An Investigation of First-time College Freshmen and Relationships Among Mathematical Mindset, Identity, Self-efficacy, and Use of Self-regulated Learning Strategies

By
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Katrina Stullken Rothrock
M.A., University of Kansas, 2006
B.S., University of Kansas, 1996

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Chairperson: Dr. A. Susan Gay

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Dr. Heidi L. Hallman

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Dr. Steven H. White

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Dr. Bruce B. Frey

____

Dr. Margaret M. Bayer

Date Defended: April 26, 2019

The Dissertation Committee for Katrina Stullken Rothrock certifies that this is the approved version of the following dissertation:

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Chairperson: Dr. A. Susan Gay

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Abstract

Students experience great social and academic challenges during their first semester of college and for many, the completion of required mathematics courses is one of those challenges. This study investigated the relationship of first-time college freshmen's mathematics course enrollment, gender, and high school mathematics course experience to their mathematical mindset, identity, self-efficacy, and use of self-regulated learning strategies in mathematics courses. Two forms of a researcher-developed survey instrument were administered to students enrolled in three mathematics courses at a Midwestern public research university to examine the differences among those constructs at the beginning and end of the Fall 2018 semester.

A multivariate analysis of variance on the data from 299 participants at the beginning of the semester indicated significant differences in students' mathematical identity and self-efficacy scores. Calculus I students reported significantly higher mathematical identity scores than Intermediate Algebra students, and students who had taken mathematics courses beyond Algebra 2 in high school had significantly higher mathematical identity and self-efficacy scores than those who had not. A multivariate analysis of variance on the data from 176 participants at the end of the semester found marginally significant differences in Intermediate Algebra and Calculus I students' mathematical identity scores. There were no significant gender differences identified for any of the constructs nor any significant differences in students' mathematical mindset or use of self-regulated learning strategies scores at the beginning or end of the semester, and no significant differences in mathematical self-efficacy were identified at the end of the semester. Multiple linear regression analyses indicated that college mathematics course enrollment contributed significantly to mathematical mindset, identity, and use of self-regulated learning strategies, and high school mathematics course experience contributed significantly to mathematical identity and self-efficacy.

Mathematical self-efficacy scores decreased over the course of the semester for all 68 of the participants who took both surveys; a repeated measures analysis of variance revealed statistically significant differences for males, Intermediate Algebra students, and those who had taken advanced mathematics courses in high school. No statistically significant differences were identified among two-time participants with regard to mathematical mindset, identity, or use of self-regulated learning strategies.

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them. During the time I was working on this degree, together you finished: a bachelor's degree in biology, a law degree, a master's degree in urban planning, and four high school diplomas. I am so proud of all of you! I love you. Go be great!

Dedication

I dedicate this dissertation to my parents, Lorna and Lloyd Stullken, who believed that all people should have the opportunity to learn and experience success, who modeled patience and persistence in the face of challenges, and who encouraged me to be confident and satisfied with who I am and what I choose to do. You have inspired me to consider ideas I had not previously, learn from those with conflicting perspectives, and believe in everyone's ability to learn and their right to the opportunity to do so. Thank you, and I love you!

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CHAPTER 1

THE RESEARCH PROBLEM

Introduction

The freshman year of college is historically a critical period of time for students, as it requires adjustment to new social and academic demands, offers the greatest possibility of transformative learning, and is also the foundational period for students' decisions to persist in college or drop out (DeBerard, Spielmans, & Julka, 2004; D'Lima, Winsler, & Kitsantis, 2014; Tinto & Goodsell, 1993). College life can be demanding, unsettling, and stressful, requiring high levels of self-regulation and independent initiative (Chemers, Hu, & Garcia, 2001), but it also offers an opportunity for students to discover new personal strengths, try out new identities, and develop independence (Clark, 2005; Terenzini et al., 1994). Freshmen differ in both their academic and psychological readiness for college (Komarraju, Ramsey, & Rinella, 2013). They experience a drastic shift in personal responsibilities (Appleby, 2014), decreased institutional and parental supports, and a sudden change of social environment and schedule flexibility (Clark, 2005; DeBerard et al., 2004; D'Lima et al., 2014; Dvořáková et al., 2017). They often underestimate the time that college academics will take (Clark, 2005; D'Lima et al., 2014; Thibodeaux, Deutsch, Kitsantis, & Winsler, 2017), experience stress-related complications (Dvořáková et al., 2017), worry about social and financial difficulties (D'Lima et al., 2014; Terenzini et al., 1994; Tinto, 2017), and do not necessarily respond with productive behaviors (DeBerard et al., 2004; Dvořáková et al., 2017).

Many first-time college freshmen are required to complete a mathematics credit in order to qualify for graduation, no matter what degree program they select (Barr & Wessell, 2018; Bryk & Treisman, 2010; Peters, 2013). Enrollment in these courses may exacerbate the challenges they face as freshmen, since many are unprepared for the quality and workload expectations of postsecondary mathematics instructors, and often do not have the skills necessary for complex mathematical thinking (Appleby, 2014; Barnes, Cerrito, & Levi, 2004; Corbishley & Truxaw, 2010). First-time freshmen may also experience frustration about a lack of personal interaction with instructors, confusion about available academic resources, and uncertainties related to a different learning environment (e.g. large lecture sections versus small high school classrooms, or class meetings two or three times per week versus every day) (Burrill, 2017; Clark, 2005; Freeman, Anderman, & Jensen, 2007). When students are not ready to tackle the challenges presented in their first year of college, failure can form a barrier that prevents them from moving on to other classes, or even finishing a college degree (Barr & Wessel, 2018).

Personal identities develop for freshmen as they construct new understandings and learn "who they are" with respect to the interactions and norms created by their learning environments (Bishop, 2012). Feelings of membership, inclusion, and commitment are basic to individuals' definitions of themselves (Boaler, William, & Zevenbergen, 2000; Davis, 1999; Walton & Cohen, 2007). A student's mathematical identity may either tell the story of one who is capable and competent at doing mathematics, or one who cannot do mathematical work and does not fit in with people who do (Aguirre, Mayfield-Ingram, & Martin, 2013; Kaasila, 2007). Identities are the ways in which people come to see and describe themselves, and they direct how individuals act as a result of those self-formed images (Aguirre et al., 2013). Students' mathematical identities can work together with other contextual dynamics, such as the social aspects of the learning environment, to affect mathematical achievement (Cohen & Garcia, 2008; Owens, 2008). As students enter a mathematics classroom, they evaluate whether or not one of their identities (e.g., as a female, as a non-White, as a non-math person, etc.) is likely to be connected to a negative outcome, which may guide how much effort they are willing to expend on participation and performance (Cohen & Garcia, 2008). Students' past and present experiences with mathematics learning contribute heavily to the development of their mathematical identity, differentiating those who have experienced positive mathematical engagement with teachers and peers from those who have experienced mathematics teaching that is exclusionary, treating them as helpless and negligible outsiders to the mathematics community of practice (Boaler, 2002; Solomon, 2007).

The mindset that students develop about the nature of mathematical intelligence, mathematics learning, and the role they play individually as a mathematics learner can make the difference between being successful and unsuccessful in mathematics (Boaler, 2016). Having a growth mindset, or believing that one's intelligence can grow with effort, may make a substantial difference in students' willingness to exert the work needed to be successful (Hong, Chiu, Dweck, Lin, & Wan, 1999). When students have growth mindsets about mathematics, they are more likely to find resources to respond to obstacles or setbacks in their mathematics coursework (Blackwell, Trzesniewski, & Dweck, 2007; Boaler, 2016; Dweck & Leggett, 1988; Hong et al., 1999). When students have a fixed mindset about mathematics, they believe that mathematical ability is a natural talent that one does or does not possess, and they tend to avoid difficult tasks because of a fear of failure (Boaler, 2016). "…[I]rrespective of the truth – or what psychometricians believe to be the truth – there is very compelling evidence that what a *student* thinks about intelligence can have a powerful effect on his or her achievement" (Aronson, Fried, & Good, 2002, p.115).

Students continuously evaluate what they believe they can do based on their personal experiences, others' experiences that they observe, feedback that they receive from peers, parents, and teachers, and the physiological reactions they experience within contexts like a mathematics classroom (Schunk & Pajares, 2001; Zimmerman, 2000b). One's level of mathematical self-efficacy, or belief in one's ability to complete specific mathematical tasks at a particular level of performance (Bandura, 1986, 1997), is highly associated with mathematics achievement (Ayotola & Adedeji, 2009; Bandura, 1997; Chemers et al., 2001; Gore, 2006; Hackett, 1985; Hsieh, Sullivan, & Guerra, 2007; Multon, Brown, & Lent, 1991; Pajares & Miller, 1994; Peters, 2013; Zimmerman, 2000b). These self-efficacy beliefs influence what tasks students choose, how much effort they plan to expend, how hard they will attempt to work at a task and for how long, and how well they actually perform (Bandura, 1997; Schunk & Pajares, 2001). When students have weak mathematical self-efficacy, they feel they do not have the skills necessary to perform a specific mathematical task (Hall & Ponton, 2005). The more proficient students judge themselves to be, the more challenging the goals they create for themselves (Zimmerman, 2000b; Zimmerman, Bandura, & Martinez-Pons, 1992). Additionally, the more efficacious students are, the better they are at monitoring their work time, the more persistent they are at working through difficult problems, and the better they are at solving conceptual problems compared to others at the same skill level (Zimmermann, 2000b).

When students take personal initiative to seek information, persevere to find resources to understand it, evaluate their understanding, and adapt their thinking and behavior to be more successful in the future, they are able to make strategic decisions about their overall academic plan, including how to achieve academic goals (Nota, Soresi, & Zimmerman, 2004; Zimmerman, 1989, 2002, 2008). Such self-regulated learners possess skill sets that help them understand and complete academic tasks, and they are motivated to seek and employ useful strategies at appropriate times to accomplish those tasks (Newman, 2002), controlling their thoughts and actions, even in the face of external factors that may otherwise influence their learning (Bandura, 1989). Self-motivational beliefs such as self-efficacy impact students' use of self-regulatory learning strategies (Cleary & Chen, 2009; Eccles & Wigfield, 2002; Zimmerman, 2000a). As a result, self-regulated learners tend to have high self-efficacy and high academic achievement (Schunk & Zimmerman, 1997; Zimmerman, 2000a, 2002). Students who express enjoyment in learning mathematics and perceive mathematics to be valuable and associated with their future goals are more likely to use self-regulatory learning strategies (Cleary & Chen, 2009), but any student can learn self-regulatory processes, which can lead to increased motivation, learning, and achievement (Schunk & Zimmerman, 1997; Zimmerman, 2002).

Statement of the Problem

The purpose of this study was to investigate the relationship of first-time college freshmen's mathematics course enrollment, gender, and high school mathematics course experience to their mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses.

Research Questions

The study was designed to answer the following research questions:

1. Does mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies differ significantly among first-time freshmen, when considering their mathematics course enrollment, their high school mathematics course experience, or their gender, as measured at the beginning of the semester?
2. Does mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies differ significantly among first-time freshmen,

when considering their mathematics course enrollment, their high school mathematics course experience, or their gender, as measured at the end of the semester?

3. What are the relative contributions of mathematics course enrollment, high school mathematics course experience, and gender to mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies?
4. Do first-time freshmen students' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies significantly differ between the beginning of the fall semester and the end of that semester, and do those differences vary significantly when gender, high school mathematics course experience, and mathematics course enrollment are considered?

To answer the research questions, the study used a quasi-experimental repeated measures design (Green & Salkind, 2014; Shadish, Cook, & Campbell, 2002) over the course of a single semester. Data were collected from students enrolled in one of three undergraduate mathematics courses commonly taken by first-time freshman students at a large Midwestern public research university, including Intermediate Algebra, College Algebra, and a Calculus I course intended for mathematics, science, and engineering majors.

All 1,844 students enrolled one of the three courses at the beginning of the Fall 2018 semester were invited to participate by taking two online surveys, one at the beginning of the semester and one at the end of the semester. The surveys were delivered through a university-licensed web-based survey tool, and were comprised of 54 items including a personal identifier, 20 demographic information items, and 33 items that formed the four subscales of mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies. Only the respondents who were identified to be first-time freshmen who adequately completed the surveys were included in the data analysis as participants. There were 299 participants at the beginning of the semester, 176 participants at the end of the semester, and 68 participants who took both surveys. Statistical analysis included multivariate analyses of variance, multiple linear regression, repeated measures analyses of variance, and paired-sample *t* tests as appropriate to answer each of the research questions.

Rationale for the Study

First-time college freshmen are beginning a new phase of their lives, looking forward to new social and academic experiences, and learning how to be on their own and take responsibility for the tasks of life (Arnett, 2016). In addition to exciting new experiences, freshmen experience inevitable stress from dealing with new relationships, learning how to manage their time and money, thinking differently than they did in high school, and dealing with new learning environments and expectations (DeBerard et al., 2004; D'Lima et al., 2014). First-time freshmen are often required by postsecondary institutions to complete a mathematics course within their first year of undergraduate study (Barr & Wessell, 2018; Bryk & Treisman, 2010; Peters, 2013). Mathematics is a subject that many do not enjoy (Herzog, 2005), and may even fear (Strogatz, 2014). Studies have found that students' success in a first year mathematics course is predictive of eventual degree attainment (Barr & Wessel, 2018; Parker, 2005). However, postsecondary institutions across the United States have seen high rates of failure and withdrawal for entry-level mathematics courses (Harper & Reddy, 2013; Ko, Edwards, & Karakok, 2007; Norton, Bridges & High, 2018; Stage, 2001; Stage & Kloosterman, 1995; Stevenson & Zweier, 2011). There is much interest among institutions to address these concerns and the present study's results provided insights about the students who may be among those at risk for lack of success.

The beliefs that students develop about themselves are largely responsible for their success or failure in school, and for that matter, all life endeavors (Pajares & Schunk, 2002). The development of both mathematical identity and mathematical self-efficacy begins early in life, long before high school or college (Aguirre et al., 2013; Bandura, 1997), as does the mindset that students develop about the nature of mathematical intelligence, mathematics learning, and the role they play individually as a mathematics learner (Boaler, 2016). Students continuously evaluate what mathematical tasks they believe they can do (Schunk & Pajares, 2001; Zimmerman, 2000b), what mathematical skills they believe they can learn (Boaler, 2016), and ultimately "who they are" as a learner of mathematics (Aguirre et al., 2013; Bishop, 2012). Many studies exist to support the strong relationship between mathematical mindset and achievement (e.g., Blackwell et al., 2007; Boaler, 2016; Rattan, Good, & Dweck, 2012), identity and achievement (e.g., Boaler, 2002; Cohen & Garcia, 2008; Walton & Cohen, 2007), and self-efficacy and achievement (e.g., Ayotola & Adedeji, 2009; Chemers et al., 2001; Chen & Zimmerman, 2007; Hall & Ponton, 2005; Hsieh et al., 2007; Multon et al., 1991; Peters, 2013; Randhawa, Beamer, & Lundberg, 1993; Vuong, Brown-Welty, & Tracz, 2010; Zimmerman et al., 1992).

There are few studies regarding how students' beliefs about mathematical mindset, mathematical identity, or mathematical self-efficacy are associated with first-time college freshmen's experiences in mathematics courses, their gender, or their high school mathematics course experience. This study provided an examination of first-time freshmen's perspectives about mathematics learning, including their beliefs about the nature of mathematical intelligence, their motivational beliefs about what they believe they can do, and how they see themselves as mathematical learners. This study also generated insight into how those beliefs differ among students enrolled in different first semester mathematics courses, of different genders, and with different levels of high school mathematics preparation, and offered information about how those beliefs change for first-time freshmen over the course of the first semester of college. Identifying what first-time freshmen in mathematics believe to be true about themselves as learners of mathematics could provide an understanding about and guidance on how to cultivate positive and confident mathematical learners.

Students' use of self-regulated learning strategies is important for academic success, especially for students balancing homework, studying, and other life activities (Kitsantis, Winsler, & Huie, 2008; Kitsantis & Zimmerman, 2009; Thibodeaux et al., 2017). Multiple studies have found a close connection between the effective use of self-regulated learning strategies and achievement (e.g., Briley, Thompson, & Iran-Nejad, 2009; Cleary & Zimmerman, 2004; Eshel & Kohavi, 2003; Schapiro & Livingston, 2000; Zimmerman, 2002), and have documented the close relationship among self-efficacy, self-regulation, and achievement (e.g., Cleary & Chen, 2009; Cleary & Kitsantis, 2017; Lee, Lee, & Bong, 2014; Malpass, O'Neil, & Hocevar, 1999; Pintrich & De Groot, 1990; Zimmerman, 2008). Few studies, however, have studied first-time freshmen's use of self-regulated learning strategies, or compared the differences among first-time freshmen's use of self-regulated learning strategies in different first year mathematics courses. Additionally, there are few studies that have documented how students' high school mathematics course experience is associated with the use of self-regulated learning strategies in college mathematics courses. The present study provided an opportunity to examine how first-time freshmen perceive their use of self-regulated learning strategies, and how that changes over the course of their first semester of college, or differs from other first-time freshmen enrolled in other mathematics courses.

Definitions of Terms

For the purposes of this study, the following definitions were used.

Advanced mathematics in high school was a term used for this study to describe courses that a student took in high school above the level of Algebra 2 such as Precalculus, Trigonometry, or Calculus. A student was designated as not having had advanced mathematics in high school if the highest level of mathematics course taken was Algebra 2, Integrated Math 3, or below. Whether or not the student received a passing grade in any of the described courses was not included as part of this study.

First-time freshmen are defined by the university Office of Institutional Research and Planning (2011) as

> [1] entering freshmen who have never attended any college;
>
> [2] students enrolled in the fall term who attended college for the first time in the prior summer term;
>
> [3] students who entered with advance standing (college credits earned before graduation from high school); [or]
>
> [4] any student who graduated from high school in the previous spring semester, regardless of whether or not they earned college credit prior to graduation or during the summer semester prior to the fall semester enrollment. (p. 1)

Mathematical identity is defined as "the dispositions and deeply held beliefs that students develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics in powerful ways across the contexts of their lives" (Aguirre et al., 2013, p. 14).

Having a *mathematical mindset* means having a growth mindset about mathematics (Boaler, 2016). A growth mindset is an incremental theory of intelligence wherein intelligence is rendered as something that can be increased through one's efforts (Boaler, 2016; Dweck, 2000, 2006; Dweck & Leggett, 1988). A mathematical mindset involves knowing that mathematics is a subject of growth and one's role is to learn and think about new ideas (Boaler, 2016).

Mathematical self-efficacy is self-efficacy specific to people's beliefs about their capabilities within the mathematical domain (May, 2009). Bandura (1993) defined perceived self-efficacy as "people's beliefs about their capabilities to exercise control over their own level of functioning and over events that effect their lives" (p. 118). It is "not a measure of the skills one has but a belief about what one can do under different sets of conditions with whatever skills one possesses" (Bandura, 1997, p. 37). "An efficacy expectation is the conviction that one can successfully execute the behavior required to produce the outcomes" (Bandura, 1977, p. 193).

Self-regulated learning strategies are the tactics or tools that students may enlist in order to learn effectively in a relatively short period of time (Cleary & Chen, 2009; Schunk, 2001). Self-regulation is defined as "the degree to which students are metacognitively, motivationally, and behaviorally active participants in their own learning process" (Zimmerman, 2008, p.167). "Self-regulation strategies facilitate students' planning and goal-setting prior to learning (forethought), enhance their attention-focusing and self-monitoring processes during learning or task performance (performance control), and enable them to evaluate the effectiveness of their learning methods after task performance (self-reflection)" (Cleary & Chen, 2009, p. 293).

Assumptions

It was assumed that the students who participated in this study were representative of students enrolled at a large Midwestern public research university in Intermediate Algebra, College Algebra, and Calculus I. There were many factors that were beyond the control of the researcher, such as the frequency of class meeting times each week, the mathematics instructors and discussion leaders, the setting in which students chose to take the survey, the time of day during which students took the survey, and the digital device on which they chose to participate. It was assumed that any differences among students with regard to those factors did not have an effect on the students' responses to the surveys.

It was assumed that students responded honestly and accurately to items on the surveys, and that they understood the information statement, directions, and the meaning of each survey item. It was also assumed that students' responses were reflective of their actual behavior and beliefs, and that they demonstrated their best effort to respond in a way that thoughtfully echoed those beliefs, rather than arbitrarily or systematically selecting responses. The surveys were available online, so it was assumed that all students had access to the survey forms and also had access to the announcement that the survey was available either through a posting in the online learning management system, through their university email, an instructor in-class announcement, or all three. It was assumed that the fact that the surveys were delivered through an online program did not have an impact on students' responses.

