Minimum	1.00	1.00	2.17	1.39
	Maximum	4.20	4.80	5.00	4.11
	Kurtosis	-.79	.14	-.40	.20
	Skewness	-.20	-.65	-.12	-.87
MTH 161 Pre-Calculus I	Mean	3.38	3.64	3.60	3.54
	N	33	33	33	33
	Std. Deviation	.90	.77	.61	.64
	Minimum	1.40	2.20	2.50	2.43
	Maximum	5.00	5.00	5.00	5.00
	Kurtosis	-.42	-.87	-.24	-.54
	Skewness	-.28	-.39	.47	.16
MTH 162 Pre-Calculus II	Mean	3.44	3.62	3.68	3.58
	N	10	10	10	10
	Std. Deviation	1.02	.97	.76	.78
	Minimum	1.80	2.40	2.17	2.73
	Maximum	5.00	5.00	4.83	4.74
	Kurtosis	-.76	-1.78	.54	-1.70
	Skewness	.21	.33	-.72	.44
MTH 167 Pre-Calculus with Trigonometry	Mean	3.86	3.89	4.10	3.95
	N	14	14	14	14
	Std. Deviation	.59	.64	.62	.48
	Minimum	2.80	2.80	3.00	3.22
	Maximum	4.80	5.00	4.83	4.69
	Kurtosis	-.86	-.72	-.99	-.82

	Skewness	-.39	-.09	-.51	.03
MTH 245 Statistics I	Mean	3.37	4.05	3.48	3.63
	N	21	21	21	21
	Std. Deviation	.98	.87	.85	.73
	Minimum	1.20	2.00	2.00	2.40
	Maximum	5.00	5.00	5.00	5.00
	Kurtosis	-.32	.03	-.60	-.35
	Skewness	-.13	-.83	.07	.13
MTH 261 Applied Calculus I	Mean	3.04	3.36	3.28	3.23
	N	9	9	9	9
	Std. Deviation	.71	1.15	.93	.80
	Minimum	1.40	1.00	1.67	1.36
	Maximum	3.80	4.80	4.50	3.97
	Kurtosis	3.85	1.10	-.20	3.78
	Skewness	-1.77	-1.12	-.25	-1.82
MTH 263 Calculus I	Mean	3.72	3.60	3.72	3.68
	N	12	12	12	12
	Std. Deviation	1.13	.96	1.07	.97
	Minimum	1.00	1.20	1.17	1.12
	Maximum	5.00	5.00	5.00	4.93
	Kurtosis	1.87	3.21	1.99	4.28
	Skewness	-1.23	-1.40	-1.35	-1.64
MTH 264 Calculus II	Mean	3.88	3.40	4.13	3.80
	N	5	5	5	5
	Std. Deviation	.56	1.23	1.02	.87
	Minimum	3.20	1.40	2.50	2.37
	Maximum	4.40	4.60	5.00	4.67
	Kurtosis	-2.69	2.00	1.30	2.77
	Skewness	-.34	-1.28	-1.33	-1.45
Total	Mean	3.27	3.60	3.63	3.50
	N	145	145	145	145
	Std. Deviation	.96	.89	.77	.73
	Minimum	1.00	1.00	1.17	1.12
	Maximum	5.00	5.00	5.00	5.00
	Kurtosis	-.41	.21	-.11	.60
	Skewness	-.30	-.61	-.31	-.47