Statements included in the surveys were taken from a variety of sources. It was assumed that combining statements from multiple sources could collectively measure each construct and also that taking a subset of items from a source would not alter the contribution of those items to the intended construct measure. It was also assumed that the order in which the items were included on the survey did not have an impact on students' responses. This includes an assumption that requesting students' demographic information, gender in particular, at the beginning of the surveys did not have an impact on students' willingness to complete the surveys, nor the students' responses.

It was assumed that the instrument was able to elicit responses from students that allowed for an accurate measure of the constructs intended. A person's identities are organized by and make up one's self-concept (Howard, 2000; Oyserman & James, 2011), a construct that is acknowledged to be closely related to self-efficacy, and yet separate from it (Schunk & Pajares, 2001; Zimmerman, 2000b). It was assumed that identity and self-efficacy were discrete constructs that could be measured distinctly. It was also assumed that the four subscales had temporal measurement invariance for first-time freshmen over the course of the semester, such that the instrument was structurally stable over time and across different groups.

Limitations

This study was conducted at a large Midwestern public 4-year research university. The findings from this study are limited to students in one university, who enrolled in one of three mathematics courses at the university, and who were first-time freshmen in Fall 2018. Only the students who voluntarily took the surveys were included in the data analysis. The results may not be generalizable to the larger population of students who take introductory college mathematics courses at this university, and may not adequately represent most first-time freshmen at this university or other postsecondary institutions. Additionally, because this was not an experimental study, conclusions cannot be drawn about causal relationships.

It is possible that students may have misunderstood one or more of the survey items and therefore responded to something other than what the researcher intended. This could have occurred with demographic items, which would have placed students into an incorrect subgroup, or with any of the construct measurement items, which could have erroneously influenced the construct measurements for those students. Students could have decided to arbitrarily select responses to construct survey statements without adequately reflecting on their actual behaviors and beliefs. Students also may have responded honestly and reflectively, but not accurately or consistently; there were a few differences from the beginning of the semester to the end of the semester in students' reports of their gender and high school mathematics course experience for participants who took both surveys.

When taking the survey, students may have been influenced by one or more experiences in recent memory such that they responded more positively or negatively toward one or more of the construct measurement items than they might have on a different day. A variety of uncontrolled and unidentified variables related to students' experiences external to this study could have influenced students' responses in unknown ways as well. Because there are multiple sections of each course, many with different instructors or discussion leaders, students may have experienced different teaching styles, learning environments, presentations of content, and help-getting opportunities that could have impacted students' perceptions about themselves and mathematics learning over the course of the semester in unknown ways.

At the beginning of the semester, students may not have understood which mathematics course they were expected to consider in response to the construct measurement items since the semester had just begun. At the end of the semester, students may have been conflicted about whether to respond to items based on their overall mathematics course experience, or their perceptions and actual behaviors they engaged in during the Fall 2018 semester. Given the windows of time during which the two surveys were available to students, it is possible that some students responded to the surveys only 10 weeks apart, but others could have responded up to 15 weeks apart. This difference in the length of time between responses could have impacted the way in which students responded to the survey items.

This study includes measurement of two constructs, self-efficacy and identity, that are highly related. One's self-concept consists of one's past, present, and future identities organized together (Howard, 2000; Oyserman & James, 2011), and self-concept is closely related to and often confused with self-efficacy (Bandura, 1997; Zimmerman, 2000b; Zimmerman & Cleary, 2006). It is possible that students' responses to the items that measure the mathematical identity and mathematical self-efficacy constructs could be confounded, since the constructs are closely related and the researcher adapted items from other instruments in order to create several of the identity and self-efficacy items.

The order of items presented in the survey may have impacted students' decisions to complete the survey or may have impacted their responses with regard to mathematical mindset, mathematical identity, mathematical self-efficacy, or their use of self-regulated learning strategies. Demographic items such as gender, age, race, and high school mathematics course experience could have raised participants' awareness of their identity within a stereotypically advantaged or disadvantaged group, which could have impacted their responses.

The instrument employed a 5-point Likert scale for the construct subscales. Participants' responses to each construct item were based on their personal interpretation of how strongly they agreed or disagreed with a statement on an ordinal scale, which is not defined precisely (Boone & Boone, 2012). Some individuals may tend toward "extreme responding" (i.e., the tendency to use extreme choices on a rating scale) and others may tend toward "moderate responding" (i.e., the tendency to use the midpoint as often as possible), whether or not the responses reflect their actual behaviors and beliefs (Paulhus & Vazire, 2007).

The data collected in this study was self-reported. Since no one other than each individual has greater knowledge of one's own beliefs and actual behaviors, self-reported data offer the greatest access to a breadth of personal information (Paulhus & Vazire, 2007). However, results from self-reported data also suffer from potential sources of inaccuracy such as self-deception, self-enhancement, denial, acquiescent responding, extreme responding, over-simplification of a surplus of information about oneself, and a limited ability to retrieve accurately from memory, especially after introspection (Paulhus & Vazire, 2007; Rosen, Porter, & Rogers, 2017). Additionally, Rosen et al. (2017) found that higher ability students self-report far more accurately than lower ability students, which may introduce additional imprecision. Relevant to this study, it has been found that students have difficulty tracking their use of self-regulated learning strategies and tend to overestimate their use of such strategies (Winne & Jamieson-Noel, 2002; Zimmerman, 2008).

Overview

This dissertation is divided into five chapters. The first chapter provides an introduction to the problem and the rationale for the study. The second chapter includes a review of the literature that is relevant to the study, including literature on first-time freshmen in postsecondary institutions and their mathematical preparation and readiness, implicit theories of intelligence and mathematical mindset, identity and mathematical identity, self-efficacy and mathematical self-efficacy, and the use of self-regulated learning strategies in mathematics coursework. The third chapter describes the research methodology used for the study, including details about the participants and setting of the study, the instruments used, the procedures, and the data analysis. The fourth chapter documents the results of the study. The fifth chapter presents a summary of the study, conclusions drawn from the results, and recommendations for practitioners as well as suggestions for future research.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

As students encounter mathematical coursework throughout primary and secondary school, they experience varying success, support, opportunities, and challenges that develop their beliefs about themselves and mathematics, which consequently impact future experiences and efforts, including students' postsecondary success (Chemers et al., 2001). The way students view themselves and approach academic demands is key to their successful college performance and eventual graduation (Hsieh et al., 2007). Graduating with a postsecondary degree or credential has become important in order to be competitive for jobs that pay comfortably and are stable (Jimenez, Sargrad, Morales, & Thompson, 2016).

The intent of this study was to examine the mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses among first-time freshmen, and the relationship of those constructs to mathematics course enrollment, gender, and high school mathematics course experience. The review of related literature includes an examination of research on first-time freshmen, including their high school mathematics course experiences, transition to college, mathematics course enrollment, and the relationship between gender and mathematics course taking in high school or college. Additionally, the review of literature includes research on mathematical mindset, mathematical identity, mathematical self-efficacy, and the use of self-regulated learning strategies by students in mathematics courses and the research available on the relationship of these constructs to academic achievement, mathematics course enrollment, high school mathematics course experience, and gender.

First-Time Freshmen

Higher education institutions are enrolling more students now than in the past (Ginder, Kelly-Reid, & Mann, 2017; McFarland et al., 2018; Moore, 2018) due to the increasing necessity to obtain a college degree in order to be competitive in the job market (Jamelske, 2009). College courses offer opportunities for students to acquire knowledge and life skills for successful employment later (Schrader & Brown, 2008). First-time students starting at colleges and universities find that they must define a new life role for themselves by responding to new opportunities presented, and coping with a number of social, academic, and emotional stressors (DeBerard et al., 2004; D'Lima et al., 2014). They undergo environmental and behavioral transitions to negotiate these new roles within new contexts, adjusting to new academic demands while being distanced from familiar support structures and former ways of life (Clark, 2005; DeBerard et al., 2004; Freeman et al., 2007).

Demographics of First-Time Freshmen in the United States

In 2017, about 67% of students graduating from high school in the spring enrolled in college the following semester, and about 67% of those college-bound students attended 4-year institutions (U.S. Department of Labor, Bureau of Labor Statistics, 2018). According to a Cooperative Institutional Research Program (CIRP) survey, which captured data for first-time full-time students entering baccalaureate granting institutions across the United States in the fall of 2016, almost all (98%) of the first-time freshmen surveyed were graduates of a high school program they completed the previous spring (Eagan et al., 2017). The majority of the remaining had taken a "gap year" between graduating from high school and entering college and only a few had waited longer than a year between high school and college (Eagan et al., 2017). Almost 20%

acknowledged that they were first-generation college students, as neither of their parents had ever attended college (Eagan et al., 2017).

Two-thirds of the students in the CIRP survey identified themselves as White or Caucasian, 16% as Mexican American/Chicano or Other Latino, 13% as African American or Black, 11% as Asian (mostly East Asian), and 2% identified as American Indian or Alaska Native (Eagan et al., 2017). About 9% identified as having a different racial or ethnic background, such as Filipino, Puerto Rican, Native Hawaiian/Pacific Islander, or other. About 55% of the first-time freshmen were female, and 92% identified as heterosexual or straight, 4% as bisexual, 4% as gay, lesbian, queer, or other, and less than 0.5% identified as transgender.

High School Mathematics Course Experience

An analysis of the High School Longitudinal Study of 2009 (HSLS:09) First Follow-Up data of high school seniors indicated that about 65% of all graduating seniors in 2012 took mathematics courses above Algebra 2, between a third and a half completed precalculus and/or trigonometry, about 19% earned credit for calculus, and 11% completed a statistics course of some kind (Champion & Mesa, 2016; National Science Board, 2018). About 3% had earned high school mathematics credit in dual-enrollment courses (Dalton, Ingels, & Fritch, 2016). About 11% of the seniors in the HSLS:09 First Follow-Up reported taking no mathematics course their senior year (Ingels & Dalton, 2013), and about three-quarters of the senior students expected to enter postsecondary education (Dalton et al., 2016).

Almost all (99%) of the first-time full-time CIRP survey respondents in 2016 had studied at least three years of mathematics in high school, with 98% having completed at least Algebra 2 and 85% having completed a precalculus and/or trigonometry course (Eagan et al., 2017). Close to 40% had taken a calculus course (mostly AP Calculus), and a little more than a third had taken a probability and statistics course of some kind (about two-thirds of those were AP Statistics). Over three quarters had taken at least one Advanced Placement (AP) or International Baccalaureate (IB) course during high school, and about the same number planned to obtain a graduate degree of some sort.

Mathematics course experience and achievement. College bound students, who become first-time freshmen, take more mathematics courses at a higher level of mathematics preparation than do non-college bound students on average (Goodman, 2011; Levine & Zimmerman, 1995). A review of U.S. students' high school transcripts and postsecondary plans by Dalton et al. (2016) confirmed this difference in mathematical preparation. Researchers have recognized that the level of mathematics courses taken in high school is a significant factor in future student achievement (Adelman, 1999, 2006; Champion & Mesa, 2018; Froiland & Davison, 2016; Long, Iatarola, & Conger, 2009; Ma & Wilkins, 2007; Tyson, Lee, Borman, & Hanson, 2007; Whiton, Rethinam, & Preuss, 2018).

Adelman (1999) found that the odds of completing a bachelor's degree doubled for students who took a course beyond Algebra 2 in high school. Trusty and Niles (2003) analyzed the National Education Longitudinal Study (National Center for Education Statistics, 2002) and found that completing Algebra 2 more than doubled the likelihood of completing a bachelor's degree within eight years of high school. These results align with other studies that have found that students who completed advanced mathematics courses in high school were less likely to enroll in a developmental mathematics course in college compared to those who did not take courses beyond Algebra 2 (Hoyt & Sorensen, 2001; Whiton et al., 2018).

Students may meet a minimum set of criteria to be admitted to a college, but whether or not they will be successful in their coursework and graduate with a college degree is influenced greatly by their pre-college course experiences, skills, and outlooks (Arnold, Lu, & Armstrong, 2012; Veenstra, 2009). Additionally, students who take more rigorous mathematics courses in high school tend to earn higher salaries a decade later (Rose & Betts, 2004).

Mathematics course experience and self-efficacy. The mathematics courses that students take in high school has been found to be closely related to students' mathematical self-efficacy (Champion & Mesa, 2018; Updegraff, Eccles, Barber, & O'Brien, 1996). Champion and Mesa (2018) found that students who reported higher levels of self-efficacy in ninth grade were more likely to complete more mathematics courses than those with lower reported self-efficacy. Perceived academic self-efficacy influences students' academic course choices and career-related decisions in mathematics (Chen & Zimmerman, 2007). Self-efficacy has also been found to be the mediating factor between male and female mathematics course-taking decisions in high school (Updegraff et al., 1996).

Mathematics course experience and gender. Studies have shown that male students are more likely to take advanced mathematics courses in high school compared to females (Champion & Mesa, 2018; Davenport et al., 1998; Finkelstein, Fong, Tiffany-Morales, Shields, & Huang, 2012; Updegraff et al., 1996). However, Tyson et al. (2007) found that females were significantly more likely to enroll in advanced mathematics courses than males, except for the highest level courses that were dominated by male students. The results from the Tyson et al. (2007) study are consistent with results from a study by Updegraff et al. (1996) that showed that gender differences were most prominent among the highest achieving students in mathematics.

Among those enrolled in advanced mathematics courses, female students are more likely to perform better than males, who have a much broader range of achievement in all mathematics courses (Champion & Mesa, 2018; Davenport et al., 1998). For the courses in which they are enrolled, male and female students have similar completion rates, indicating that mathematics course completion during high school is not strongly related to students' gender (Champion & Mesa, 2018). Levine and Zimmerman (1995) found that taking more mathematics courses in high school was positively related to increased wages after college graduation for females in particular.

College Readiness

According to Conley (2007a), college readiness is

> the level of preparation a student needs in order to enroll and succeed – without remediation – in a credit-bearing general education course at a postsecondary institution that offers a baccalaureate degree or transfer to a baccalaureate program. "Succeed" is defined as completing entry level courses at a level of understanding and proficiency that makes it possible for the student to consider taking the next course in the sequence or the next level of course in the subject area. (p. 5)

About 90% of the freshmen participating in the national High School Longitudinal Survey of 2009 (HSLS:09) reported that they probably or definitely could complete college (Ingels, Dalton, Holder, Lauff, & Burns, 2011). Students' expectation of attending and completing a college degree, however, is not associated with their high school academic performance or course preparation; similarly, students' academic performance in high school does not necessarily correlate to their educational and professional aspirations (Goyette, 2008; Kurlaender & Howell, 2012). There is a disconnect between students' perceptions of college and career readiness and actual preparedness (Center for Community College Student Engaement, 2016). Lowery (2004) described millennial students, those born between 1982 and 2002 (Keeling, 2003; Rickes, 2011), as having an unrealistic confidence about their academic skills that is not supported by their true academic capabilities. A little more than three quarters of the first-time full-time students surveyed by CIRP felt they were above average or even in the highest 10% of others their age regarding their drive to achieve (Eagan et al., 2017). Almost three quarters of the freshmen felt the same about their academic ability, and 60% thought their intellectual self-confidence was above average or in the highest 10% compared to others their age. Just under half of the first-time freshmen on the CIRP survey felt their mathematical ability was above average or in the highest 10% compared to others their age.

According to the National Assessment of Educational Progress (NAEP), about a third of the nation's high school graduates are ready for college-level coursework in mathematics and reading (Snyder, de Brey, & Dillow, 2019; Sadler & Sonnert, 2017, 2018; Venezia & Jaeger, 2013). ACT (2017) reported that 41% of the 2017 graduating class of high school seniors who took the ACT met the ACT College Readiness Benchmarks in Mathematics, and 27% met all of the College Readiness Benchmarks (English, Mathematics, Reading, and Science). Almost two decades ago, Greene and Forster (2003) found that only 32% of high school graduates were prepared for college-level coursework at 4-year colleges. Low rates of college readiness translate into high rates of postsecondary remediation (Herzog, 2005; Roderick, Nagaoka, & Coca, 2009; U.S. Department of Education, Office of Planning, Evaluation and Policy Development, Developmental Education, 2017), a problem that has persisted for decades (Boylan, Bonham, & White, 1999; Rutschow, 2018; U.S. Department of Education, Office of Planning, Evaluation and Policy Development, Developmental Education, 2017).

There are many factors, both academic and nonacademic, that contribute to students' underpreparedness for college (Venezia & Jaeger, 2013). Academically, studies have found differences between what college instructors expect and what secondary teachers teach or believe students are learning (Appleby, 2014; Gordon, 2005; Sadler & Sonnert, 2018). For some students, learning in high school has been reduced to completing predefined tasks that do not require deep thinking or analysis of context (Conley, 2007b). In order to be considered college ready, students need to have mastery over core concepts and acquire new ways of thinking (Arnold et al., 2012). Additionally, college readiness is enriched when students demonstrate an ownership of learning, which can lead to improved self-efficacy as students recognize that they can reach their goals by putting forth effort (Conley & French, 2014). Simply passing mathematics courses in high school does not necessarily indicate that students are prepared for the independent rigorous thinking that is expected in college (Benken, Ramirez, Li, & Wetendorf, 2015).

Aside from academic factors, students' families, cultural communities, and noncognitive skills affect college readiness (Venezia & Jaeger, 2013). Studies show that students are more likely to attend college if their parent attended college (Goyette, 2008; Ingels & Dalton, 2013; Venezia & Jaeger, 2013). Differences in students' psychosocial skills translate into effective problem solving abilities and smooth transitions or a lack of ability to cope with ambiguous goals and direction (Komarraju et al., 2013; Venezia & Jaeger, 2013).

Mathematics Course Enrollment

In the fall of 2015, there were 2,213,000 students enrolled in mathematics courses at 4-year colleges and universities (Blair, Kirkman, & Maxwell, 2018). Of those students, 11% were enrolled in developmental mathematics courses, 45% were enrolled in introductory level courses (e.g. college algebra, precalculus, trigonometry, etc.), 36% were in enrolled in a calculus course, and the remaining were in advanced level courses. Developmental mathematics, introductory level mathematics, and calculus are the primary courses that first-time freshmen enroll in their first semester of college (Andrews & Brown, 2015). An additional number of first-time freshmen do not enroll in any mathematics course, having already gained credit for required mathematics courses, either during high school through a dual enrollment program or through an exam such as Advanced Placement (Bressoud, 2017; Hoffman, Vargas, & Santos, 2009).

Freshmen mathematics courses are also frequently a gatekeeper to other major courses, such that success in those mathematics courses is predictive of student achievement in college overall (Cribbs, Hazari, Sonnert, & Sadler, 2015; Ndum, Allen, Way, & Casillas, 2018; Thiel, Peterman, & Brown, 2008). Passing a first-year mathematics course along with attaining a high GPA in the first year are the two most meaningful factors during the first semester to lower the dropout risk for first-time freshmen (Callahan & Belcheir, 2017; Herzog, 2005).

Developmental Mathematics

Each year, there are millions of students who enroll in college, and are surprised to learn that they are not prepared for college, and will be required to pay for and take developmental coursework that will not contribute to their credits toward a degree (Jimenez et al., 2016). The Center for Community College Student Engagement (CCCSE) found that data from the Survey of Entering Student Engagement revealed that 40% of students who had high grades in high school (A average) also reported being placed into one or more developmental education classes in college (CCCSE, 2016). Between 2010 and 2015, estimated enrollments in precollege level mathematics courses in 4-year colleges increased by 21% according to the 2015 Conference Board of Mathematical Sciences (CBMS) survey by the American Mathematical Society (Blair et al., 2018).

Enrollment in developmental mathematics is highly diverse (Boylan, Bonham, & Tafari, 2005). The majority (66%) of students placed into an Intermediate Algebra course in the fall of

2008 in a large, urban state university had taken mathematics all four years of high school, and almost 60% of them had completed advanced mathematics courses beyond Algebra 2 (Benken et al., 2015). However, almost one-fourth of the same population of students also took three or four years to earn a passing credit in Algebra 2 (Benken et al., 2015). Atuahene and Russell (2016) found that there were many factors that contributed to students' eventual placement in a college developmental mathematics course, including students' family income level, the quality and rigor of prior mathematics courses regardless of level of advancement, and the educational degree attained by their mathematics instructors.

Results from the Beginning Postsecondary Students 2009 study showed that about half of all undergraduates take one or more developmental courses during their time as a student (Armstrong & Zaback, 2014; Scott-Clayton & Rodriguez, 2012). If postsecondary institutions were to require developmental education for all students receiving inadequate scores on entry assessments, the number would be even higher (Chen & Simone, 2016), but many students who are told to enroll in developmental courses never do (Bailey, 2009). As the demand for such courses grows, so does the cost to educate each underprepared student (Bailey, Jeong, & Cho, 2008; Bettinger & Long, 2009; Boatman & Long, 2018; Howard & Whitaker, 2011).

Postsecondary institutions offer developmental education opportunities to address the cognitive and affective needs of students who are not college-ready in order to help them successfully progress toward their degree goals (Bahr, 2008; Boylan & Bonham, 2007; Scott-Clayton & Rodriguez, 2012). Developmental courses often reteach secondary-level content (Jaggars & Stacey, 2014), but they also frequently include material aimed at teaching study skills and learning strategies (Boylan & Bonham, 2007; Boylan, Bonham, & White, 1999). Attewell, Lavin, Domina, and Levey (2006) reported that only about 30% of students pass the developmental mathematics courses in which they enroll. Developmental education, in an effort to offer an opportunity for academic enrichment, also erects a barrier to college completion (Bonham & Boylan, 2012; King et al., 2017).

Parsad and Lewis (2003) reported that, in the year 2000, mathematics courses were the most commonly offered subject for developmental courses at postsecondary institutions, with almost three-quarters of those offered through mathematics departments (Boylan & Bonham, 2007). Given the low passing rate, there is substantial ambiguity regarding the overall value of developmental courses for students (Boatman & Long, 2018; Kurlaender & Howell, 2012). Results of multiple studies regarding the effectiveness of remediation coursework have been mixed (Boatman & Long, 2018; Chen & Simone, 2016). According to some studies, developmental mathematics courses may create the single greatest obstacle to students' pathways to graduation, since fewer than half of the students enrolled in such courses ever complete the developmental pathway, and even fewer pass subsequent college-level courses (Park, Woods, Hu, Jones, & Tandberg, 2018; Rutschow, 2017). Bahr (2008) argued that developmental mathematics courses have positive results for a subset of students who achieve college-level mathematics skills and progress toward degree completion, but noted that more research is needed to identify the obstacles that impede successful remediation for others. Bettinger and Long (2009) supported this conclusion, finding that developmental education plays a significant role in serving the needs of underprepared students. Boatman and Long (2018) proposed that differential results may be based on students' prior academic preparation, and that more accurate methods to determine course placements could improve the success rates of students in developmental mathematics.

Common characteristics and challenges. Benken et al. (2015) found that students placed into developmental mathematics exhibited some common characteristics at the beginning of the semester, including a sense that they possessed an average level of mathematical skill and felt confident that they would pass the course, but did not enjoy mathematics nor display significant confidence in their ability to justify a mathematical response. Upon closer inspection, Benken et al. (2015) found that there was a statistically significant difference once students' high school mathematics course experience was considered; students enrolled in developmental mathematics who had passed either Statistics or Calculus in high school rated their skill level significantly higher than those who had not passed a course beyond Algebra 2. At the end of the semester, the same participants reported increased enjoyment, confidence, and comfort level related to mathematics, and a statistically significant increase in mean mathematical skill level; there was also a statistically significant decrease in the number of participants who believed that mathematical ability was changeable (Benken et al., 2015).

Ley and Young (1998) suggested that underprepared students enrolling in postsecondary education may differ from other students not only in academic preparation, but also in their ability to structure learning opportunities, organize thinking, evaluate understanding, and monitor their progress toward success. A large number of students placed into developmental mathematics courses discover they do not have the time or resources required to adequately complete the work needed to be successful in their courses (Jimenez et al., 2016). Some students never enroll in required courses because they are discouraged by the additional time and money they will need to spend on developmental courses before being allowed entry into credit-bearing classes, and leave college instead (Bailey & Cho, 2010). Self-efficacy mediates students' motivation and performance (Bandura, 1997), and students enrolled in developmental mathematics tend to exhibit low self-efficacy (Hall & Ponton, 2005). Taking developmental coursework may weaken students' perceptions of their mathematical abilities and mathematical identities (Bettinger & Long, 2009; Boatman & Long, 2018).

Developmental mathematics and gender. Even as early as elementary school, research indicates that the mathematics achievement gender gap increases each year (Robinson-Cimpian, Lubienski, Ganley, & Copur-Gencturk, 2014). Gender gaps in mathematics are socially constructed to some extent and families and schools are central to the development of those social constructions (Beilock, Gunderson, Ramirez, & Levine, 2010; Eccles, 1986; Gunderson, Ramirez, Levine, & Beilock, 2012). Girls develop higher mathematics self-efficacy when they grow up in homes and classrooms where the importance and value of mathematical skills are emphasized, where they are encouraged to persevere when faced with academic or social complications, and where stereotypical conceptions of academic domains are not validated (Zeldin & Pajares, 2000). Walker and Plata (2000) found that college mathematics course enrollment did not have a significant relationship to gender, but gender was more strongly related to pass-fail frequencies in mathematics courses, with women failing more often than men.

College Algebra

A traditional role of College Algebra, combined with a course in precalculus, is to prepare students for success in a calculus course (Gordon, 2005; Herriott & Dunbar, 2009; Small, 2002). However, most students who take College Algebra do so in order to satisfy a general education requirement, so College Algebra is often a terminal mathematics course (Gordon, 2005; Small, 2002). A survey at the University of Nebraska showed that more than 20% of the students enrolling in College Algebra eventually repeated the course, almost a third progressed to non-mainstream calculus courses intended for business, life science, and social science majors, and 11% progressed to the mainstream mathematics-intensive Calculus I course (Herriott & Dunbar, 2009). According to the 2015 CBMS survey, enrollment in College Algebra increased 27% since 2010, but enrollment in Calculus I of any type increased by about 8% (Blair et al., 2018).

The vast majority of students enrolled in College Algebra are planning to get degrees in management, the social sciences, life science, and allied health sciences (Gordon, 2005; Herriott & Dunbar, 2009). Students with these degree paths need to understand functional relationships of quantitative variables, and develop mathematical reasoning and graphical analysis skills that will prepare them for future statistical and data analysis (Herriott & Dunbar, 2009). Some students who choose to enroll in College Algebra as a terminal course have placement scores that would allow them to take a more advanced course, but their degree only requires College Algebra (Wang, Eccles, & Kenny, 2013).

College Algebra is often a prerequisite for other courses required for a degree (Gordon, 2005). Introductory courses such as College Algebra can be problematic for students who lack interest in mathematics or fear they will fail (Thiel et al., 2008). For students who took advanced mathematics courses in high school, being placed into an introductory college level mathematics course may leave them feeling insulted, disappointed, and less motivated because they had evaluated their own mathematical skills to be higher (Bahr, 2008; Sadler & Sonnert, 2017). Studies on DFW rates (percent of students who receive a grade of D or F, or who withdraw) in College Algebra commonly report a DFW rate between 40 – 60% (Gordon, 2005; Small, 2002; Thiel et al., 2008; Twigg, 2009). For thousands of students each semester, College Algebra is an obstacle, stopping them from progressing toward their academic and career goals (Small, 2002).

Calculus

College calculus is not only the introduction to higher level mathematics, it is the gatekeeper to future careers in science, technology, engineering, and mathematics (STEM) (Ayebo, Ukkelberg, & Assuah, 2017; Sadler & Sonnert, 2017, 2018). For many students, calculus will be the pivotal factor determining whether they pursue a STEM career path, or change to a career that is less mathematically demanding (Ayebo et al., 2017). Students who do not complete calculus in their first year of college, either due to placement in prerequisite courses or failure in a calculus course, are almost assured to take longer than four years to obtain a bachelor's degree, which discourages many from pursuing their previously intended career (Ayebo et al., 2017).

Students who enroll in college calculus tend to have a strong mathematics identity; they like mathematics, express interest in it, believe it is relevant to their future career, and generally feel mathematically knowledgeable (Bressoud, 2015; Sadler & Sonnert, 2017). They are privileged, talented, very confident (Bressoud, 2015), and exhibit a statistically higher level of mathematical self-efficacy than students in developmental mathematics courses (Hall & Ponton, 2005). Conversely, college calculus instructors are frequently frustrated with their students' lack of algebra and precalculus knowledge that is needed for success in the course (Sadler & Sonnert, 2017). Some calculus students' confidence, enjoyment, and persistence diminish from the beginning to the end of the semester as their lack of mathematical preparedness and negative course experiences become an obstacle to progressing (Bressoud, 2015; Bressoud, Mesa, & Rasmussen, 2015; Sonnert & Sadler, 2014; Sonnert, Sadler, Sadler, & Bressoud, 2015).

Over half of the students who enroll in college calculus have already taken calculus in high school, including those who had received a high AP Calculus exam score (Bressoud, 2015;

Bressoud et al., 2015; Ellis, Kelton, & Rasmussen, 2014; Sadler & Sonnert, 2018). High school calculus is different than college calculus, as it emphasizes differentiation and integration, as opposed to the considerable amount of attention given in postsecondary calculus courses to concepts such as limits, graphical interpretations, and applications (Ellis et al., 2014). Almost a third of students who took AP Calculus in high school will retake Calculus I in college, while others (close to 20%) will receive credit for calculus and subsequently enroll in more advanced mathematics courses (Bressoud, 2017). Another third will choose to take (or be placed in) an introductory or developmental level mathematics course, such as College Algebra, Precalculus, or even Intermediate Algebra (Bressoud, 2017; Sadler & Sonnert, 2018), and almost 20% of the AP Calculus students will take an alternative mathematics course such as a statistics course, or no mathematics course at all (Bressoud, 2017). Students who take calculus for the first time in college are more likely to be historically underrepresented, less likely to have completed more than three mathematics courses in high school, and are more likely to have a weaker mathematics preparation (Champion & Mesa, 2016, 2018).

Persistence in calculus. A large number of students who enroll in calculus with the intention of continuing with advanced mathematics coursework change their mind by the end of the first semester (Bressoud, 2015; Bressoud et al., 2015; Champion & Mesa, 2016; Ellis, Rasmussen, & Duncan, 2013). Mathematics professors complain that students in introductory calculus lack the mathematical preparation needed to succeed (Sadler & Sonnert, 2017, 2018), but high school teachers feel that students are well prepared for college mathematics, especially if they took calculus in high school (Sadler & Sonnert, 2018). Rasmussen et al. (2019) proposed that, contrary to popular belief, a lack of academic preparation is not the fundamental problem with students choosing to leave STEM majors, but rather the instructional experiences students have in their first-year mathematics course.

Students who switch to a less mathematically intensive degree path report that when they were in calculus, they did not feel comfortable asking questions or contributing to class discussions, and there were not engaging and interesting activities like they had experienced in their high school coursework (Ellis et al., 2013). Different learning environments and expectations between high school and college may account for much of the difficulty students experience in their transition to freshman mathematics coursework, especially in calculus (Appleby, 2014; Burrill, 2017). College students are expected to take responsibility for their own learning (Appleby, 2014), seeking out resources and assistance as they personally deem necessary (Burrill, 2017), and self-monitoring their understanding of knowledge and skills necessary to progress in the course (Ayebo et al., 2017).

Calculus and gender. Women account for less than half of the students who enroll in calculus courses (Bressoud, 2015; Ellis, Fosdick, & Rasmussen, 2016; Wade, Sonnert, Wilkens, & Sadler, 2017), but those who enroll in calculus have similar mathematics course backgrounds as their male counterparts (Champion & Mesa, 2016), mathematics achievement scores that are often higher (Champion & Mesa, 2016; Lindberg, Hyde, Petersen, & Linn, 2010), and equivalently high levels of confidence in their ability to succeed in their college mathematics course (Bressoud, 2015). However, women's and men's degree path choices are substantially different, in that men predominantly plan to go into engineering or computer science, and women plan for a career in the biological sciences or teaching (Bressoud, 2015; Ganley & Lubienski, 2016; Lindberg et al., 2010).

Although both men and women have significantly decreased confidence by the end of the first semester of calculus, women are twice as likely to decide to change their degree path, even if they receive a grade of A or B (Bressoud, 2015; Ellis et al., 2016). Students' choices to take mathematics courses are impacted by students' mathematics identity and their attributions and expectations for success and failure in mathematics (Cheryan & Plaut, 2010; Gunderson et al., 2012). Men generally express higher self-efficacy and interest in mathematics (Stoet & Geary, 2018), and women are more likely to be highly self-critical of their understanding or performance in mathematics (Bressoud, 2015). Even when comparing students with above-average mathematical abilities, females tend to begin and end college calculus with significantly lower mathematical confidence than males (Ellis et al., 2016; Wade et al., 2017).

Implicit Theories

Implicit theories are theories that people construct in their minds informally about themselves, others, and phenomena in the world (Sternberg, Conway, Ketron, & Bernstein, 1980). They are knowledge structures fabricated from beliefs about the way humans behave and the way social organizations work (Reich & Arkin, 2006). Whether or not these theories are true to reality, they guide people's interpretations of observations and experiences, and ultimately the judgements people make about themselves and others (Heider, 1958).

Implicit Theories of Intelligence: Mindsets

Dweck and Leggett (1988) identified two implicit theories of intelligence, an entity theory and an incremental theory, that have come to be known as fixed and growth mindsets, respectively (Dweck, 2003, 2006). These theories form how individuals understand intelligence both in themselves and others (Dweck, 2003, 2006; Dweck et al., 1995; Hong et al., 1999). They shape how individuals respond to success, setbacks, praise, and challenges, and they play a central role in how individuals build or diminish their self-confidence (Dweck, 1999). Because of these diverse perspectives, individuals may understand reality differently, and therefore set different goals for themselves, and demonstrate different patterns of behavior to reach those goals (Dweck, Chiu, & Hong, 1995).

The fixed mindset (an entity theory of intelligence). Individuals who hold a fixed mindset tend to believe that intelligence is a static and largely uncontrollable trait (Dweck & Leggett, 1988). It is viewed as an entity that exists within each individual in a fixed quantity that cannot be changed (Dweck, 2006; Dweck & Leggett, 1988). Intelligence, then, is a noteworthy source of concern for fixed mindset students because they do not know how much of it they have or when they will reach their limit, and therefore they continuously work to look smart rather than taking the risk of appearing less intelligent (Dweck, 2006). Hence, those with a fixed mindset tend to avoid challenging situations (Dweck & Leggett, 1988; Elliott & Dweck, 1988), and feel an urgency to prove themselves again and again, no matter the context (Dweck, 2006).

Individuals who hold a fixed mindset generally pursue performance-type goals with the intent to gain positive judgements from others regarding their competence, or at least avoid negative judgements (Dweck & Leggett, 1988). Individuals with performance goals are deeply engrossed in continuous measurements of their ability, simultaneously evaluating whether or not that ability is adequate or inadequate (Dweck & Leggett, 1988). Outcomes and performances become the primary focus, and if the outcome happens to be failure, it is interpreted as proof of inadequacy, and frequently results in a helpless response (Dweck & Leggett, 1988; Elliott & Dweck, 1988).

The growth mindset (an incremental theory of intelligence). Those who hold a growth mindset believe that intelligence is malleable, controllable, and thus increasable (Dweck

& Leggett, 1988). They believe intelligence is something that can be fostered through learning opportunities and effort (Dweck, 1999). Because intelligence is viewed as something that can grow, individuals with a growth mindset are not focused on demonstrating how smart they are, but instead are focused on learning more (Dweck, 2006), and therefore tend to pursue challenging opportunities and engage in creative thinking to develop strategies to complete more difficult tasks (Elliott & Dweck, 1988). Those who hold a growth mindset do not claim that everyone has or is born with the same brain or same abilities, but rather they believe that everyone can grow their intellectual abilities with effort and guidance (Boaler, 2016; Dweck, 1999).

Growth-minded individuals perceive that they are in control of the development of their intellectual abilities through practice and instruction (Dweck, 1999), and therefore often pursue learning goals that involve additional effort (Dweck & Leggett, 1988). Individuals with learning goals are deeply absorbed with extending their knowledge and skills, continuously evaluating the best way to increase their ability or attain mastery (Dweck & Leggett, 1988). Outcomes and performances become only a signal of whether or not a current strategy is productive; when an outcome is failure, it provides the opportunity to revise and redirect efforts to reach mastery (Dweck & Leggett, 1988; Elliott & Dweck, 1988). With a learning-focused perspective, one can bounce back from failure with a willingness to learn and continue to confront and stick to future challenging tasks (Dweck, 1999). This ability to self-monitor and persist in tasks in order to reach personal goals is in stark contrast to the helpless response of individuals with a fixed mindset (Dweck & Leggett, 1988). Students usually endorse one theory over the other, although it is possible that they can endorse both fixed and growth mindsets, particularly with respect to different contexts (Hwang, Reyes, & Eccles, 2019; Murphy & Dweck, 2010).

Mindset and Managing Failure

All students will face adversity at some point during their educational journey, and how they decide to respond to those inevitable challenges is key to their resilience (Yeager & Dweck, 2012). Research shows that implicit theories may have the greatest impact for individuals when they are faced with failure or the threat of failure (Dweck et al., 1995; Hong et al., 1999). When confronted with uncertainty or setbacks, students with a fixed mindset tend to act defensively in an effort to avoid meaningful true failure that would indicate a lack of ability (Dweck, 2006, 2008a, 2009; Yeager & Dweck, 2012). Fixed-minded students tend to procrastinate, minimize effort, and avoid taking steps to improve learning, which eventually threatens their prospect of being successful, and simultaneously opens the door to claim that any evident failure was a personal choice rather than an inevitable outcome due to a lack of ability (Hong et al., 1999; Rhodewalt, 1994). For these students, failure demonstrates an ability deficiency, rather than an effort deficiency, thusly making it pointless to attempt to change or learn, and therefore promoting a helpless response (Binning, Wang, & Amemiya, 2019; Hong et al., 1999). For students with a growth mindset, failure demonstrates an opportunity to learn, because they believe they can use their experiences with failure to improve their understanding and skills (Dweck, 2006, 2008a, 2009). They see challenges as something to overcome and use as a means to find new strategies and learn from others (Yeager & Dweck, 2012).

Messages That Influence Mindset

Parents, teachers, peers, and other significant relationships can influence students' mindsets significantly (Dweck, 1999, 2008b; Yeager & Dweck, 2012; Yeager, Walton, & Cohen, 2013). Messages inferred through praise (Dweck, 1999, 2007, 2008a, 2008b; Mueller & Dweck 1998), mathematics course placement (Benken et al., 2015), stereotyping (Dweck, 2006), cultural influences (Hwang et al., 2019), and instruction (Sun, 2018a) can be productive for students or reinforce harmful self-perceptions (Dweck, 2006).

Messages inferred through praise. Used effectively, praise can teach students to take pleasure in intellectual challenge, understand the importance of effort, and respond productively to unexpected obstacles; in other words, praise can facilitate the development of a growth mindset (Dweck, 1999; Gunderson et al., 2013; Sun, 2018a). However, when students' level of intelligence is praised in order to bolster confidence (e.g., "you must be smart at these problems"), it does just the opposite, guiding students to become dependent upon others' opinions, and generating uncertainty that they will not be able to live up to the praise (Dweck, 1999, 2007). Praising students for their intelligence delivers a message that their abilities are fixed, which in turn reduces motivation to explore additional challenges for fear they may no longer be perceived by others as smart (Dweck, 1999, 2007, 2008a; Mueller & Dweck, 1998). Worse, when a complication arises, they are likely to feel vulnerable and unable to develop creative solutions, until eventually their ability to execute any task diminishes along with any pleasure in doing it (Dweck, 2008a). Alternatively, praising students for their ongoing progress (e.g., "you must have worked hard at these problems") encourages students to seek additional learning opportunities and strategies, because it is the effort that is being rewarded (Dweck, 2008a; Haimovitz & Dweck, 2017; Mueller & Dweck, 1998; Sun, 2018a). When students receive the message that effort is essential for learning, they are given the opportunity to be in control of their achievement as well as their self-esteem as they take on and master new challenges (Dweck, 1999).

Messages inferred through mathematics course placement. Placement in a developmental mathematics course communicates to students that they do not have the skills they need to succeed in college level mathematics; for fixed-minded students, placement in developmental mathematics may also confirm their fear that mathematics requires some amount of mathematical intelligence that they do not and will not ever possess (Yeager & Dweck, 2012). Placement into a calculus course can communicate to students that they have what they need to succeed in calculus, when in fact they may have strong procedural knowledge partnered with weak conceptual knowledge, creating an incongruity between perception and reality (Zollman, 2014). Students with a fixed mindset are likely to avoid opportunities to deepen their learning because it would expose personal areas of weakness (Zollman, 2014). Students with a growth mindset placed into any course level recognize that academic tests assess current knowledge and skills, not one's potential to learn mathematics (Dweck, 2008a).

Messages inferred through stereotyping. Stereotypes, such as who is or is not able to do mathematics, fill students' minds with concerns about the validity of the stereotype, disrupting their ability to perform other tasks by dominating their train of thought, and making them feel that they might not belong (Dweck, 2006). When stereotypes focus on a supposed inherent lack of ability for some group of individuals, students with a fixed mindset miss valuable learning opportunities because they are afraid of demonstrating that the negative stereotype is true (Yeager et al., 2013). Even a positive stereotype can be problematic, because fixed mindset students fear they may not be able to meet the exemplary expectations (Dweck, 2006). Fixed mindset students who are aware of stereotypes, whether or not they believe them, may worry that others are biased by a stereotype, and consequently refrain from actively participating even when others are truly unbiased (Yeager et al., 2013). Students who hold a growth mindset, however, are not significantly impacted by stereotypes, because they do not believe in perpetual inferiority, superiority, or any categorizations of who is or is not capable of doing something (Dweck, 2006). Importantly, it is not necessary for a student to believe in the stereotype itself to feel the extra cognitive and emotional burden of the stereotype (Aronson et al., 2002; Good, Aronson, & Harder, 2008).