Appendix B

Figure B1

Code Frequencies for Students with High Views and Beliefs

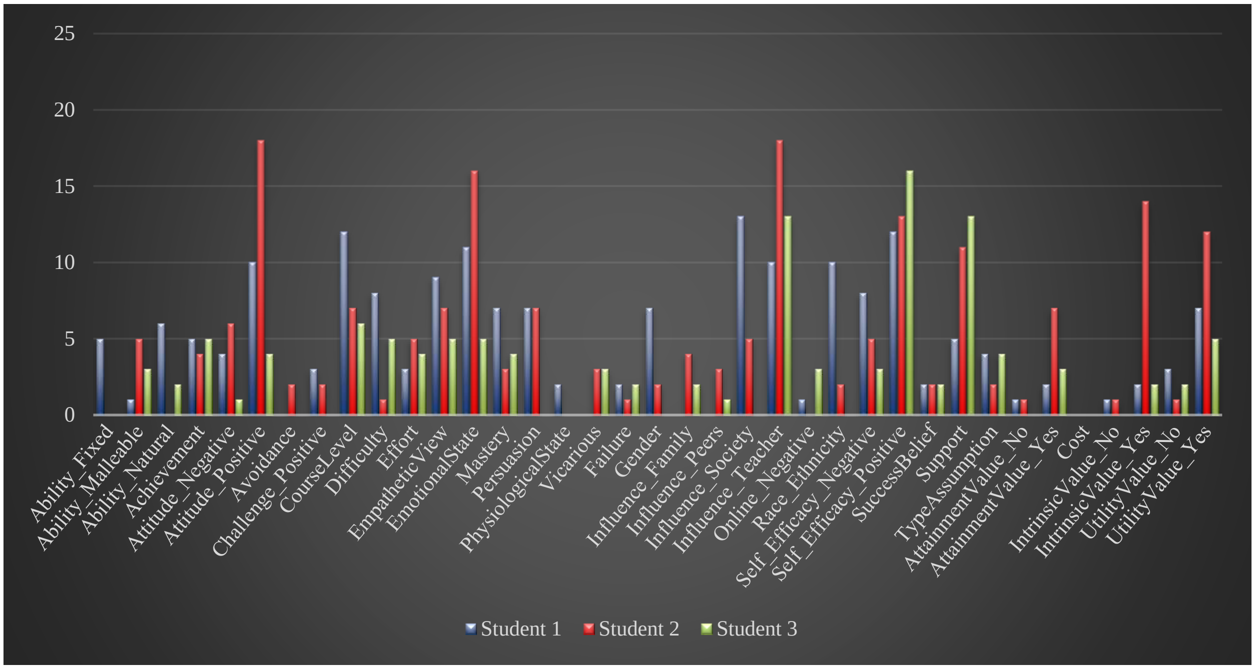
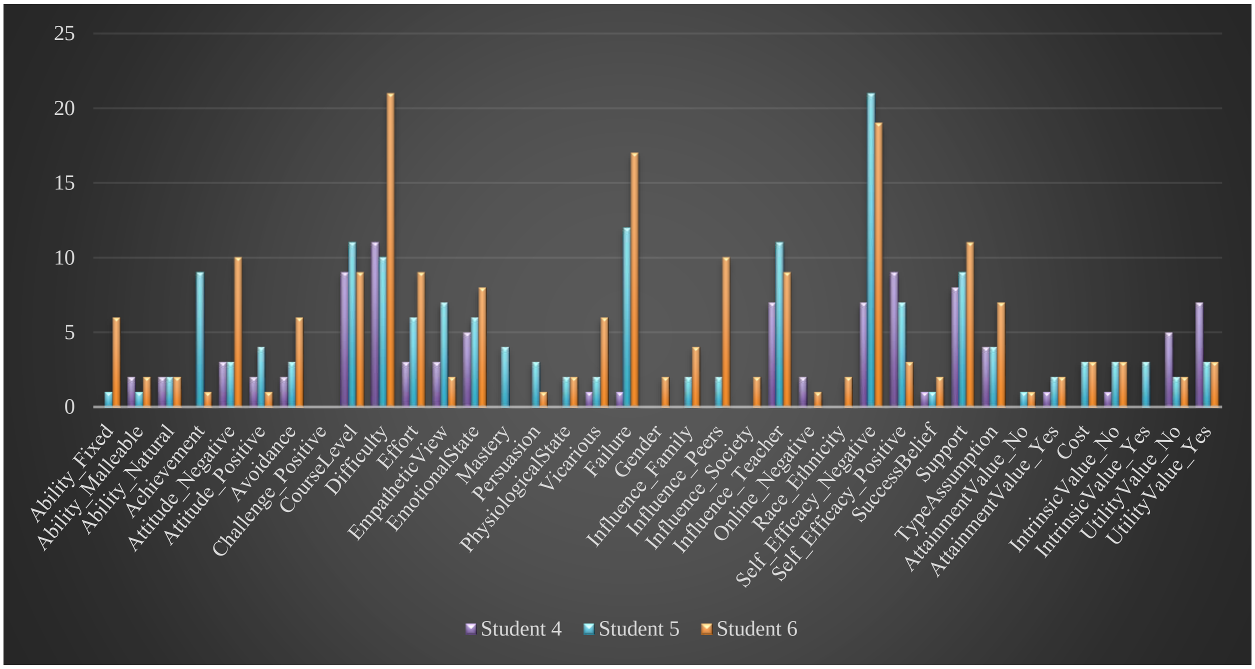