Messages inferred through cultural influences. Culturally embedded perspectives about the nature of intelligence have an impact on individuals' mindsets (Hwang et al., 2019; Jackson & Nyström, 2014; Kurtz-Costes, McCall, Kinlaw, Wiesen, & Joyner, 2005; Rattan, Savani, Naidu, & Dweck, 2012). Americans tend to believe that a limited number of people have the potential to be very intelligent (Hwang et al., 2019; Rattan, Savani, et al., 2012), and tend to view those who achieve highly with little or no effort to have "authentic" intelligence (Jackson & Nyström, 2014). Students from nonminority and more privileged backgrounds tend to view intelligence, mathematical intelligence in particular, as innate and associated with a higher social status (Hwang et al., 2019). In a culture that predominantly values innate ability, a common interpretation of those who put great effort into accomplishing tasks is that they are less intelligent (Jackson & Nyström, 2014).

Messages inferred through instruction versus rhetoric. Sun (2016) found that many mathematics classrooms use language associated with a growth mindset, discussing the value of mistakes, the importance of hard work, and talking about how the brain can grow. However, in the same classrooms, she found that the teachers were unintentionally sending fixed mindset messages to students through their instructional decisions by giving more challenging tasks to students who finish quickly, focusing on procedures rather than sense-making, or even labeling students as "high versus low" (Sun, 2016, 2018a). How adults respond to students' struggles, frustrations, and failures is fundamental to the mindset those students develop (Haimovitz & Dweck, 2016). Making work more simple for struggling learners or ignoring their mistakes sends a message that they are not capable of the intellectual rigor of a task, which is not supportive of a growth mindset (Sun, 2018a).

Changing Mindset

Changing one's mindset plays a significant role in changing how one functions (Dweck, 2008a; Mangels, Butterfield, Lamb, Good, & Dweck, 2006). Learning in part from brain surgery patients, neuroscientists have discovered extensive evidence that the brain grows in response to effort (Beilock, 2010; Boaler, 2010, 2013, 2016). Brain plasticity, or neuroplasticity, is the brain's ability to change at any age, for better or worse (Boaler, 2016; Coch, 2018). Understanding that all brains are capable of change is fundamental to learning and development (Coch, 2018). Researchers have proposed that the study of neuroplasticity be leveraged for research in education in order to better understand individual differences in learning (Abiola & Dhindsa, 2011; Coch, 2018; Woollett, Spiers, & Maguire, 2009) and to challenge traditional ideas about fixed ability and limited student potential (Boaler, 2010, 2016).

Neuroplasticity research. Studies have found that the neural networks in the brain that support cognitive skill development have the capacity to grow and process new skills at any age (Abiola & Dhindsa, 2011; Boaler, 2013, 2016; Coch, 2018; Skoyles, 1997). Changes in the brain associated with learning occur significantly between neurons; as new connections develop, the organization of previous synapses transform (Abiola & Dhindsa, 2011; Coch, 2018). Because of this, when people work to increase their skill or knowledge in a specific domain, the corresponding areas of the brain that support that skill grow noticeably (Abiola & Dhindsa, 2011; Woollett et al., 2009). Researchers found this when they studied taxi drivers in London (Abiola & Dhindsa, 2011; Boaler, 2016; Woollett & Maguire, 2011; Woollett et al., 2009). Structural MRI brain scans of taxi drivers who studied the layout and navigation of London's circuitous and complex streets over four years showed that they had increased gray matter volume in the area of their brain related to organizing spatial information, the hippocampus, whereas control participants had no structural brain changes (Woollett & Maguire, 2011; Woollett et al., 2009). Woollett et al. (2009) also discovered that after retirement, London taxi drivers' brains showed less hippocampal gray matter volume, their navigational skills declined, and other skill deficiencies they had developed while driving appeared to be regained to a state similar to control participants.

Incremental theory intervention research. Multiple research studies with middle school, high school, and college students have demonstrated that incremental theory interventions have been successful at shifting students' motivation, sense of belonging, and academic performance (e.g., Blackwell et al., 2007; Dweck, 2006; Walton & Cohen, 2011). Studies that involved implementing growth mindset interventions have produced large shifts in thinking and performance with minimal effort (Dweck, 2008a; Dweck, Walton, & Cohen, 2014). These brief and seemingly small social-psychological interventions that target students' beliefs, feelings, and views regarding school have had extraordinary effects on academic achievement, even over long periods of time (Yeager & Walton, 2011). Timing has been found to be essential to the success of interventions (Binning et al., 2019; Wang, Degol, & Ye, 2015).

In a seminal study by Aronson et al. (2002), African American and White college students were invited to participate in a purported pen pal program to mentor struggling middle school students. The college students were randomly assigned to one of three groups: a malleable pen pal group, a control pen pal group, and a non pen pal group. Those in the malleable pen pal group were asked to write encouraging letters to the middle school students, including any words of encouragement they desired in addition to persuasive messaging about the malleable nature of intelligence. Participants were told that the brain can grow like a muscle with work, and were shown videos demonstrating how the brain develops new neurons, citing the work of brain researchers to increase the scientific validity of the intervention. Those in the control pen pal group were also asked to write letters of encouragement using their own words, and were concurrently informed that research on intelligence shows that it is not a single entity, but rather made up of many talents, and therefore all individuals have both intellectual strengths and weaknesses. The control pen pal participants were encouraged to include persuasive messaging to their supposed middle school partner about how they should stay in school and keep working to find and develop their areas of strength. There was no intervention with the non pen pal group. Those who learned about the malleability of the brain and the ability to expand intelligence with hard work experienced significant achievement gains, and demonstrated greater enjoyment and valuation of academic work when compared to students in either of the other groups who did not. The African American participants demonstrated the greatest gains, diminishing the documented initial achievement gap between the African American and White participants. After just three incremental theory intervention sessions, all of the malleability pen pal students had shifted how they viewed intelligence, and received higher grades than either of the other groups, even when measured nine weeks later.

In another noteworthy study, Blackwell et al. (2007) conducted a series of workshops for academically struggling minority junior high school students wherein some students learned that the brain gets stronger with use and forms new connections when learning, and other students simply learned about study strategies. Those who had received the incremental theory intervention showed significant improvement in grades compared to the minimal achievement changes in the control group. Moreover, the intervention improved students' motivation in their mathematics classes, which supports the notion that students' perception of intelligence is an important factor in their achievement motivation.

Achievement gaps disappeared for seventh grade students who received a growth mindset intervention in a study by Good, Aronson, and Inzlicht (2003), which focused on adolescents' vulnerability to stereotype threat. The seventh grade students were paired with college student mentors who shared the intervention messaging about expandable intelligence in addition to discussing the difficulty of transitioning to seventh grade and suggesting some study strategies. The college students met with the seventh grade students in person on two occasions, for 90 minutes each time, and otherwise stayed in contact throughout the school year via email. The intervention was found to significantly increase the performance of girls, minority, and low-income students on the measure of mathematics achievement. Endorsement of a growth mindset may create a more equitable standardized testing condition for students who experience stereotype threats that undervalue their intellectual abilities.

Mathematical Mindset

A mathematical mindset is a growth mindset about mathematical ability; it is the belief that mathematical intelligence is acquirable and that anyone can learn mathematics (Boaler, 2016). Growth and fixed mindset beliefs can be domain specific (Sun, 2018b; Yeager & Dweck, 2012). In her book, *Mathematical Mindsets*, Boaler (2016) wrote, "Students have such strong and often negative ideas about math that they can develop a growth mindset about everything else in their life but still believe that you can either achieve highly in math or you can't" (p. ix).

Students commonly regard mistakes as a sign of their inadequate mathematical ability, even though studies have shown that mistakes are an important step in the process of learning and growth (Boaler, 2013, 2016, 2019). Out of all of the core academic subject areas, mathematics tends to communicate such fixed ability messages and thinking the most (Boaler, 2010; 2016; Sun, 2018b). The learning environment itself often conveys an implicit message about who is and who is not able to do high-level work, and this message can shape students' mindsets, at least temporarily (Good, Rattan, & Dweck, 2012; Murphy & Dweck, 2010). Ability grouping, for instance, sends the message to low-ability groups that they are not capable of doing more challenging work (Sun, 2018b). Classroom norms that focus on mastery goals rather than performance goals send the message that mathematics class is about learning and not performing (Boaler, 2019). Teaching that goes beyond valuing mistakes to deeply engaging students in exploring their mistakes sends a message that mistakes are an important part of the road to successful mathematics learning (Sun, 2018b). The classroom environment shapes how students decide to present themselves, how they view themselves, and how they assess and behave toward others in the environment (Murphy & Dweck, 2010).

Students who have a mathematical mindset seek learning opportunities and are not bothered by mistakes (Boaler, 2001, 2002, 2013, 2016). They understand their role as learners of mathematics to think about mathematical concepts and relationships and make sense of them (Boaler, 2019). Students who only desire to produce correct mathematical work miss out on opportunities to develop their mathematical thinking, and are hindered by their fixed mindset-driven desire to demonstrate adequate performance (Boaler, 2016). These students see mathematics as a series of tasks to complete, and do not recognize the opportunity for personal growth and learning (Boaler, 2019). When students approach mathematics as a list of rules to remember rather than concepts to explore, their brains are unable to organize ideas or adequately retrieve the numerous lists of rules and methods (Boaler, 2019; National Council of Teachers of Mathematics, 2014). Learning new mathematical ideas involves building conceptually on prior mathematical knowledge, not memorizing rules and methods (Boaler, 2019; Edwards & Beattie, 2016; National Research Council, 2005; National Council of Teachers of Mathematics, 2014). "Approaching mathematics conceptually is the essence of what I describe as a mathematical mindset" (Boaler, 2019, p. 30).

Mathematical mindset and gender. Mathematical mindsets begin to form as early as preschool and elementary school, and are influenced by mathematics-gender stereotypes that negatively affect girls (Gunderson et al., 2012). A fixed mindset about mathematics contributes to women's eroded sense of belonging in mathematics courses and mathematics-related career choices (Dweck, 2008a). Although studies have shown that teachers praise boys and girls generally equivalently, teachers tend to praise girls more frequently for their intelligence, and praise boys more frequently for their work (Gunderson et al., 2013). Well-meaning praise, then, unintentionally communicates opposing messages, encouraging a fixed mindset in girls, and a growth mindset in boys (Rattan, Good, et al., 2012). Further, there is evidence that many parents' and teachers' feedback influences mindset differentially, offering consolation and comfort praise to girls who struggle, and demanding increased persistence from boys who struggle (Mueller & Dweck, 1998).

Some of the students most damaged by fixed mathematical mindsets are high-achieving girls, who, having been praised for being smart, infer from any failure that they are not smart after all (Boaler, 2016). These women may come to believe that mathematical ability is due to innate intelligence, that innate intelligence is required for certain fields of study, and that they belong to a group that, according to gender stereotypes, is less likely to have those qualities (Wang & Degol, 2017). Women in college calculus courses who have a growth mindset about mathematics express significantly greater interest in upper level mathematics courses (Good et al., 2012). A study by Good et al. (2012) found that college women who held a growth mindset about mathematics earned high grades, felt they belonged in the mathematics community, and intended to pursue future mathematics coursework. Those college women who held a fixed mindset about mathematics reported widespread negative stereotypes about women and mathematics, described a decreasing sense of community in their mathematics courses, and received lower final grades in their mathematics courses (Good et al., 2012).

One common stereotype that impacts students' aspirations for pursuing education and careers in mathematics is the association of males with high-level intellectual ability more often than females (Bian, Leslie, & Cimpian, 2017; Chestnut, Lei, Leslie, & Cimpian, 2018). Gendered concepts of brilliance are deeply embedded in cultural norms, such that Bian et al. (2017) found that girls as young as six years old avoid activities described to be for "really, really smart" children, and are less likely than boys the same age to believe that women are "really, really smart." Parents inadvertently cultivate this bias because these deeply held beliefs shape the way parents and others interact with children (Chestnut et al., 2018; Haimovitz & Dweck, 2017). A New York Times opinion piece (Stephens-Davidowitz, 2014) shared statistical results from a study of Google searches that revealed that parents are about twice as likely to Google, "Is my son a genius?" than, "Is my daughter a genius?" Children are adept at learning from social cues, including unintended inferences of males as setting the standard for mathematics ability in statements like, "Girls are as good as boys at math" as opposed to, "Boys are as good as girls at math" (Chestnut et al., 2018).

Mathematical mindset and achievement. When students believe that everyone's intellectual ability can grow, their achievement increases significantly (Blackwell et al., 2007; Boaler, 2016; Dweck, 2006; Hwang et al., 2019). Studies have found this to be especially true for underperforming and stereotypically low-achieving students in mathematics (Aronson et al., 2002; Claro, Paunesku, & Dweck, 2016; Good et al., 2003; Good et al., 2012; Hwang et al., 2019; Paunesku et al., 2015). Studies have also found that for students who are usually high achievers, having a fixed mindset does not predict lower performance or have a detrimental effect on achievement (Binning et al., 2019; Hwang et al., 2019). Dweck (2014) observed that studies have found that fixed mindset students who are well prepared tend to continue to have high achievement; the proposed concern is that when these students encounter obstacles that they are not prepared for, they may be at a disadvantage.

Identity and Mathematical Identity

Identity is a self-created construct, developed both by how one perceives oneself and how one perceives his or her relationship to others (Kaasila, Hannula, & Laine, 2012). Solomon (2007) characterized identity as "the experience of a common enterprise, with shared values, assumptions, purpose and rules of engagement and communication" (p. 6). It is context-bound, which allows people to develop multiple identities, depending on the relationship they develop within any particular context (Boaler et al., 2000; Black et al., 2010; Gee, 2000; Kaasila, 2007; Lutovac & Kaasila, 2011). An individual's perception of identity powerfully influences one's choices to interact, engage, behave, and learn (Bishop, 2012; Garcia & Cohen, 2012; Markus & Wurf, 1987; McCarthey & Moje, 2002) because those identities enrich or diminish attitudes and emotional development, and overall sense of self (Bishop, 2012).

Identities form as students construct new understandings and learn "who they are" with respect to the interactions and norms created by their learning environment (Bishop, 2012). Boaler et al. (2000) identified three components that may define one's perception of identity within a particular group, including a sense of belonging, a sense of achievement according to group expectations, and an interest and ability to exhibit behaviors common to group members.

A mathematical identity is defined as “the dispositions and deeply held beliefs that students develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics in powerful ways across the contexts of their lives” (Aguirre et al., 2013, p. 14). One uses mathematical identity to make sense of his or her position in relation to mathematics and others within mathematical communities (Cribbs et al., 2015; Kaasila et al., 2012), which may include classroom communities, professional communities, and social communities outside of mathematics (Solomon, 2007). Students become accustomed to sitting in mathematics classrooms as they complete years of mandatory education, and they develop an idea about how to be mathematics learners (Anderson, 2007; Boaler et al., 2000). Teachers, parents, and peers all influence the mathematical identity that students form (Aguirre et al., 2013; Anderson, 2007; Boaler & Greeno, 2000; Cobb, Gresalfi, & Hodge, 2009). In mathematics classrooms, students learn when to respond or resist, whether or not they can safely take a risk, how to appear busy yet avoid additional work, and how to feel about success or failure; the way they see themselves in a mathematics classroom may be very different than other students in the room, and different than the way they see themselves in other classrooms (Boaler et al., 2000)

Students’ mathematical identities influence what a student enjoys, pursues, and finds meaningful, and therefore what they learn (Bishop, 2012; Cobb 2004). The National Research Council (NRC) (2001) concluded that in order for anyone to learn mathematics successfully, part of what is required is a strong mathematical identity, seeing “oneself as an effective learner and doer of mathematics” (p. 131). When students develop a strong and productive mathematical identity, they can maneuver through obstacles while learning mathematics, and for that matter, life (Bishop, 2012). Through their interactions, learners develop ideas about the roles of others (Beijaard, Meijer & Verloop, 2004) and develop a sense of self, based on the ways in which they talk and interact with each other (Anderson, 2007; Bishop, 2012). Students' actions affirm or reject their position as a member of a particular group (e.g. high achievers, at-risk, slow, gifted), and these actions subsequently influence the learning experiences and social interactions that students choose to have with others (Aguirre et al., 2013).

Mathematical Identity and Mathematics Proficiency

Identity is a powerful factor in mathematics learning and is essential to mathematical proficiency (Bishop, 2012) and mathematical engagement (Black et al., 2010). Students who feel competent in their mathematical ability are more likely to believe that others such as their parents, friends, and teachers see them as mathematical people and are more likely to express interest in mathematics; interest and recognition of mathematical ability are both factors that reinforce the development of a stronger mathematical identity (Cribbs et al., 2015). Classroom dialogue that promotes the importance of performance, speed of understanding, and fixed ability undermines students' efforts to creatively participate in mathematical discussions, and leads to identities of marginalization (Solomon, 2007). Students who feel helpless and susceptible to failure in mathematics begin to develop negative mathematical identities in an environment in which they have attempted to function, but over which they do not feel they have control (Solomon, 2007). Students such as those may begin to feel that thinking mathematically is not important to their personal development, and therefore do not exert effort to do so (Kargar, Tarmizi, & Bayat, 2010). They often arrive in their college mathematics classrooms with a high level of anxiety from prior failures (Benken et al., 2015; Rosin, 2012).

As students share their experiences, conclusions, and feelings about mathematics, they develop what eventually becomes their mathematical story that they share in different ways, with different emphases, to fit different audiences (Aguirre et al., 2013; Kaasila, 2007; Lutovac & Kaasila, 2011). These stories, used at first for social engagement, eventually construct learners' personal beliefs about themselves and their own identity (Black et al., 2010). Identity develops as a collection of self-representations, continually shifting, depending on the context and circumstances (Bishop, 2012). A large part of the identity that students develop, especially adolescents, is based on how others engage with and respond to them (Anderson, 2007; Bishop, 2012; Erikson, 1968), making even the ways in which students are grouped for classroom work greatly influence the identity they choose to endorse (Bishop, 2012). Identities are negotiated in every moment, and depend on each individual's past experiences (Gee, 2000). Over time, though, repeated interactions and behaviors become predictable and a specific identity may be increasingly associated with a particular context for an individual (Bishop, 2012), a process called the "thickening" of identity (Wortham, 2004).

A person's mathematical identity is always under construction, impacted significantly by social interactions and reflection (Anderson, 2007; Kaasila, 2007). When students are able to reflect on past mathematical experiences and recognize that they can change their interpretations of these experiences, they are able to contemplate new perspectives on their past and future mathematical experiences (Kaasila 2007). When beginning such mathematical identity work, sharing interpretations of experiences with others is as important as reflecting on them (Lutovac & Kaasila, 2011). Social settings where students receive social support for trying new approaches, whether successful or not, encourage students to engage in higher order thinking with others, which may "teach students that they have the ability, the permission, and even the obligation" (p.41) to challenge an otherwise accepted position (Resnick, 1987). Black et al. (2010) argue that such positive settings provide a structured hierarchy for students' identities such that students' mathematical identities become more important to their developing selves.

Mathematical Identity and Stereotype Threat

When students enter mathematics classrooms, they will often make a rapid informal assessment, asking themselves implicitly whether or not the environment they are entering is one in which their identity (e.g., as a minority, as a female, as a developmental mathematics student) could potentially be associated with a negative outcome (Cohen & Garcia, 2008). If they believe the answer is yes, that identity is likely to become psychologically engaged and begin to actively monitor for cues regarding vulnerabilities, negative treatment, and bias (Cohen & Garcia, 2008; Kaiser, Vick, & Major, 2006). When students recognize that they may be devalued in a particular setting because of one of their social identities, a psychological stereotype threat is established (Murphy, Steele, & Gross, 2007). Students who have strong mathematical identities tend to experience high levels of cognitive interference and diminished achievement when they experience stereotype threat because they are invested in doing well, want to continue to be included in the mathematical community, and are distracted by the prospect of being judged or treated according to the stereotype (Cohen & Garcia, 2008; Gates, 2009; Steinberg, Okun, & Aiken, 2012).

Self-efficacy

Humans are proactive and hopeful creatures, with desires and expectations about what the future might hold, and what strategies would be best to realize those aspirations (Bandura & Locke, 2003). But unless they believe that they can actually produce those results, they have minimal reason or desire to act (Bandura, 1986). So, humans not only look forward, they also regularly reflect on their own efficacy, revisiting their purpose, considering their strategies and actions, and making changes as necessary to stay focused on their vision (Bandura & Locke, 2003). Self-efficacy has come to be recognized over the past four decades as a valid and highly effective predictor of motivational outcomes, academic achievement, and even college and career choices (Bandura, 1997; Betz & Hackett, 1983; Gore, 2006; Hackett, 1985; Lent, Brown, & Larkin, 1984; Lent, Lopez, & Bieschke, 1991; Zeldin & Pajares, 2000; Zimmerman, 2000b). Self-efficacy beliefs regulate human thinking and action through cognitive, motivational, affective, and selective processes (Bandura, 1993), and therefore impact how individuals think about themselves, respond when faced with difficulty, maintain their emotional well-being, and make choices at critical junctures (Bandura & Locke, 2003). Bandura and Locke (2003) added that:

> Among the mechanisms of human agency, none is more central or pervasive than beliefs of personal efficacy. Whatever other factors serve as guides and motivators, they are rooted in the core belief that one has the power to produce desired effects; otherwise one has little incentive to act or to persevere in the face of difficulties. (p. 87)

Bandura (1997) described perceived self-efficacy as “not a measure of the skills one has but a belief about what one can do under different sets of conditions with whatever skills one possesses” (p. 37). These beliefs shape how people feel, think, motivate themselves, and behave (Bandura, 1993), and are related to how much effort they choose to expend, whether they employ self-hindering or self-helping thought patterns, and their affective and neurophysiological reactions to obstacles (Bandura, 1986). Perceived self-efficacy is about what people believe they are capable of achieving, rather than a personal characteristic, psychological trait, or how they feel about themselves (Bandura, 2006; Zimmerman, 1995, 2000b). More specifically, it is about what they believe they can achieve in the future specific to a certain domain or context, such that self-efficacy beliefs for mathematics may vary from those for English, and self-efficacy beliefs in a competitive learning environment may vary from those in a cooperative learning environment (Bandura, 1977, 1986, 1997, 2006; Zimmerman, 1995).

Self-efficacy beliefs are conceptually different than several very closely related constructs, such as outcome expectations, self-concept, effectance motivation, and perceived control (Bandura, 1997; Schunk & Pajares, 2001; Zimmerman, 1995, 2000b). Outcome expectations are the actual consequences expected from an individual's own actions, not what an individual believes he or she is able to achieve (Schunk & Pajares, 2001; Usher & Pajares, 2009). Self-concept is who one believes one is, based on one's interpretations of relationships and environmental experiences (Pajares & Schunk, 2002; Schunk & Pajares, 2001; Shavelson, Hubner, & Stanton, 1976; Zimmerman, 1995). Effectance motivation describes one's perceived ability to influence interactions with others and the environment, but is instinctual and not specific to a task or domain (Schunk & Pajares, 2001; White, 1959; Zimmerman, 1995). Perceived control is the belief that one can control one's capabilities and performance outcomes, so it is a component of self-efficacy itself (Schunk & Pajares, 2001; Zimmerman, 1995, 2000b).

Judgements of one's skills, knowledge, experience, strategies, and effort all play a part in the formation of efficacy beliefs (Bandura, 1993; Zimmerman, 1995). According to Bandura (1986, 1997), those judgements are guided by four main spheres of influence: mastery experiences, vicarious experiences provided by social models, social persuasion, and interpretations of emotional and physical states and reactions. Mastery experiences are personal performance accomplishments that succeed (or fail), and are the most effective way to build (or minimize) one's self-efficacy; they alone can cultivate a deeply embedded sense of what one perceives to be one's capabilities (Bandura, 1977; Schunk & Pajares, 2001; Usher & Pajares, 2009; Zimmerman, 2000b). When a student observes another student he or she considers equal in ability, then observing that student succeed or fail can vicariously influence his or her own self-efficacy (Zimmerman, 2000b). In comparison to mastery and vicarious experiences, verbal social persuasion has a limited impact on self-efficacy beliefs because students hear others' descriptions about their capabilities instead of gathering the information for themselves, and can easily dismiss the information based on the credibility of the source (Zimmerman, 2000b). Finally, students' self-efficacy beliefs are influenced by their perceptions of their emotional and physical reactions, leading them to feel exhilarated and strengthened, or incompetent and unqualified (Zimmerman, 2000b).

Research studies have found evidence of specific sources that lead to the development of self-efficacy, including home, peer, school, and transitional influences (Schunk & Pajares, 2001). Parents who provide many mastery experiences, opportunities for exploration, encouragement to try novel activities and puzzles, and who also support children's hard work with kind, patient, and responsive home environments tend to develop children who feel confident in their ability to meet new and unexpected challenges (Schunk & Pajares, 2001). Peers provide the means to offer vicarious experiences to each other, and peer networks increase access to new activities, ideas, and additional vicarious experiences (Schunk, 1987; Schunk & Pajares, 2001). Schools provide a forum for competitive comparison both academically and socially, and feedback from peers and instructors affect and validate students' assessments of their own efficacy (Schunk & Pajares, 2001). Furthermore, as students make educational transitions from familiar environments to unfamiliar schools and classes, they tend to reassess their perceptions of academic competence, often negatively (Midgley, Feldlaufer, & Eccles, 1989; Schunk & Pajares, 2001).

Self-efficacy and Achievement

Students' perceived academic self-efficacy is a powerful predictor of achievement (Arnold et al., 2012; Multon et al., 1991; Recber et al., 2018; van Dinther, Dochy, & Segers, 2011) because students' beliefs about their academic abilities become the foundation for their academic engagement and performance (Diseth, Meland, & Breidablik, 2014; Levpuščček & Zupančič, 2009). Self-efficacy beliefs guide students' choice of tasks and persistence with those tasks, so highly efficacious students are more willing to participate, work harder, persist longer when they encounter obstacles, and subsequently achieve at a higher level (Bandura, 1997; Schunk & Pajares, 2001). When students notice that they are developing skills and performing well, their perceived self-efficacy increases (Schunk & Pajares, 2001; Talsma, Schüza, Schwarzer, & Norris, 2018). Aspirations and expectations imposed on students, however, are ineffective, because it is the students' personal perceptions, ambitions, and experiences that impact self-efficacy, not expectations from others (Zimmerman et al., 1992).

Self-efficacy and goal-setting. Self-efficacy impacts achievement significantly through its influence on students' goal-setting (Mone, Baker, & Jeffries, 1995; Schunk & Pajares, 2001; Talsma et al., 2018; Zimmerman & Bandura, 1994). By setting goals, students specify and acknowledge the requirements for personal success, which prompts self-monitoring and self-evaluations of performance (Bandura, 1997; Bandura & Cervone, 1983; 1986; Locke, Cartledge, & Knerr, 1970; Zimmerman et al., 1992). The higher the perceived self-efficacy, the more challenging the goals students tend to set for themselves, accompanied by a higher level of effort and persistence they are willing to exert when they encounter difficulties (Bandura & Wood, 1989; Locke & Latham, 1990; Mone et al., 1995; Zimmerman et al., 1992). Concurrently, self-efficacy influences students' use of learning strategies to meet those goals (Zimmerman et al., 1992; Zimmerman & Martinez-Pons, 1986, 1988, 1990). There is evidence that students' awareness of learning strategies alone is not predictive of achievement; rather, it is the effective and consistent use of those strategies that leads to superior academic performance, and it is students' perceived self-efficacy that strategically regulates their motivation to employ those strategies (Lee et al., 2014; Zimmerman et al., 1992).

Self-efficacy and performance. Students' belief in their ability to succeed must be reinforced as they progress through their first year of college, when even students who have previously experienced academic success often struggle to adjust to new academic demands (Tinto, 2017). Self-efficacy both guides other behaviors and is molded by a variety of interacting factors, including performance (Bandura, 1997). Self-efficacy and performance both modify each other repetitively in continual partnership (Multon et al., 1991; Talsma et al., 2018). A meta-analysis of literature by Talsma et al. (2018) provided support for a reciprocal effects model between self-efficacy and performance, such that interventions to improve either self-efficacy or performance have had statistically significant positive effects on the other over time.

Mathematical Self-efficacy

Mathematical self-efficacy describes people's beliefs about what they can achieve within the mathematical domain (May, 2009). Among equally mathematically talented students, those with higher mathematical self-efficacy perform better than those with lower mathematical self-efficacy (Valentine, DuBois, & Cooper, 2004; Zimmerman, 1995). Therefore, researchers have focused attention on mathematical self-efficacy as a substantial contributor to students not succeeding in mathematics (Hackett, 1985; Pajares & Miller, 1994; Peters, 2013; Siegle & McCoach, 2007).

According to Bandura's (1986, 1997) proposed spheres of influence, students' mastery experiences in mathematics courses play a significant role in the evolution of their mathematical self-efficacy (Hall & Ponton, 2005; Higbee & Thomas, 1999). When students repeatedly encounter mathematical tasks that they perceive to be overly challenging, not only does their mathematical self-efficacy determine their willingness to persevere, it is also their actual behavior and outcomes that reflectively build or diminish their mathematical self-efficacy (Valentine et al., 2004; Zimmerman, 1995). Students do not easily dismiss feelings of victory when they experience success with difficult mathematical problems, and neither do they easily dismiss feelings of failure or inferiority when outcomes are not desirable; these deeply embedded experiential memories powerfully influence mathematical self-efficacy (Campbell, 2015; Usher & Pajares, 2009).

Parents' academic goals for their children, and both parents' and teachers' beliefs about mathematical ability (often influenced by gender stereotypes and their theory of intelligence), influence students' mathematical self-efficacy beliefs (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996; Schunk & Pajares, 2001; Wang & Degol, 2017). Students' perceptions of their parents' and teachers' dissatisfaction, criticism, and unrealistic expectations are associated with reduced mathematical self-efficacy and mathematical performance, and reciprocally, low achievement in mathematics may lead to increased pressures from parents and teachers (Levpušček & Zupančič, 2009). Because students' self-efficacy is influenced by frequent and immediate feedback, and self-efficacy promotes academic achievement, the nature of the feedback on students' mathematical efforts from parents and teachers may have significant implications on students' course performance and future engagement in mathematics (Pajares, 2002; Robinson-Cimpian et al., 2014).

Mathematical self-efficacy and mathematics course-taking. Students' mathematical self-efficacy has an impact on their mathematics course-taking decisions (Champion & Mesa, 2016; Chen & Zimmerman, 2007; Recber et al., 2018; Updegraff et al., 1996). Champion and Mesa (2016) found that students with higher mathematical self-efficacy as freshmen in high school were more likely to complete almost all types of mathematics courses when compared to those with lower reported mathematical self-efficacy. Randhawa et al. (1993) discovered that college students would avoid courses that involved deeper engagement with mathematical topics if they had low mathematical self-efficacy, even if they were otherwise interested in the field of study (Zimmerman, 1995). Students' choice of college majors as well as their success in course work and perseverance in their field of study is positively correlated with their self-efficacy, particularly in mathematics, and particularly for women (Hackett & Betz, 1989; Lent et al., 1984; Zeldin & Pajares, 2000; Zimmerman, 1995). Regardless of their actual mathematical performance, females report lower mathematical self-efficacy than males at all levels of education (Hackett, 1985; Jain & Dowson, 2009; Lent et al., 1991), and are more consistently self-critical of their mathematical performance, no matter their actual mathematical abilities or performance scores (Bandura, 1997; Ganley & Lubienski, 2016; Jain & Dowson, 2009; Robinson-Cimpian et al., 2014).

Mathematical self-efficacy and gender. Research on mathematical self-efficacy has had inconclusive results with regard to gender (D'Lima et al., 2014; Recber et al., 2018). An early study by Betz and Hackett (1983) found that males had significantly stronger mathematical self-efficacy scores than females in an introductory psychology course. More recently, Hall and

Ponton (2005) did not find a statistically significant difference in mathematical self-efficacy among Calculus I students or among Intermediate Algebra students, although males had higher mathematical self-efficacy scores on average compared to the females in both courses. Peters (2013) found that male College Algebra students had statistically significantly higher mathematical self-efficacy scores than female College Algebra students. Recent studies have indicated that male and female students begin the freshman year with varying levels of motivation and preparation for their college education (Ndum et al., 2018).

Self-regulation

Effective learners use a metacognitive approach to take control of their own learning (National Research Council, 2005), exhibiting an awareness of a purposeful relationship among their beliefs and actions and associated social, academic, and environmental consequences (Zimmerman, 1986). Such learners are not in possession of a particular mental ability or academic skill, rather, they employ a self-directed process through which they organize their mental abilities into academic skills (Zimmerman, 2002). This process involves planning and adapting thoughts, feelings, and behaviors based on feedback from themselves or others to meet personal goals (Cleary & Chen, 2009; Cleary & Kitsantis, 2017; Zimmerman, 1989, 2000a) because learning is a proactive activity that students do for themselves rather than a passive occurrence in response to teaching (Zimmerman, 2002). Self-regulation is “the degree to which students are metacognitively, motivationally, and behaviorally active participants in their own learning process” (Zimmerman, 2008, p.167).

Zimmerman (2002) proposed that self-regulated learners move through a cyclical process: actions and beliefs that occur prior to efforts to learn (forethought), actions during learning (performance), and actions and beliefs after learning has occurred (self-reflection).

Decisions made during forethought are heavily influenced by learners' experiences, beliefs and outcome expectations, as well as intrinsic interest and motivation (Butler, 2002; Cleary & Zimmerman, 2004; Perels, Dignath, & Schmitz, 2009; Pintrich, 1999; Zimmerman, 2002). Productivity and decisions made during the performance period are impacted by learners' use of self-control and self-observation to gather information that is later used to evaluate effectiveness (Cleary & Zimmerman, 2004; Perels et al., 2009; Pintrich, 1999; Zimmerman, 2002). Decisions made during self-reflection are often closely associated with a learner's mindset, in that attributing poor performance to a lack of ability (a fixed mindset) is likely to damage motivation, causing a learner to withdraw from future learning opportunities, but attributing poor performance to the use of the wrong strategy (a growth mindset) allows the learner to adapt for future learning opportunities (Zimmerman, 2002).

In order to facilitate their planning and learning processes, students will often choose to enlist the use of self-regulated learning strategies (Cleary & Chen, 2009; Weinstein, Husman, & Dierking, 2000). Self-regulated learning strategies support learners' goals to obtain knowledge and proficiency in a short period of time (Cleary & Chen, 2009; Medina, 2011; Nota et al., 2004; Pintrich, 1999; Schunk, 2001; Weinstein et al., 2000). Students choose different strategies for different tasks to maximize the effectiveness of their self-regulation (Cleary & Chen, 2009). The National Council of Teachers of Mathematics (NCTM) advocates for students to actively engage learning strategies such as setting goals, reflecting and monitoring their own progress and understanding, asking questions, engaging in discussion with peers and instructors to deepen understanding, and persevering through challenging tasks (National Council of Teachers of Mathematics, 2014). Students may choose to organize and develop study schedules, seek informational resources or help from others, find tactics to stay on task, organize an environment that makes learning easier, review notes or tests, or find other ways to make sense of material (Medina, 2011; Zimmerman & Martinez-Pons, 1986).

Just obtaining the knowledge of self-regulated learning strategies, however, does not mean that one will necessarily be skilled in using them, or be motivated to use them efficiently in academic environments (Cleary & Chen, 2009). Zimmerman (1986) elaborated on the characteristics of self-regulated learners in the following manner.

> Metacognitively, self-regulated learners are persons who plan, organize, self-instruct, self-monitor, and self-evaluate at various stages during the learning process. Motivationally, self-regulated learners perceive themselves as competent, self-efficacious, and autonomous. Behaviorally, self-regulated learners select, structure, and create environments that optimize learning. (p. 308)

Self-regulated learners are cognizant of their strengths and limitations (Zimmerman, 2002) and possess self-awareness during task completion so that they recognize when their environment or strategies need to change in order to reach their goals (Medina, 2011; Sanz de Acedo Lizarraga, Ugarte, Cardelle-Elawar, Iriarte, & Sanz de Acedo Baquedano, 2003; Zimmerman, 2002, Zimmerman & Martinez-Pons, 1986). Self-regulated learners also seek help from others when necessary (Newman, 2002; Zimmerman, 2002).

Self-regulated Learning and Mathematics Achievement

A student's ability to self-regulate has been linked to academic success (Briley et al., 2009; Cleary & Kitsantis, 2017; Ley & Young, 1998; Nota et al., 2004). Students' use of self-regulated learning strategies has been connected to mathematics achievement for students at all levels of education, including elementary (Eshel & Kohavi, 2003), secondary (Dembo & Eaton, 2000; Pokay & Blumenfeld, 1990), and postsecondary (Briley et al., 2009; Ley & Young, 1998;

Pape & Smith, 2002). Highly self-regulated learners successfully prepare for learning, organize a learning structure, and employ more self-monitoring strategies than other, less self-regulated students (Dembo & Eaton, 2000; Pintrich & De Groot, 1990). There is limited research on the long-term effect that self-regulated learning strategy use might have on academic resilience, such as attaining a college degree (Nota et al., 2004). However, given that academic resilience requires a realistic perspective on both the difficulty of learning tasks and one's ability to find strategies to respond to them (Zimmerman, 2002), learners who become highly self-regulated should have increased educational options and opportunities (Nota et al., 2004).

Self-regulated Learning and Self-efficacy

How well students are able to strategize and implement self-regulating learning strategies both in and out of the classroom serves as a predictor of not only their academic performance, but also how they feel about themselves as learners within a particular learning context (Cleary & Kitsantis, 2017). Students' use of such strategies directly impacts their perceptions of their personal capacity to learn (Jain & Dowson, 2009). Self-efficacy and self-regulation are inextricably linked (Berger & Karabenick, 2011; Pintrich, 1999; Pintrich & De Groot, 1990; Zimmerman, 2008). Self-efficacy and inherent interest influence learners' decisions about behavior and perseverance when completing tasks (McClain, 2015; Zimmerman, 2002). Students with higher self-efficacy are more likely to be cognitively engaged (D'Lima et al., 2014; Pintrich, 1999), and more likely to exhibit self-regulatory characteristics such as effort and persistence (Zimmerman, 2002), which predict achievement (Pintrich & De Groot, 1990; Schunk & Pajares, 2001). In mathematics specifically, Berger and Karabenick (2011) found that students' mathematical self-efficacy measured at the beginning of a semester predicted more frequent use of metacognitive learning strategies, as well as time and study environment management strategies. Students with high mathematical problem solving self-efficacy persist longer and demonstrate more performance monitoring than students with lower mathematical self-efficacy (Schunk & Pajares, 2001). Ultimately, students' academic self-regulatory skill development depends significantly on the combined effect between their ability to effectively use self-regulated learning processes and their level of perceived self-efficacy (Schunk & Zimmerman, 1997).

Self-regulated Learning and Mathematics Course Enrollment

Many students taking collegiate mathematics courses, and especially those taking developmental mathematics and introductory courses, are doing so to satisfy degree requirements, and are likely not personally interested in mathematics (Briley et al., 2009). Developmental and introductory college mathematics courses often focus on helping learners, especially struggling learners, gain specific academic content knowledge (Cohen, 2012). Because self-regulatory skills are closely linked to achievement, researchers have proposed that it would be beneficial to help students at all ability levels improve their knowledge and implementation of self-regulated learning strategies, especially in developmental courses (Briley et al., 2009; Cohen, 2012; Ley & Young, 1998; Schapiro & Livingston, 2000; Tinnesz, Ahuna, & Kiener, 2006; Young & Ley, 2003).

Environmental factors and learning contexts influence students' use of self-regulatory behaviors as well as their engagement in the learning environment; consequently, students' self-regulatory behaviors may differ significantly from one course to another (Cleary & Chen, 2009; Hadwin, Winne, Stockley, Nesbit, & Woszczyna, 2001; Reeve & Jang, 2006). Given that strategy use is time consuming and requires extra motivation and effort from students, students who value mathematics are more likely to implement strategies that increase their probability for success in a mathematics course (Berger & Karabenich, 2011; Zimmerman, 2000a). Additionally, students who choose to enroll in a course because of their interest in personal development and its relevance to their field of study tend to use more deep-processing strategies such as reflection and self-monitoring of understanding as compared to students who enroll in a course simply for required course credit (Berger & Karabenich, 2011; Cleary & Chen, 2009). Students who are not interested in mathematics are more likely to limit their learning strategy use to memorization, which they perceive to be less costly in terms of time and effort than other self-regulated learning strategies shown to be linked to achievement (Berger & Karabenich, 2011).

CHAPTER 3

METHODS

Introduction

The purpose of this study was to investigate the relationship of first-time college freshmen's mathematics course enrollment, gender, and high school mathematics course experience to their mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses.