Figure B2

Code Frequencies for Students with Low Views and Beliefs



Appendix C

Participation Email to Faculty

Greetings colleagues,

I am emailing, both as your colleague here at Participating Community College and as a doctoral student at Virginia Commonwealth University. I am conducting dissertation research on student views and beliefs surrounding mathematics inclusive of their attitudes, self-efficacy (i.e., their perception of their own abilities), and values. I am interested in better understanding how complex motivational factors work together to influence college students' views and beliefs relative to mathematics in order to guide future research involving the improvement of these views and beliefs.

I am requesting voluntary study participation from all mathematics faculty teaching a fully synchronous 12- or 15-week college credit-level mathematics course between the hours of 8am and 5pm. Your involvement in this study will include permitting your qualifying classes to take part in the study by forwarding a student participation email to your eligible class(es) via email or Canvas class announcement. If agreed upon, I will send you the student participation email for forwarding. This email will include a link to a short online survey for voluntary student completion outside of your class time unless you choose to allow time for completion during your class. Students who complete the survey will be entered into a drawing for a chance to win one of six twenty-dollar VISA gift cards. Students who indicate that they would like to participate in future research may be contacted for a future research opportunity later in the semester.

Important Note: Although your participation sincerely is desired, you are not obligated to do so. Your name, student names, and any other personally identifying articles will be removed from all results before reporting.

Thanks so much for your time and consideration,

Marquita

Appendix D

Participation Request Email/Announcement to Students (Survey)

Greetings,

My name is Marquita Sea and I am both an Associate Professor of Mathematics here at PCC and a doctoral student at Virginia Commonwealth University. I am conducting a project on student views and beliefs surrounding mathematics inclusive of attitudes, perception of their own abilities, and values.

If you are 18 years of age or older, I am requesting your voluntary completion of an online survey regarding personal attitudes, ability beliefs, and values in mathematics. Students who complete the survey will be entered into a drawing for a chance to win one of six twenty-dollar VISA gift cards. Please access the survey using the following link:

https://docs.google.com/forms/d/e/1FAIpQLSdWO3CIoDiVQJacfBwLR9umRce88x7EO8NnctSmssDc1HVv1w/viewform

This survey is a research activity and your completion of any part of it is considered to be voluntary participation in the research study/project. It should take no longer than 10 minutes of your time. Useful data will come from your accurate and honest responses.

Again, participation in this project is voluntary and is not connected to coursework for your current mathematics class. Although your participation sincerely is desired, you are not obligated to do so. Your name and any other personally identifying articles will be removed from all results before reporting.

Thanks for your consideration,

Marquita Sea
Doctoral Student at Virginia Commonwealth University
Associate Professor of Mathematics at Participating Community College
PCC Street Address – Office Location
Richmond, VA *****
Phone: (804)***-****
E-mail (VCU): seamh@vcu.edu
E-mail (PCC): msea@pcc.edu

Appendix E

Participation Request Email to Students (Interview)

Greetings,

My name is Marquita Sea and I am both an Associate Professor of Mathematics here at PCC and a doctoral student at Virginia Commonwealth University. I am conducting a project on student views and beliefs surrounding mathematics inclusive of attitudes, perception of their own abilities, and values.

I am requesting volunteers to participate in a one-on-one interview to be held within the next three to four weeks. Your involvement in this portion of my study will include participation in a 45- to 60-minute audio-recorded interview with me. Interviews taking place via Zoom are preferred. However, in-person interviews taking place in my PCC office are also possible. Please reply to this email as soon as possible if you are available and willing to participate in interviews within the next three to four weeks.

Important Note: Although your participation sincerely is desired, you are not obligated to do so. Your name and any other personally identifying articles will be removed from all results before reporting.