The study was designed to answer the following research questions:

1. Does mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies differ significantly among first-time freshmen, when considering their mathematics course enrollment, their high school mathematics course experience, or their gender, as measured at the beginning of the semester?
2. Does mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies differ significantly among first-time freshmen, when considering their mathematics course enrollment, their high school mathematics course experience, or their gender, as measured at the end of the semester?
3. What are the relative contributions of mathematics course enrollment, high school mathematics course experience, and gender to mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies?
4. Do first-time freshmen students' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies significantly differ between the beginning of the fall semester and the end of that semester, and do

those differences vary significantly when gender, high school mathematics course experience, and mathematics course enrollment are considered?

Setting of the Study

Data were collected from students enrolled in undergraduate mathematics courses commonly taken by first-time freshman students at a large Midwestern university. The university main campus total enrollment (both undergraduate and graduate) in Fall 2018 was just under 25,000 students (Office of Institutional Research and Planning, 2018), with just over 4,000 of those being first-time freshmen (Office of Institutional Research and Planning, 2019). The university is a 4-year public research and teaching institution with four satellite campuses offering bachelor's, master's, and doctoral degree opportunities.

Undergraduate degree requirements at the university targeted six educational goals with distinct learning outcomes, including an expectation to demonstrate quantitative literacy. Due to the expectation that the quantitative literacy requirement be completed within the first three semesters of a student's undergraduate study (College of Liberal Arts and Sciences, n.d.), and that mathematics coursework often serves as a prerequisite to other required coursework, most students are advised to enroll in a mathematics course during their first semester at the university.

Mathematics course placement is determined by students' ACT or SAT scores or a placement exam given by the university (Department of Mathematics, n.d.d); high school grade point average might also be considered for special cases of course enrollment (M. Bayer, personal communication, July 12, 2018). Although there are first-time freshmen who enroll in higher-level courses, and others who do not enroll in mathematics courses at all, about half (49% on average) of first-time freshmen at the university enroll in one of three courses: Intermediate

Algebra, College Algebra, or Calculus I. These mathematics courses are taught by professors, teaching specialists, graduate students, and lecturers.

Kansas Algebra Program

The Kansas Algebra Program (KAP) coordinates the Intermediate Algebra and College Algebra courses. The program is structured so that students experience small classes for more individualized interactions, have access to an algebra help room, can participate in program-supported study groups, and have flexibility in test-taking (e.g., time of day, opportunities to retake, and untimed test sessions). The program offers face-to-face classes with supplementary online instructional resources, and requires both written assignments and online homework. All exams are proctored paper-and-pencil common exams, with randomized variants of exam questions so that most students solve unique problems. KAP employs undergraduate students, graduate students, lecturers, and teaching specialists who lead study groups, tutor students in the KAP Help Room, proctor examinations, and grade tests. All classes are led by a lecturer, teaching specialist, or graduate teaching assistant (I. Peterson, personal communication, April 9, 2019). In order to encourage instructional uniformity as well as share insights into successful pedagogical strategies, instructors meet with a lead instructor weekly to prepare instructional strategies for upcoming content, share ideas, share experiences and concerns, and practice instructional delivery (I. Peterson, personal communication, April 9, 2019).

Students who score lower than 22 on the mathematics section of the ACT or below 570 on the mathematics section of the SAT are placed into Intermediate Algebra (Department of Mathematics, n.d.d). There is no prerequisite for Intermediate Algebra; however, students who score lower than 16 on the mathematics section of the ACT or below 460 on the mathematics section of the SAT may not be adequately prepared for the course and are encouraged to take an introductory algebra course at a community college prior to enrolling in order to prepare for a more successful experience (Department of Mathematics, n.d.d). Instruction in Intermediate Algebra focuses on algebraic operations and equation-solving procedures, emphasizing linear and quadratic functions (Department of Mathematics, n.d.b). Because the course is offered only to prepare students for enrollment in a college-level mathematics course such as College Algebra or Precalculus, it is considered a developmental course and does not fulfill degree credit requirements.

Students who score at least 22 on the mathematics section of the ACT or at least a 570 on the mathematics section of the SAT are eligible to enroll in College Algebra (Department of Mathematics, n.d.d). College Algebra is designed to reinforce basic skills and deepen conceptual understanding of the algebraic principles fundamental to mathematical reasoning with a focus on the study of functions through multiple representations (Department of Mathematics, n.d.c). Students have the option of enrolling in a traditional College Algebra course, or they may request permission to enroll in an applied "data-driven" variation of the course or an "enhanced" section that requires concurrent enrollment in a special topics course to supplement instruction. Successful completion of College Algebra fulfills one unit of the Critical Thinking and Quantitative Literacy General Education Goal for the graduation requirement at the university (Department of Mathematics, n.d.c), and is the terminal mathematics requirement for most bachelor's degrees in the arts and humanities at the university.

Calculus I

The Calculus I course in this study is the first course of a Calculus I, II, and III sequence that is intended for mathematics, science, and engineering majors (Department of Mathematics, n.d.a). A member of the mathematics department serves as the coordinator for Calculus I, organizing the curriculum and common assessments for all sections of the course (M. Bayer, personal communication, April 20, 2018). The coordinator is also a pedagogical supervisor for the instructors of the lecture sections, lab sections, and discussion groups.

Students who score at least 28 on the mathematics section of the ACT or at least 660 on the mathematics section of the SAT are eligible to enroll in Calculus I (Department of Mathematics, n.d.d). Calculus I topics include limits, derivatives, applications of differentiation, and the integral and basic applications of the integral, using exponential, logarithmic, and trigonometric functions (Department of Mathematics, n.d.a). The course is offered in a large lecture format of 175 – 250 students, and each student is required to enroll in one lab section with 30 – 35 students. Students take two common midterms and a final exam. Calculus I is a requirement for mathematically robust bachelor's degrees such as engineering, mathematics, physics, and the bachelor of science in chemistry and biochemistry.

Help Rooms

The mathematics department offers support to all students enrolled in undergraduate mathematics courses through instructor office hours or free help rooms. Students enrolled in Intermediate Algebra and College Algebra have access to the KAP Help Room staffed by KAP employees. Students taking Calculus I courses may seek help in a calculus help room that is staffed by mathematics graduate teaching assistants.

Participants

The participants in this study were students enrolled in one of three mathematics courses offered in the Fall 2018 semester (Intermediate Algebra, College Algebra, and Calculus I). All students enrolled in all sections of those courses were invited to participate in the study, but only those who chose to participate and were identified as first-time freshmen were included in the study analysis as a participant. First-time freshmen are defined by the university Office of Institutional Research and Planning (2011) as

> [1] entering freshmen who have never attended any college;
>
> [2] students enrolled in the fall term who attended college for the first time in the prior summer term;
>
> [3] students who entered with advance standing (college credits earned before graduation from high school); [or]
>
> [4] any student who graduated from high school in the previous spring semester, regardless of whether or not they earned college credit prior to graduation or during the summer semester prior to the fall semester enrollment. (p. 1)

Demographic data were collected from participants, including age, gender, ethnicity, race, status as an international student, intended major, current mathematics course, what mathematics courses they took in high school, and the geographical location of their high school. Data regarding participants' year of high school graduation were collected, along with whether they had taken any courses at a postsecondary institution (such as another university, 4- or 2-year college, technical, vocational, or business school) after high school graduation but before attending this university, and the semester and year they began work at this university. These data were used to determine who was a first-time freshman.

Total enrollment for the three mathematics courses included in the study was 1,844 students as of August 20, 2018, the first day of fall classes. The researcher did not have access to data regarding how many students added or dropped any of the courses after that date.

There were two groups of students who took part in the study. Group 1 included those who participated in late August and early September of 2018. Group 2 included those who participated in November and early December of 2018. Some students were part of both groups. From the total number of participants in each of the groups, those who did not qualify as a first-time freshman or who had incomplete data were removed from each sample. Demographic information is summarized for each of the groups of first-time freshman participants. For additional details, see Appendix E.

Group 1 Participants

Group 1 participants were those who participated in the study at the beginning of the semester. Almost 60% of the 299 Group 1 participants identified as female, almost 40% identified as male, and one preferred to self-identify as fluid. Participants ranged in age from 16 years (two participants) to 25 years (two participants), with the majority (82%) of the participants 18 years of age. Most of the participants (94%) graduated from high school in 2018, but nine graduated in 2017 (including one who passed the GED), six graduated in 2016, and three graduated from high school in 2015 or earlier.

About two-thirds (68%) of the participants were enrolled in College Algebra, and the remaining were split approximately equivalently between Intermediate Algebra (17%) and Calculus I (15%). A majority (72%) of all participants had taken at least one advanced mathematics course including precalculus, trigonometry, or calculus while in high school; most (77 of the 81) participants who had not taken advanced mathematics coursework took Algebra 2 or Integrated Math 3.

Over half of the participants enrolled in Intermediate Algebra and College Algebra were female (63% and 64%, respectively) but females made up less than half (39%) of the participants enrolled in Calculus I. Over half of the participants who had taken advanced mathematics coursework in high school were female (63%).

A few (7%) of the participants were international students, but the majority were domestic students who were from 23 different states. About 10% of the participants identified as Hispanic in ethnicity. About three-quarters of the participants were White, with the remaining quarter mostly Asian, Black or African American, or of two or more races. Participants were not equally distributed among the three mathematics courses with regard to racial identity. Intermediate Algebra participants were 62% White, and all but four of the remaining were Black or African American or of two or more races. College Algebra participants were about 80% White and all but two of the remaining split among Asian (7.4%), Black or African American (5.4%), and two or more races (3.9%). Calculus I participants were 73% White, with all but two of the remaining participants Asian, and no Black or African American participants.

Participants anticipated majoring in a variety of fields. Participants identified majors that were grouped into major categories as defined by BigFuture (College Board, 2019), including science, technology, engineering, or mathematics (STEM) (28%), business (25%), social sciences (20%), health and medicine (18%), arts and humanities (4.5%), and about 4.5% were undecided. Participants that were enrolled in Intermediate Algebra listed majors that were generally equally distributed across STEM, business, social science, health and medicine, with a few less in arts and humanities. Almost a third of the participants enrolled in College Algebra expected to major in business, and the remaining were generally equally distributed. The participants enrolled in Calculus I were predominantly expecting to major in a STEM field (91%). Participants' listed majors were not equally distributed with regard to gender; almost 90% of the health and medicine majors were female, a little over 80% of the social sciences majors were female, exactly two-thirds of the business majors were male, and the number of males and females expecting to major in a STEM field were about the same.

Group 2 Participants

Group 2 participants were those who participated in the study at the end of the semester. About 62% of the 176 Group 2 participants identified as female, and about 38% identified as male, with no participants electing to self-identify otherwise. Participants ranged in age from 16 years (one participant) to 52 years (one participant), with the majority (91%) of the participants 18 – 19 years of age. Most of the participants (97%) graduated from high school in 2018, but three graduated in 2017, and three passed the GED (in 1984, 2016, and 2017).

About half (51.7%) of the participants were or had been enrolled in College Algebra, about a third (34.7%) in Calculus I, and 13.6% in Intermediate Algebra. There were 10 students who were no longer enrolled in one of the three mathematics courses; four had dropped College Algebra, three had dropped Calculus I, two had moved from Calculus I into a more advanced calculus course, and one had dropped Intermediate Algebra. A majority (78%) of all participants had taken at least one advanced mathematics course including precalculus, trigonometry, or calculus while in high school; most (34 of the 39) participants who had not taken advanced mathematics coursework took Algebra 2 or Integrated Math 3.

About three-quarters of the participants enrolled in Intermediate Algebra and College Algebra were female (75% and 74%, respectively) but females made up less than half (39%) of the participants enrolled in Calculus I. Over half of the participants who had taken advanced mathematics coursework in high school were female (58%).

A few (5%) of the participants were international students, but the majority were domestic students who were from 16 different states. About 7% of the participants identified as Hispanic in ethnicity. About 84% of the participants were White, with the remaining participants identifying as mostly Asian or being of two or more races. Participants were not proportionally distributed among the three mathematics courses with regard to racial identity. Intermediate Algebra participants were 71% White and all but three of the remaining were Black or African American or of two or more races. College Algebra participants were about 87% White and all but three of the remaining were of two or more races. Calculus I participants were 84% White, with all but one of the remaining participants Asian or of two or more races. There were no Black or African American participants enrolled in Calculus I.

Participants anticipated majoring in a variety of fields. Participants identified majors that included science, technology, engineering, or mathematics (STEM) (42%), social sciences (24%), business (15%), health and medicine (14%), arts and humanities (3%), and public and social services (1 participant). About 3% of participants were undecided about a major. Participants that were enrolled in Intermediate Algebra most frequently expected to major in business and social sciences, and fewer expected to major in STEM or health and medicine. A single Intermediate Algebra student was interested in arts and humanities. Over a third of the College Algebra participants expected to major in social sciences, more than 20% expected to major in health and medicine, and about 20% expected to major in business. About 14% expected to major in a STEM field, 5% in arts and humanities, and a single College Algebra student expressed interest in public and social service. The participants enrolled in Calculus I were predominantly expecting to major in a STEM field (92%). Participants' listed majors were not equally distributed with regard to gender. Females made up 100% of the arts and humanities majors, 88% of the health and medicine majors, and 78% of the social sciences majors. The number of males and females expecting to major in business or a STEM field was about the same.

Participants in Both Groups

There were 68 students who participated in both Group 1 at the beginning of the semester as well as Group 2 at the end of the semester. About 71% of these two-time participants identified as female and about 29% identified as male. One expressed a preference to self-identify as fluid at the beginning of the semester, but identified as female at the end of the semester. At the beginning of the Fall 2018 semester, the two-time participants ranged in age from 16 years (one participant) to 19 years (seven participants), with the majority (82%) of the participants 18 years of age. Most of them (96%) graduated from high school in 2018, but three graduated in 2017 (including one who passed the GED).

Over half (60%) of the two-time participants were enrolled in College Algebra, and the remaining were split approximately equivalently between Intermediate Algebra (18%) and Calculus I (22%). A majority (78%) of these participants had taken at least one advanced mathematics course including precalculus, trigonometry, or calculus while in high school; all 15 of the two-time participants who had not taken advanced mathematics coursework took Algebra 2 or Integrated Math 3.

About three-quarters of the two-time participants enrolled in Intermediate Algebra and College Algebra were female (75% and 78%, respectively) and females made up about half (47%) of the two-time participants enrolled in Calculus I. Over two-thirds of the participants who had taken advanced mathematics coursework in high school were female (70%).

A few (9%) of the two-time participants were international students, but the majority were domestic students who were from 12 different states. About 6% of these participants identified as Hispanic in ethnicity. About 87% of the two-time participants were White; participants were not proportionally distributed among the three mathematics courses with regard to racial identity. Intermediate Algebra two-time participants were 75% White, with the three remaining identifying as Black or African American or Other. College Algebra two-time participants were about 90% White and the remaining were split equally between those who identified as Asian and those who identified as being of two or more races. Calculus I two-time participants were 87% White, with the remaining two participants identifying as Asian.

At the beginning of the Fall 2018 semester, the two-time participants identified majors including science, technology, engineering, or mathematics (STEM) (38%), business (21%), social sciences (19%), health and medicine (16%), arts and humanities (1%), and about 4% were undecided. Those enrolled in Intermediate Algebra and College Algebra listed majors that were generally equally distributed across STEM, business, social science, health and medicine, with less in arts and humanities. The two-time participants enrolled in Calculus I were all expecting to major in a STEM field. The majors identified by the two-time participants were not proportionally distributed with regard to gender; over 90% of the health and medicine majors were female, about 85% of the social sciences majors were female, and the number of males and females expecting to major in a STEM field were equal.

By the end of the Fall 2018 semester, 19 of the two-time participants had changed their expected major, but only half of those shifted their expected major category. Participants expected to major in social sciences increased by four, but participants expected to major in a STEM field or health science decreased by three and one, respectively. The quantity of two-time participants expected to major in arts and humanities or business had no net gain or loss.

Instruments

Two forms of a researcher-developed survey instrument were used to gather data in this study. The Mathematics Experience and Perspectives Survey form 1 (MEPS1) was designed to be delivered as close to the beginning of the semester as possible in order to capture students' perspectives as mathematics learners before they had experienced much in their fall semester college mathematics course. The MEPS1 was used to gather data about participants' demographics as well as their perspectives on mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies for mathematics courses. It is assumed that students' responses were greatly influenced by their past experiences in mathematics. The Mathematics Experience and Perspectives Survey form 2 (MEPS2) was designed to be delivered as close to the end of the semester as possible, but before all semester assignments were complete, and before the final exam. The MEPS2 was intended to capture students' perspectives as mathematics learners after they had completed the majority of the mathematics coursework for their first semester of college. The MEPS2 collected the same set of data as MEPS1 collected, but with the wording of some items shifted to reflect the change from being anticipatory in nature to descriptive of students' past actions that semester and anticipatory toward the course completion. A copy of each survey is included in Appendices A and B, respectively.

The MEPS1 and MEPS2 forms included a combination of items adapted from multiple survey instruments to measure mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses. Several of these source survey instruments have been used nationally with high reliability. The source instruments included the Openness to Pedagogical Change Survey (OPCS) (Williams, 2015), the High School Longitudinal Study of 2009 (HSLS:09) (National Center for Education Statistics, 2009), the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, 1991), Sources of

Middle School Mathematics Self-Efficacy Scale (SMSES) (Usher & Pajares, 2009), and the Online Self-Regulated Learning Questionnaire (OSLQ) (Barnard, Lan, To, Paton, & Lai, 2009).

The MEPS1 and MEPS2 instruments were formatted to be delivered through a university-licensed Qualtrics web-based survey tool. There were 54 items: one personal identifier, 20 demographic information items, and 33 items that formed the four subscales of mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies.

Mathematics Experience and Perspectives Survey form 1 (MEPS1)

Demographics. The MEPS1 survey form started with items to gather participants' descriptive data. The first item requested the participant's university online username (university email address), which served as a mechanism to match an individual participant's survey responses from the MEPS1 to the MEPS2. There were ten additional descriptive items that collected data on each participant's fall mathematics course enrollment, age, gender, ethnicity and race, high school location, high school mathematics course enrollment history, major or intended major, the reason for taking the current mathematics course, and expectations and reasons for taking additional mathematics courses in the future. The year of the student's high school graduation, the date of the student's first semester enrolled at the university, and the courses taken at a post-secondary institution since the completion of high school were three additional items that were used to identify whether or not the participant was a first-time freshman at the university. The wording for the two items requesting the participant's ethnicity and race was guided by the instructions given by the U.S. Department of Education to educational institutions and other recipients of grants and contracts regarding the collection and reporting of racial and ethnic data (Final Guidance on Maintaining, Collecting, and Reporting

Racial and Ethnic Data to the U.S. Department of Education, 2007), although a category of "other" with space for the participant to fill in additional information was also included.

Measure of mathematical mindset. The mathematical mindset subscale was comprised of seven items taken directly from the mathematical mindset subscale of the OPCS (Williams, 2015) survey. Although the OPCS (Williams, 2015) was developed to measure openness to pedagogical change among mathematics teachers, the mathematical mindset subscale is broadly relevant to any population with regard to perceptions of mathematical intelligence or talent. The nine items on the OPCS (Williams, 2015) mathematical mindset subscale originated from both the Stipek, Givvin, Salmon, and MacGyvers (2001) inventory (specifically, the entity versus incremental view of intellectual ability subscale) and items adapted from Dweck's (2000) Theories of Intelligence Scale, modified for mathematical intelligence. The OPCS (Williams, 2015) mathematical mindset subscale published a reliability analysis with a Cronbach's alpha of 0.72.

Measure of mathematical identity. Mathematical identity was measured by seven items, two taken directly from the HSLS:09 (NCES, 2009), and five researcher-developed items, three of which were adapted from items from the SMSES (Usher & Pajares, 2009), and two of which were adapted from items from the OPCS (Williams, 2015). The HSLS:09 survey (National Center for Education Statistics, 2009) reported a Cronbach's alpha of 0.88 for the mathematical identity subscale that consisted of the two items that were utilized on the MEPS1. The three items from the SMSES (Usher & Pajares, 2009) did not have a separate reliability calculated for those individual items on any SMSES survey distribution, nor did the two items from the OPCS (Williams, 2015).

A few studies have focused on mathematical identity dissonance, the difference between an individual's personal mathematical identity and social mathematical identity (Heller, 2015). Although mathematical identity dissonance was not a focus of this study, items representative of both personal mathematical identity and social mathematical identity were intentionally included in the mathematical identity construct measure. An individual's personal mathematical identity is the degree to which one sees oneself as a "math person", whereas an individual's social mathematical identity is the degree to which one believes others see oneself as a "math person" (Heller, 2015, p. 27). The five researcher-developed items were written to build internal consistency with the two items taken from the HSLS:09 (National Center for Education Statistics, 2009) that were representative of one's personal mathematical identity and one's social mathematical identity. Mathematical identity subscale items are labeled as personal or social in Appendix C.

Measure of mathematical self-efficacy. Mathematical self-efficacy was measured by seven items that were adapted from a combination of existing measures including the Mathematics Self-efficacy subscale of the OPCS (Williams, 2015), the Mathematics Self-efficacy subscale of the HSLS:09 (National Center for Education Statistics, 2009), the Self-efficacy for Learning and Performance subscale of the MSLQ (Pintrich, 1991), and the Mastery Experiences and Vicarious Experiences subscales of the SMSES (Usher & Pajares, 2009). The Mathematics Self-efficacy subscales of the OPCS (Williams, 2015) and the HSLS:09 (National Center for Education Statistics, 2009) reported a Cronbach's alpha of 0.75 and 0.89, respectively. The Self-Efficacy for Learning and Performance subscale of the MSLQ reported a Cronbach's alpha of 0.93 (Pintrich, 1991; Pintrich, Smith, Garcia, & McKeachie, 1993). The Mastery

Experiences and Vicarious Experiences subscales of the SMSES reported a Cronbach's alpha of 0.88 and 0.84, respectively (Usher & Pajares, 2009).

There have been numerous self-efficacy scales developed by researchers; however, the scales have differed in item content and specificity, and therefore they have differed in the particular measurement of self-efficacy (Bandura, 1997; Pajares & Miller, 1994). One of the earliest and most frequently referenced mathematics self-efficacy scales was the Mathematics Self-Efficacy Scale (MSES) published in 1983 by Betz and Hackett. The MSES included items that addressed participants' anticipated performance on specific tasks that would require varying levels of mathematical knowledge and mastery (Betz & Hackett, 1983). For the current study, items that referenced such precisely defined tasks were not utilized due to a concern that the broad spectrum of mathematics skill and knowledge among students in the three courses could become confounding to the interpretation of study results.

Bandura (1997) noted that self-efficacy scales should measure people's beliefs about their abilities to complete various tasks within a particular domain at a particular level of performance, and Zimmerman (2000b) emphasized that self-efficacy judgements are inherently about future performances, and must be assessed prior to actual performance of the tasks. The items in the MEPS1 self-efficacy subscale were selected because of their specificity regarding a particular task within the mathematical domain that all students would encounter (e.g., assignments, tests, course grade, skill development), as well as their focus on future performance in their mathematics course.

Measure of self-regulation. The measure of use of self-regulated learning strategies in mathematics coursework included 12 items that had been adapted from the OSLQ (Barnard et al., 2009), which is a 24-item Likert scale questionnaire that was constructed to address self-regulated learning in blended or online learning environments. Barnard et al. (2009) identified six subscale constructs that addressed self-regulated learning attributes, including goal setting, environment structuring, task strategies, time management, help seeking, and self-evaluation. The six subscale constructs were a subset of the 14 types of self-regulated learning strategies originally identified by Zimmerman and Martinez-Pons (1986). Goal setting items on the Barnard et al. (2009) questionnaire focused on a student's ability to set goals or subgoals. Environment structuring items related to student-initiated efforts to select or arrange the studying environment to make learning easier. Items categorized as task strategies referenced specific tasks that a student might use while studying to be more successful. Time management items accounted for a student's ability to manage personal studying time outside of class. Help seeking items related to student-initiated efforts to solicit assistance from others. Lastly, the self evaluation items on the Barnard et al. (2009) questionnaire focused on a student's ability to evaluate the quality of personal learning and monitor the progress of their work.

The OSLQ reported a reliability of 0.92 for the 24 items (Barnard et al., 2009). In an attempt to keep the MEPS1 at a reasonable length, and yet representative of the six subscale constructs, two items were selected from each of the six subscales within the OSLQ. Additionally, because the OSLQ was intended to measure the use of self-regulated learning strategies in online and blended learning college courses not specific to mathematics, questions were modified to pertain to the mathematics classroom. Although students enrolled in the Intermediate Algebra and College Algebra courses in this study did utilize some blended learning experiences, the Calculus I course did not, and blended learning was not a focus of this study. Therefore, references to online learning environments in OSLQ items were removed for use in the MEPS1.

Students’ short- and long-term goals, as well as goals specific to study time made up the two goal setting items in the MEPS1. Finding a space and time without too many distractions, and identifying where and how students can work most efficiently on mathematics were the two environment structuring items. The two task strategy items targeted students’ decisions to work extra problems or read directions out loud to avoid distractions. Students’ choices for spreading out work load (e.g., doing a little every day) and finding a consistent time to do mathematics work were the two selected time management items. The two help-seeking items concerned students’ persistence to get help from the instructor or seek help from other students, tutors, or the help room. The two self-evaluation items focused on whether or not students take time to summarize what they have learned or ask questions of themselves to evaluate their understanding.

Reliability and construct validity. An internal consistency estimate of reliability was computed for the 33 MEPS1 item scores overall, as well as for each of the four subscales using Cronbach’s alpha. The values for coefficient alpha ranged between .73 and .91, indicating satisfactory reliability (Friedenberg, 1995). Specific values are shown in Table 1.

Table 1
Internal Estimates of Reliability for MEPS1 Subscales

	No. of items	Item numbers	Cronbach’s alpha
MEPS1 overall	33	15 – 47	.90
Mathematical mindset subscale	7	18, 21, 26, 30, 35, 42, 47	.73
Mathematical identity subscale	7	17, 22, 25, 31, 34, 39, 45	.90
Mathematical self-efficacy subscale	7	16, 20, 29, 36, 40, 43, 46	.91
Use of self-regulated learning strategies subscale	12	15, 19, 23, 24, 27, 28, 32, 33, 37, 38, 41, 44	.80

The construct validity of the four subscales was analyzed using maximum likelihood factor analysis (Friedenberg, 1995). The scree plot in the initial analyses confirmed that four factors were appropriate for rotation, so four factors were rotated using a Varimax rotation procedure. The rotated factors accounted for about 44% of the item variance in the overall scale. The factor loadings (shown in Appendix G) were examined for items that were highly correlated (defined here as $\geq .40$) with more than one factor or were not correlated highly with any factors. Item 22, a mathematical identity item, loaded on two factors (mathematical identity and mathematical self-efficacy), but loaded more highly onto the mathematical identity factor, and was retained for data analysis. A mathematical mindset item (item 18) and three use of self-regulated learning strategies items (items 32, 37, and 38) did not meet the minimum correlation of .40 for any factor, and were eliminated.

A second maximum likelihood factor analysis using a Varimax rotation procedure on four factors was completed with the 29 remaining items. This analysis yielded four interpretable factors that accounted for about 47% of the item variance in the overall scale. The mathematical self-efficacy factor accounted for about 15% of the item variance, the mathematical identity factor accounted for about 14% of the item variance, the use of self-regulated learning strategies factor accounted for about 11% of the item variance, and the mathematical mindset factor accounted for about 7% of the item variance. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy was .903, and the Goodness-of-fit Test computed a $\chi^2 = 499.2$, with 296 degrees of freedom, $p < .001$, indicating that there was no systematic covariance among the items after four factors had been extracted (Landau & Everitt, 2004). The factor loadings (shown in Table 2) were examined for items that were highly correlated with more than one factor or were not correlated highly with any factors. Item 22, a mathematical identity item, loaded on the same two factors, with a higher correlation to mathematical identity than mathematical self-efficacy, and was retained for analysis. All other items were highly correlated with a single factor.

Table 2

MEPS1 Factor Loadings for Maximum Likelihood Factor Analysis With Varimax Rotation of Construct Subscales – Items 18, 32, 37, 38 Removed

	Factors			
Item	Mindset	Identity	Self-eff	Self-reg
Mathematical mindset				
21. I can improve my math skills, but I can't change my basic math ability.	**.454**	.064	.020	-.053
26. To be honest, you can't really change how much math talent you have.	**.657**	.100	.212	.096
30. It's possible to change even your basic level of math intelligence.	**.412**	.056	.268	.220
35. In math, there will always be some students who just don't "get it" and others that do.	**.579**	.194	.025	.020
42. Math ability is something that remains relatively fixed throughout a person's life.	**.546**	.007	-.032	-.206
47. Some people just have a knack for math, and some just don't.	**.515**	.201	.013	.097
Mathematical identity				
17. People think of me as someone who is good at math.	.029	**.824**	.286	.076
22. I often feel out of place in math classes.	.246	**.473**	**.407**	-.002
25. I see myself as a math person.	.078	**.764**	.266	.129
31. I have been praised for my ability to do math.	.143	**.747**	.201	.101
34. I don't really fit in with "math people".	.293	**.521**	.254	.065
39. Others think I'm not very good at math.	.258	**.571**	.271	.025
45. Others see me as a math person.	.145	**.818**	.244	.023
Mathematical self-efficacy				
16. I am confident that I will do an excellent job on assignments in my math course this semester.	-.005	.366	**.693**	.233
20. I am certain I will be able to understand the material presented in my math course.	.061	.301	**.558**	.178
29. I expect to do well in my math class this semester.	.045	.226	**.778**	.185
36. I believe that I will receive an excellent grade in my math course.	.078	.278	**.742**	.241
40. I am certain that I can master the skills being taught in my math course this semester.	.098	.240	**.749**	.183
43. I can imagine myself successfully solving challenging math problems.	.226	.370	**.480**	.181
46. I am confident that I can do an excellent job on tests in my math course.	.107	.255	**.738**	.162
Use of self-regulated learning strategies in mathematics courses				
15. When I study for math, I try to study a little every day instead of waiting until the test or until the work is due.	.066	.121	.136	**.472**
19. I usually choose a location to study math where there are few distractions.	.108	-.106	-.018	**.534**
23. When I need help with math, I find someone who is knowledgeable in math, or I go to a math help room or tutor.	-.027	-.027	.103	**.460**
24. I set goals to help manage studying time for my math classes.	-.003	.162	.080	**.725**
27. I know where I can study most efficiently for math classes.	.062	-.016	.221	**.423**
28. I try to schedule the same time every day or every week to study for my math classes, and I stick to the schedule.	-.172	.100	.014	**.607**
33. I am persistent in asking for help from my math instructors.	-.034	.086	.233	**.460**

41. I set short-term (daily or weekly) goals as well as long-term (monthly or for the semester) goals for getting work done in my math classes.	.020	.085	.130	**.678**
44. I summarize my learning in math to examine my understanding of what I have learned.	.043	.122	.319	**.423**

Note. Factor loadings > .40 are in boldface. Mindset = mathematical mindset subscale; Identity = mathematical identity subscale; Self-eff = mathematical self-efficacy subscale; Self-reg = use of self-regulated learning strategies subscale.

Revised subscales. In response to the factor analysis, two of the subscale measures were revised. The mindset subscale was revised to eliminate item 18, and the use of self-regulated learning strategies subscale was revised to eliminate items 32, 37, and 38. The internal consistency estimate of reliability was computed again for the remaining 29 MEPS1 item scores overall, as well as for the two revised subscales using Cronbach's alpha. Each of the values for coefficient alpha indicated satisfactory reliability, ranging between .72 and .91. Specific values are shown in Table 3.

Table 3
Internal Estimates of Reliability for MEPS1 Subscales (Revised After Factor Analysis)

	No. of items	Item numbers	Cronbach's alpha
MEPS1 overall	29	15-17, 19-31, 33-36, 39-47	.90
Mathematical mindset subscale	6	21, 26, 30, 35, 42, 47	.72
Mathematical identity subscale	7	17, 22, 25, 31, 34, 39, 45	.90
Mathematical self-efficacy subscale	7	16, 20, 29, 36, 40, 43, 46	.91
Use of self-regulated learning strategies subscale	9	15, 19, 23, 24, 27, 28, 33, 41, 44	.80

Mathematics Experience and Perspectives Survey form 2 (MEPS2)

The MEPS2 was designed to be administered during the last few weeks of the semester to capture students' perspectives nearing the completion of their fall college mathematics course. It was expected that students' responses on this second survey would be reflective of their experiences during the fall semester mathematics course rather than their pre-college mathematics experiences. Items on the MEPS2 were the same as items on the MEPS1, except that some items were revised to reflect the change in timing of the survey distributions from the beginning of the semester to the end. Changes included shifts in verb tense, wording changes to acknowledge the timing of the semester, or additional options for items that might have no longer included an appropriate choice for participants (e.g., Item 2, "In which math course are you currently enrolled at KU?" added the option, "I am no longer enrolled in math this semester. The course I was previously enrolled in was: _____."). All revisions are presented in more detail in Appendix C.

Mathematical self-efficacy item changes from the MEPS1 to the MEPS2. Because self-efficacy is defined as a measurement of beliefs about future behavior, it was important to have items written in future tense. However, since the MEPS2 was distributed toward the conclusion of the semester, students had already completed the majority of the required course work, so items from the MEPS1 that asked a participant to anticipate a level of performance on work already completed did not make sense. Items 16, 20, 40, and 46 were changed to refer specifically to the remaining work in the class, such as a final assignment, final exam, or final grade.

Use of self-regulation strategies item changes from the MEPS1 to the MEPS2. A few of the items required wording revisions in order to encourage participant responses that were reflective of actual behaviors occurring over the course of the first semester rather than participants' generalizations of behavior as was requested at the beginning of the semester in the MEPS1. Some items, such as Item 15, "When I study for math, I try to study a little every day instead of waiting until the test or until the work is due" were modified to more directly reflect work completed during the fall semester, specifying, "This semester, when I studied for math, I tried to study a little every day instead of waiting until the test or until the work was due." Item

24, “I set goals to help manage studying time for my math classes” was also modified in this way, resulting in a statement of, “This semester, I set goals to help manage studying time for my math class.” Items 23, 28, 32, and 41 also underwent similar modifications.

Reliability and construct validity. All items used for subscale measures in MEPS1 were included in MEPS2. An internal consistency estimate of reliability was computed overall for the 29 MEPS2 item scores used for analyses, as well as for each of the four subscales using Cronbach's alpha. The values for coefficient alpha ranged between .77 and .93. Specific values are shown in Table 4.

Table 4
Internal Estimates of Reliability for MEPS2 Subscales

	No. of items	Item numbers	Cronbach's alpha
MEPS2 overall	29	15-17, 19-31, 33-36, 39-47	.91
Mathematical mindset subscale	6	21, 26, 30, 35, 42, 47	.77
Mathematical identity subscale	7	17, 22, 25, 31, 34, 39, 45	.93
Mathematical self-efficacy subscale	7	16, 20, 29, 36, 40, 43, 46	.93
Use of self-regulated learning strategies subscale	9	15, 19, 23, 24, 27, 28, 33, 41, 44	.79

The construct validity of the four subscales was analyzed using maximum likelihood factor analysis (Friedenberg, 1995). The scree plot in the initial analyses confirmed that four factors were appropriate for rotation, so four factors were rotated using a Varimax rotation procedure. This analysis yielded four interpretable factors that accounted for about 53% of the item variance in the overall scale.

The mathematical self-efficacy factor accounted for about 17% of the item variance, the mathematical identity factor accounted for about 15% of the item variance, the mathematical mindset factor accounted for about 11% of the item variance, and the use of self-regulated learning strategies factor accounted for about 10% of the item variance. The Kaiser-Meyer-Olkin

Measure of Sampling Adequacy was .885, and the Goodness-of-fit Test computed a $\chi^2 = 449.6$, with 296 degrees of freedom, $p < .001$, indicating that there was no systematic covariance among the items after four factors had been extracted (Landau & Everitt, 2004). The factor loadings are shown in Table 5. Item loadings confirmed the factor structure, except two items that did not meet the minimum correlation criteria imposed of .40 (mathematical mindset item 21 and self-regulatory item 19), one item that loaded onto two factors (mathematical identity item 34), and one self-efficacy subscale item (item 43) that was more highly correlated with mathematical mindset. All other items were highly correlated with only the anticipated factor.

Table 5

MEPS2 Factor Loadings for Maximum Likelihood Factor Analysis With Varimax Rotation of Construct Subscales

	Factors			
Item	Mindset	Identity	Self-eff	Self-reg
Mathematical mindset				
21. I can improve my math skills, but I can't change my basic math ability.	.343	.195	.043	-.126
26. To be honest, you can't really change how much math talent you have.	**.571**	.147	.154	.135
30. It's possible to change even your basic level of math intelligence.	**.505**	.090	.310	.076
35. In math, there will always be some students who just don't "get it" and others that do.	**.704**	.222	.043	-.028
42. Math ability is something that remains relatively fixed throughout a person's life.	**.615**	.139	.045	-.191
47. Some people just have a knack for math, and some just don't.	**.711**	.186	.070	-.047
Mathematical identity				
17. People think of me as someone who is good at math.	.202	**.757**	.371	.012
22. I often feel out of place in math classes.	.241	**.543**	.398	.017
25. I see myself as a math person.	.341	**.740**	.309	.010
31. I have been praised for my ability to do math.	.185	**.863**	.205	-.010
34. I don't really fit in with "math people".	**.439**	**.492**	.234	.022
39. Others think I'm not very good at math.	.338	**.644**	.319	-.167
45. Others see me as a math person.	.272	**.813**	.249	-.048
Mathematical self-efficacy				
16. I am confident that I will do an excellent job on assignments in my math course this semester.	.016	.196	**.791**	.120
20. I am certain I will be able to understand the material presented in my math course.	.162	.228	**.772**	.159
29. I expect to do well in my math class this semester.	.142	.244	**.805**	.203
36. I believe that I will receive an excellent grade in my math course.	.165	.291	**.764**	.160
40. I am certain that I can master the skills being taught in my math course this semester.	.176	.240	**.787**	.157
43. I can imagine myself successfully solving challenging math problems.	**.436**	.359	.393	.038
46. I am confident that I can do an excellent job on tests in my math course.	.182	.333	**.804**	.080
Use of self-regulated learning strategies in mathematics courses				
15. When I study for math, I try to study a little every day instead of waiting until the test or until the work is due.	-.014	-.045	-.050	**.615**
19. I usually choose a location to study math where there are few distractions.	.029	-.042	.125	.285
23. When I need help with math, I find someone who is knowledgeable in math, or I go to a math help room or tutor.	-.049	.002	.122	**.541**
24. I set goals to help manage studying time for my math classes.	.002	-.083	.103	**.813**
27. I know where I can study most efficiently for math classes.	.072	.119	.337	**.316**
28. I try to schedule the same time every day or every week to study for my math classes, and I stick to the schedule.	-.128	.047	-.031	**.584**
33. I am persistent in asking for help from my math instructors.	-.127	-.144	.209	**.589**

41. I set short-term (daily or weekly) goals as well as long-term (monthly or for the semester) goals for getting work done in my math classes.	-.005	.036	.073	**.627**
44. I summarize my learning in math to examine my understanding of what I have learned.	.132	.269	.158	**.412**

Note. Factor loadings > .40 are in boldface. Mindset = mathematical mindset subscale; Identity = mathematical identity subscale; Self-eff = mathematical self-efficacy subscale; Self-reg = use of self-regulated learning strategies subscale.

Procedure

Field Test of Survey Items: April 2018

In order to receive feedback on the clarity of construct measures and the mathematics experience and demographic statements, a shortened form of the survey instrument was given in April 2018 to 25 students enrolled in a Mathematics for Elementary School Teachers course at the university, and to one student assistant for the course. The purpose of the field test of survey items was to gain insight into any confusing, missing, or inappropriate items, as well as to develop an estimate regarding the length of time to complete the survey. None of the students in the course were first-time freshmen, so none of the data gathered from this field test was relevant to the data analysis nor was there any possibility that any of these students would be asked to participate in the Fall 2018 study.

Survey format. The survey was administered in paper-and-pencil format. The three pages of survey items were positioned to the left such that an area for comments could be included in the right sidebar, with the following statement at the top of the first page: "What was unclear, confusing, or awkward? Please share any suggestions for how to improve these questions." See Appendix H for the form administered.

Survey items. There were 42 items included on the field test survey form. These items included demographic questions about age, year of high school graduation, location of last high school, gender, ethnicity and race, first semester at the university, postsecondary coursework completed since leaving high school, and secondary mathematics course history. Additionally, seven mathematical mindset items, seven mathematical identity items, seven mathematical self-efficacy items, and twelve items related to the use of self-regulated learning strategies in mathematics courses were included.

Items intentionally excluded from the field test version of the survey included: university online username, current mathematics course enrollment, major or intended/expected major, the reason for taking the current mathematics course, and intent to take future mathematics courses. The username was unnecessary because there was no need to link students to another survey. All other listed items were unnecessary because all students were enrolled in the same course, majoring in education, and taking the course as a program requirement.

Survey administration. The student assistant passed out paper copies of the survey while the researcher gave an introduction and directions (see Appendix H). Participants completed the survey quickly, the fastest being done in three minutes, and the majority turning it in after five minutes. Papers were collected in a folder at the front of the classroom.

Survey analysis. After reviewing students' comments, several items were identified for clarification. These were the ethnicity and race questions, the questions about postsecondary courses taken since leaving high school, and the tense of the self-efficacy items.