Thanks for your consideration,

Marquita Sea
Doctoral Student at Virginia Commonwealth University
Associate Professor of Mathematics at Participating Community College
PCC Street Address – Office Location
Richmond, VA *****
Phone: (804)***-****
E-mail (VCU): seamh@vcu.edu
E-mail (PCC): msea@pcc.edu

Appendix F

RESEARCH PARTICIPANT INFORMATION SHEET

CLARITY STATEMENT

The information contained in the form is intended to give further clarification of the purpose of this project and your participation in it. If anything stated (or not) is unclear, please ask me to give further details and clear explanations in order to resolve any confusion.

PURPOSE OF THE PROJECT

I am and will always be a lifelong learner. I believe that unremitting inquiry and education will enhance my abilities for the betterment of my students and all others who have a hand in touching student lives. I am currently a doctoral student at Virginia Commonwealth University in the School of Education with a concentration in Educational Psychology. My research focus is on learning what motivates students to learn and absorb information and how I, as an educator, can help motivate and encourage students to be successful in class. More specifically related to this project, I am interested in understanding college students' views and beliefs relative to mathematics inclusive of attitudes, self-efficacy (i.e., their perception of their own abilities), and values so that future attempts at improving these views and beliefs can be pursued with student perceptions in mind. Improving students' views and beliefs regarding math has multiple benefits including improved learning behaviors, achievement, and likelihood they will persist in school. This particular project is being completed as part of my doctoral program requirements. This portion of my project will focus on gaining greater awareness of individual students' views and beliefs associated with mathematics. Furthermore, this portion of my project will seek to identify student perceptions of needed support in an effort to improve these views and beliefs. This will give educators an awareness of potential future support they can provide to meet student needs.

YOUR INVOLVEMENT AND CONFIDENTIALITY

This project is intended to enhance my knowledge of experiences that influence student views and beliefs in an effort to effect change that will foster positive views and beliefs relative to mathematics, uplift student ability beliefs in mathematics, and motivate student learning in mathematics classes. Our relationship is not a hierarchical one. We have similar goals in that you want to be successful in your mathematical pursuits and I want you and all students to be successful in these quests as well. I want to understand what you perceive to be causes of undesirable views and beliefs with respect to mathematics so that you and other students can possibly benefit from educators having that knowledge and making changes in an effort to improve student views and beliefs relative to the subject in the future.

You are being asked to participate in this project since you are currently enrolled in a credit-level college mathematics course. If you decide to participate in this project, you will be asked to sign and date this information sheet after making sure you thoroughly understand the purpose of the project and fully understand the answers to all associated questions you may have regarding the project. Your involvement in this project will include participation in a 1-hour audio-recorded interview with me, Marquita Sea. This interview will be specifically geared toward obtaining detailed information with regard to your current views and beliefs of mathematics, the factors and experiences you believe influence these views, and your opinions regarding needed support from mathematics teachers to nurture positive views and beliefs. Fruitful data will come from your thorough, open, and honest responses. Your name, school, and any other personally identifying articles will be removed from the results before reporting. All notes and recordings will be kept safely away from others. Your signature will serve as your permission to be interviewed and your understanding of the details associated with your participation.

VOLUNTARY PARTICIPATION AND WITHDRAWAL

Your participation in this project is voluntary. Although your participation is desired, you are in no way obligated to follow through with it. If at any point you decide that you do not want to participate, please let me know. You may end your participation at any time.

QUESTIONS

If you have any questions, please contact me:

Marquita Sea
Doctoral Student at Virginia Commonwealth University
Associate Professor of Mathematics at Participating Community College
PCC Street Address – Office Location
Richmond, VA *****
Phone: (804)***-****
E-mail (VCU): seamh@vcu.edu
E-mail (PCC): msea@pcc.edu

PERMISSION

I have read this information sheet and asked all questions I have associated with it along with the project itself. I understand the purpose of the project and agree to participate in it. I also understand that I can ask further questions and/or end my participation at any time.

______________________	______________________	________
Participant Name (Printed)	Participant Signature	Date

______________________	________
Signature of Researcher	Date

Appendix G

ONE-ON-ONE INTERVIEW PROTOCOL

An Exploration of the Experiences That Underpin Community College Students' Attitudes, Self-Efficacy, and Values in Mathematics

I. INTRODUCTION:

Thanks so much for taking the time to participate in this interview! What I learn from our discussion will help me better understand your thoughts on mathematics, mathematics ability, and how your past experiences influenced those thoughts. The interview will last between 45 and 60 minutes.

II. INTERVIEW SESSION:

I am interested in all of your viewpoints whether negative or positive. All responses will be helpful. As indicated on the information sheet, I want to learn what motivates students to learn and how educators help motivate and encourage students to be successful in math. More specifically related to this project, I am interested in understanding college students' views and beliefs relative to mathematics inclusive of attitudes, self-efficacy (i.e., their perception of their own abilities), and values so that future attempts at improving these views and beliefs can be pursued with student perceptions in mind.

This interview will be recorded so that your responses can be noted in a complete and accurate form; then, further transcribed for analysis. I will not use any personally identifying information in any papers or presentations. It will not be possible to identify any individuals who participated in the project. Before I record, do you have any questions or concerns?

[Start Recording]

RQ2) What is the nature of community college students' attitudes, self-efficacy, and values related to mathematics?

A. How do students describe their perceptions of mathematics, in general?

1. Do you like mathematics? Why or why not?
   a. What do you like about the subject?
   b. What do you dislike about the subject?
2. Do you feel that mathematics ability is innate or is it an acquired skill?
3. Do you believe that it is possible for people to learn mathematics and get better with effort? If yes, why? If no, why not?
4. Subject Task Values:
   a. Attainment Value: Is mathematics important to you?
   b. Intrinsic Value: Do you enjoy doing math?

c. Utility Value: Is math useful? Is taking mathematics at the college level helpful and relevant to your life outside of school?
d. Cost: Does completing mathematics coursework require too much time and/or effort? If so, is it worth the time and effort?

B. How do students describe their mathematics ability?

1. How do you feel when given mathematical tasks?
2. How do you feel about your ability to use math in everyday life (outside of school)?
3. How do you feel about your mathematics ability relative to school related tasks?
    a. Have you been successful in your previous math classes?
    b. What does success in mathematics look like? How would you describe it?
4. Beliefs and Expectancies for Success:
    a. Did you or are you try(ing) to get all of your mathematics requirements out of the way immediately or did you wait (are you putting off certain courses)? Why?
    b. Do you feel that you can be successful when presented with mathematical tasks in life? Please elaborate (if necessary). Have you always felt this way? If not, when did it change and why?
    c. Do you feel that you can be successful when presented with mathematical tasks in school? Please explain (if necessary). Have you always felt this way? If not, when did it change and why?

RQ3) How do students' various identity markers and mathematics learning experiences relate to their attitudes, self-efficacy, and values in mathematics?

A. How do students describe their perceptions of mathematics their beliefs about who is successful in the domain?

1. Can you describe your view of the typical mathematician?
    a. What types of people are experts at math?
    b. What types of people are good at math?

B. Are there particular experiences perceived to cause low self-efficacy or related competence beliefs in mathematics?

1. What do you believe causes feelings of low ability or lack of confidence in mathematics?
2. Did you take any developmental mathematics courses in college?
    a. If so, how many? Were they helpful?
    b. Were you placed in the course(s) or did you enroll by choice?
        i. If placed, how did you feel about being placed in them?
        ii. If chosen, what made you choose to take them before enrolling into college-level mathematics courses for credit toward your degree?

c. Did taking developmental mathematics courses make you feel any different about your ability to do mathematics? If so, did it make you feel better or worse about your mathematics ability?

3. Can you think of any particular instances that may have made you doubt your mathematics ability? Please describe them in as much detail as possible.
   Probe:
   a. Experience at home (parents, other family members, peers, etc.)
   b. Experience at school (teachers, grades, high-stakes testing, etc.)
   c. Do you believe race or gender had any impact on your experiences with math?

RQ4) What do community college students report about what supports would improve/increase their attitudes, self-efficacy, and values?

A. What do students propose for educators in support of student perceptions of mathematics ability?

1. Reflecting back on the school-related experiences that may have made you doubt or question your ability to do well in mathematics, do you believe the teacher could have helped change your views?
   a. What actions could your teacher(s) have taken? What could they have done differently?
   b. Was there anything specific that your teacher(s) did to make you feel good or better about your mathematics ability?
   c. What experiences encouraged your efforts and/or perceived ability to be successful in mathematics?