Ethnicity and race. The ethnicity and race items included two items. The first inquired about ethnicity: "Are you Hispanic?" with a yes or no response available. The second item inquired about race: "Are you: (Mark all that apply)" with possible responses including American Indian/Alaskan Native, Asian, Black, Native Hawaiian/Pacific Islander, White, and Two or More Races. The two items were originally obtained from the university Office of

Institutional Research and Planning student data self-report questions (Office of Institutional Research and Planning, 2017), in order to follow university guidelines for race and ethnicity data collection. However, one student commented, "I'm Mexican and Puerto Rican – might be confusing to Hispanics." This student marked "yes" to the "Are you Hispanic?" item, did not mark a response to the item regarding race, and included her comment beside that section. Upon further review, the researcher identified that the US Department of Education requires institutions to collect and report data regarding ethnicity and race as described in the following excerpt from the Federal Register (Final Guidance, 2007).

> Educational institutions and other recipients will be required to collect racial and ethnic data using a two-part question. The first question is whether the respondent is Hispanic/Latino. The second question is whether the respondent is from one or more races using the following five racial groups: American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, and White. Respondents will not be offered the choice of selecting a "two or more races" category. (p. 59267)

The Final Guidance (2007) document describes the intent for all educational institutions to collect racial and ethnic data in a consistent manner. The first question regarding whether or not a participant is Hispanic/Latino is asking if a person is of "Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin, regardless of race" (Final Guidance, 2007, p. 59274). The second question asks participants to select one or more races, if appropriate. A respondent may choose one or multiple races, or choose none at all in the case of a person of only Mexican or Puerto Rican descent. Educational institutions, however, will report aggregated racial and ethnic data in the following categories: "1) Hispanic/Latino of any race;

and, for individuals who are non-Hispanic/Latino only, 2) American Indian or Alaska Native, 3) Asian, 4) Black or African American, 5) Native Hawaiian or Other Pacific Islander, 6) White, and 7) Two or more races." (p. 59274)

The study survey items were revised to reflect federal guidelines for educational institutions, as well as to address the field test participant's expressed concerns about clarity. The first item regarding ethnicity was revised: "Are you Hispanic or Latino?" with possible responses of yes or no. The second item regarding race was revised: "Are you: (Mark all that apply, if any)" with possible responses including American Indian or Alaskan Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, and the additional possible response of Other: _______.

Postsecondary coursework. There were three students who made comments regarding the item about coursework after high school, indicating they were confused by the wording. The original item wording was, "Since leaving high school, have you ever taken courses, whether for credit or not for credit, anywhere besides KU (university, 4- or 2-year college, technical, vocational, or business school)?" Two of the participants indicated they had completed collegiate coursework while in high school, and one participant indicated she had transferred from another institution in between high school and the university. The item wording was revised, changing "Since" to "AFTER" with an emphasis in capital letters, in an attempt to guide understanding of the item.

Self-efficacy. There were two students who made comments about two of the mathematics self-efficacy questions ("What specific course?" and "???"). It is likely that this confusion resulted because the wording was not appropriate for use at the end of the semester or because the students were not currently in one of the three courses that were going to be part of this study.

Pilot Study: July 2018

Students in two sections of Summer 2018 mathematics courses were selected to participate in the pilot study on July 16, 2018. There were 22 students enrolled in the selected section of Intermediate Algebra and 16 students enrolled in the selected section of College Algebra. The MEPS2 survey was used for the pilot study since the summer session was nearing completion at that date.

Survey administration. After permission was granted from the Kansas Algebra Program Director, the researcher contacted the instructors of the two selected classes and scheduled a day to visit them to introduce and administer the pilot study. The researcher arrived about five minutes prior to the conclusion of the classes on July 16, 2018 in order to explain the purpose of the survey, share the URL address to the pilot study version of the survey, and answer any questions. Each instructor also posted a link to the survey in an announcement in the class's online learning management system for students who were absent, or who chose to take the survey at another time. Through the URL address, the survey was available to anyone who knew the address, and could be completed on any digital device such as a computer, laptop, tablet, or mobile phone.

Purpose of the pilot study. The pilot study provided an opportunity to practice administering the instrument with the online delivery platform (Qualtrics) and observe the accessibility and ease of use of the instrument for participants. This rehearsal allowed the researcher to confirm that the online delivery platform was operating correctly and effectively, and that the researcher could access the responses as expected. The pilot study also offered an opportunity to examine participants' responsiveness, for example, whether or not they were willing to complete the survey in its entirety before quitting.

Results of the pilot study. Of the 38 possible pilot study participants, 20 students participated, and 18 students completed the instrument in its entirety. Students were able to access the survey successfully, some using smart phones, and others using tablets or laptop computers. The researcher was able to check to see that responses were accessible, and the data could be downloaded in a useable form for data analysis. The survey appeared to be not too arduous for students to complete, since 17 of the 20 students who began the survey actually completed the survey in an average time of 6.2 minutes. One student completed the survey in about 95 minutes, and two students did not complete the survey.

Expert Review: August 2018

In order to ensure content validity for the four construct subscales, the 33 items that comprised the four original subscale measures were subjected to review by mathematics education experts. The experts were asked to read the definitions provided by the researcher for each of the four subscale constructs, then categorize each of the items as a statement of mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies in mathematics courses. The document used for the expert review is located in Appendix F.

Of the 10 experts invited to participate in the expert review, five responded with their perception of which construct each item was measuring, as well as any questions they had while completing the exercise. All five experts unanimously agreed on the categorization of 26 of the 33 items, and four of the five experts agreed on the categorization of five additional items. Due to inconsistent categorizations by the experts, two mathematical identity items (items 22 and 39) were revised to better fit the mathematical identity subscale.

Gathering the Data

Group 1: MEPS1 August 2018. The MEPS1 was administered to students in Intermediate Algebra, College Algebra, and Calculus I courses the first week of Fall 2018 classes at the university. The survey was first available to students on August 23, 2018. An online link to the survey was included in an announcement that the researcher wrote and the course coordinators posted to students' learning management system pages for the courses. Instructors and course coordinators also shared the rosters of students enrolled during the first week in the Intermediate Algebra, College Algebra, and Calculus I sections, and the researcher entered those students' emails into the university Qualtrics program for use with the second survey. Instructors were also asked to make an in-class announcement about the survey, which was intended to make students aware of the survey and how to access the survey, as well as encourage students to participate. A suggested script for the in-class announcement was offered to the instructors as follows:

> There is a research study being done by a mathematics education doctoral student at KU that examines students' experiences and perceptions as mathematics students. You are invited to help by completing a short survey that provides information about you, your own high school math experiences, and your views about being a math student. The survey should take less than 10 minutes. You can find a link to the survey in an email sent to your university email account from "Math Education Study" with a subject of "Invitation to Mathematics Survey August 2018."

The survey remained active for student submissions until the completion of the second week of classes. The survey was closed on September 10, 2018 and no longer accepted submissions.

Group 2: MEPS2 November 2018. The MEPS2 was administered by email invitation through the Qualtrics program three weeks before the last day of classes, on November 14, 2018, the Thursday prior to Thanksgiving break. The email invitation was sent to all of the original 1,844 students, regardless of their enrollment status in a mathematics course. The researcher contacted course instructors in order to remind them of the MEPS2 administration. Instructors were asked to make an announcement about the survey in class, similar to the first announcement encouraging students to participate. In addition to the emailed invitation to complete the survey and the in-class announcement, reminder emails were sent to students who had not yet completed a survey response on Monday, November 19, Monday, November 26, and Monday, December 3. The survey was closed and no longer accepted submissions at the close of Stop Day (December 7, 2018), the day that follows the last day of classes, before final examinations began.

Identifying Participants

Group 1 participants. As of September 10, 2018, the closing date of the MEPS1 survey, there were 407 complete and partially complete responses. Of these, eight students had submitted more than one response. In order to include only one response per student, these duplicate responses were deleted from the sample; the least complete response was removed for two of the duplicates, and the latter of two complete responses was removed for six of the duplicates. Another 34 of the participants did not qualify as a first-time freshman, having graduated from high school before the spring of 2018 and subsequently taking post-secondary courses at either this university or another institution before the summer of 2018. There were 47 participants who did not identify the year of their high school graduation, the year of their first semester at this university, or whether or not they had taken post-secondary courses at another institution after graduating from high school, so their status as a first-time freshman was considered unknown and therefore they were removed from the sample. Of the remaining 318 unique first-time freshmen participants, 19 were not included in the sample due to insufficient participation (less than 50% of the survey items had responses), which left 299 participants for the demographic description and statistical analyses of Group 1.

Group 2 participants. As of December 7, 2018, the closing date of the MEPS2 survey, there were 275 complete and partially complete responses, with no duplicate respondents. A review of the responses revealed that 35 of the respondents did not qualify as a first-time freshman, having graduated from high school before the spring of 2018 and subsequently taking post-secondary courses at either this university or another institution before the summer of 2018. There were 44 respondents who did not identify the year of their high school graduation, the year of their first semester at this university, or whether or not they had taken post-secondary courses at another institution after graduating from high school, so their status as a first-time freshman was considered unknown and therefore they were removed from the sample.

Of the remaining 196 first-time freshmen respondents, eight did not respond to any of the 33 items on the construct subscales, and 12 responded to less than 50% of the items for any of construct subscales. After removing these 20 respondents from the data set, there were 176 participants included in the demographic description and statistical analyses of the MEPS2.

Group 1 and 2 two-time participants. The personally identifiable username was utilized to pair the responses for participants who were in both Groups 1 and 2. Group 1 and Group 2 shared 68 participants. These participants were not only included in the demographic description and statistical analyses of both Groups 1 and 2, but were also described as a separate group of “two-time participants”, and included in the statistical analyses for this separate group.

Analysis

To answer the research questions, the study used a quasi-experimental repeated measures design (Green & Salkind, 2014; Shadish et al., 2002). This section describes the variables included in the study, the preparation of the data for analysis, the descriptive statistics computed, and the statistical analyses completed.

Variables

This study included multiple variables. The independent variables for this study included first-time freshmen’s mathematics course enrollment, high school mathematics course experience, and gender. Mathematics course enrollment was a nominal variable with three groups: Intermediate Algebra, College Algebra, and Calculus I. High school mathematics course experience was a nominal variable with two groups: advanced mathematics (those who had taken at least one course in precalculus, trigonometry, or calculus) and not advanced mathematics (those whose highest level of mathematics course enrollment in high school was Algebra 2, Integrated Math 3, or below). Gender was a nominal variable with two groups: female and male. Although the gender variable included a “Prefer to self-describe” option, there was only a single participant who selected this choice, so “Prefer to self-describe” was not included as a third group.

Students’ mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses were the dependent variables. Each of these variables was measured at two different times using the survey instruments, once at the beginning of the semester and once at the end, which created a repeated measures factor for each of the dependent variables.

Preparing the Data

The survey items that utilized a Likert scale of strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, or strongly agree were recoded into numerical values in order to compute the subscale measures. For all but eight of the items, responses were recoded such that strongly disagree changed to a score of 1, somewhat disagree changed to a score of 2, neither agree nor disagree changed to a score of 3, somewhat agree changed to a score of 4, and strongly agree changed to a score of 5.

Reverse-scaled items. The eight items that had been worded in the opposite direction of the assessed construct were reverse-scaled so that higher values reflected higher levels of the construct, and lower values reflected lower levels of the construct. Items 21, 22, 26, 34, 35, 39, 42, and 47 required reverse-scaling. Appendix C also identifies these items.

Independent variable computation. The independent variable called "advanced mathematics" was created based on participants' responses to which mathematics courses they had taken in high school. Those who identified having taken precalculus, trigonometry, or calculus in high school were marked with "yes" for this variable, and the remaining participants were marked with "no."

Two dummy variables were created for the mathematics course enrollment in order to create dichotomous variables that could be included in a regression analysis as described by Fox (2016). Intermediate Algebra was used as the reference group for both, with College Algebra as the dummy regressor for the first dummy variable, and Calculus I as the dummy regressor for the second.

Subscale measures. The means of each participant's responses to items on the mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies subscales were computed for both the MEPS1 and MEPS2 surveys. If a participant did not respond to at least half the items on a subscale, then that subscale mean was not computed for that participant. It was possible for a participant to have a score for one subscale but not another, depending on that participant's responsiveness to items.

Descriptive Statistics

For both the MEPS1 and the MEPS2, the sample size and frequencies were reported for each demographic variable, as well as for each independent variable. The mean and standard deviation were also reported for mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies for each mathematics course, each group of high school mathematics course experience, and for each gender group. The same information was reported for the subset of Group 1 and Group 2 participants who took both surveys.

The sample size and frequencies were also reported for three items regarding participants' reasoning for taking their current mathematics course, whether or not they planned to take another mathematics course after completing the current semester course, and if so, their reasoning for doing so. Frequencies were tallied for groups overall, and also disaggregated by mathematics course enrollment and gender for each of the fixed response choices as well as additional student-initiated responses for Group 1 participants, Group 2 participants, and the Group 1 and 2 two-time participants. Participants' responses to these three items provided insight into students' mathematical identity and mathematical self-efficacy.

Statistical Analyses

Group 1 analyses. A three-way multivariate analysis of variance was conducted on the MEPS1 sample mean subscale scores of mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses. The multivariate analysis of variance was used to determine whether there were any statistically significant differences in the dependent variables among participants enrolled in different mathematics courses, between those who had taken advanced mathematics courses in high school and those who had not, or between the two gender groups. The multivariate analysis of variance was also used to identify whether or not any linear composite of those dependent variables differed significantly among any of the groups, and whether or not there was an interaction among any of the independent variables to cause a significant difference in one or more dependent variables (Frey, 2015).

Following the statistically significant multivariate analysis of variance, analyses of variance were conducted to see which of the dependent variables had significant difference among subgroups. For each of the analyses of variance that identified a significant difference in a dependent variable, further examination was required to identify which of the independent variable subgroups were significantly different. Pairwise comparisons were conducted for statistically significant analyses of variance for between-subjects variables with two subgroups in order to identify which of the independent variable subgroups was significantly higher or lower than the other subgroup. Post hoc multiple pairwise comparison *t* test analyses using the Bonferroni method were conducted for statistically significant analyses of variance involving the mathematics course enrollment factor to identify which mathematics course enrollment group had significantly higher or lower scores for the dependent variable. Statistical significance was selected to be $\alpha = .05$.

Four multiple linear regression analyses were conducted, one for each of the dependent variables of mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies for mathematics courses. Predictor variables included gender, high school mathematics course experience, and the two dummy variables that were created to represent students' mathematics course enrollment. The regression analyses identified the relative linear contributions of individual predictor variables to each of the dependent variables (Frey, 2016).

Group 2 analyses. Data gathered from the MEPS2 were analyzed in a similar manner to identify relationships between groups. A three-way multivariate analysis of variance was conducted on the MEPS2 sample mean subscale scores of mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses. The multivariate analysis of variance was used to determine whether there were any statistically significant differences in the dependent variable among participants enrolled in different mathematics courses, between those who had taken advanced mathematics courses in high school and those who had not, or between the two gender groups. The multivariate analysis of variance was also used to identify whether or not any linear composite of those dependent variables differed significantly among any of the groups, and whether or not there was an interaction among any of the independent variables to cause a significant difference in one or more dependent variables (Frey, 2015).

Following the marginally significant multivariate analysis of variance, analyses of variance were conducted to see which of the dependent variables had marginally significant differences among subgroups. For each of the analyses of variance that identified a significant difference in a dependent variable, further examination was required to identify which of the independent variable subgroups were different. Pairwise comparisons were conducted for statistically significant analyses of variance for between-subjects variables with two subgroups in order to identify which of the independent variable subgroups was significantly higher or lower than the other subgroup. Post hoc multiple pairwise comparison *t* test analyses using the Bonferroni method were conducted for statistically significant analyses of variance involving the mathematics course enrollment factor to identify which mathematics course enrollment group had significantly higher or lower scores for the dependent variable. Statistical significance was selected to be $\alpha = .05$.

Four multiple linear regression analyses were conducted, one for each of the dependent variables of mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies for mathematics courses. Predictor variables included gender, high school mathematics course experience, and the two dummy variables that were created to represent students' mathematics course enrollment. The regression analyses identified the relative linear contributions of individual predictor variables to each of the dependent variables (Frey, 2015).

Group 1 and 2 repeated measures analyses. Repeated measures analyses of variance were conducted on the subset of MEPS1 and MEPS2 data that included only the participants who took both surveys. One analysis was computed for each of the four constructs. Each repeated measures analysis included the three between-subjects factors of mathematics course enrollment, gender, and high school mathematics course experience, and a within-subjects factor of either mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies measured at two different times (beginning of the semester and end of the semester). The results of the repeated measures analyses were reviewed to determine whether there were any significant differences in mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies for first-time freshmen between the beginning of the semester and the end of the semester, taking into consideration students' mathematics course enrollment, gender, and high school mathematics course experience. Significant results from the repeated measures analyses were followed up with paired-samples *t* tests to determine which independent variable subgroups experienced significant change over the course of the semester. Statistical significance was selected to be $\alpha = .05$.

CHAPTER 4

RESULTS

Introduction

The purpose of this study was to investigate the relationship of first-time college freshmen's mathematics course enrollment, gender, and high school mathematics course experience to their mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses. The study was designed to answer the following research questions:

1. Does mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies differ significantly among first-time freshmen, when considering their mathematics course enrollment, their high school mathematics course experience, or their gender, as measured at the beginning of the semester?
2. Does mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies differ significantly among first-time freshmen, when considering their mathematics course enrollment, their high school mathematics course experience, or their gender, as measured at the end of the semester?
3. What are the relative contributions of mathematics course enrollment, high school mathematics course experience, and gender to mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies?
4. Do first-time freshmen students' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies significantly differ between the beginning of the fall semester and the end of that semester, and do

those differences vary significantly when gender, high school mathematics course experience, and mathematics course enrollment are considered?

This chapter summarizes the results of the data analysis for this study in three sections. The first section includes the results of the quantitative analysis for the Group 1 data gathered at the beginning of the Fall 2018 semester using the MEPS1 survey. The second section includes the results of the quantitative analysis for the Group 2 data gathered at the end of the Fall 2018 semester using the MESP2 survey. The third section includes the results of the quantitative analysis for the subset of participants who completed both the MEPS1 and the MEPS2 during the Fall 2018 semester. Both descriptive and inferential statistical analyses are included in each section. IBM SPSS Statistics for Windows, Version 24.0, was used to analyze the student data.

There were 402 students enrolled in Intermediate Algebra, 950 students enrolled in College Algebra, and 492 students enrolled in Calculus I at the beginning of the Fall 2018 semester. All were invited to participate in both the MEPS1 and MEPS2 surveys by verbal invitations in class, through online announcements in the course learning management system, and by emails delivered to university email accounts from the researcher through the survey administration software.

Group 1: Beginning of Semester

Of the 1,844 students listed on the combined rosters of Intermediate Algebra, College Algebra, and Calculus I, there were 407 student responses to the MEPS1 survey, which was a 22.1% survey response rate. The majority (59.5%) of the responses were students enrolled in College Algebra, and the remaining identifiable responses were split approximately equally between students enrolled in Intermediate Algebra (16.7%) and Calculus I (15.0%). There were additional students (8.8% of the responses) who began the survey but quit before responding to the item identifying the current mathematics course enrollment.

The MEPS1 data were examined and cleaned in preparation for analyses by eliminating duplicate responses, incomplete responses, and responses from students who could not be identified as first-time freshmen. After cleaning, there were 299 responses available for analysis.

Descriptive Statistics

Descriptive statistics were computed for each demographic variable, each independent variable, and MEPS1 items that related to participants' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses. Demographic data is reported in Appendix E. Additionally, items 13, 14a, and 14b gathered data related to participants' mathematical identity and mathematical self-efficacy.

Dependent variable construct subscales. The mean and standard deviation for each of the dependent variables are presented in Table 6 for all participants, as well as for each mathematics course, both groups of high school mathematics course experience, and both gender groups. Values were calculated by computing the mean and standard deviation of participants' subscale mean scores. All subscale items used the same 5-point Likert scale, and the eight negatively-worded items were reverse-scaled. Therefore, mean subscale values close to 1 correspond to a low score on the subscale, and mean values close to 5 correspond to a high score on the subscale.

Table 6

Means and Standard Deviations of MEPS1 Construct Subscale Scores

			Mathematics course enrollment			HS mathematics course experience		Gender	
Subscale	α	Total *n*=293[a]	Int Alg *n*=50	Coll Alg *n*=201	Calc I *n*=42	Not advanced *n*=80	Advanced *n*=213	Male *n*=117	Female *n* =175
Mindset	.72	2.78 (0.67)	2.57 (0.62)	2.77 (0.63)	3.07 (0.85)	2.71 (0.69)	2.80 (0.67)	2.85 (0.73)	2.73 (0.63)
Identity	.90	2.95 (0.97)	2.55 (0.91)	2.87 (0.92)	3.81 (0.74)	2.50 (0.87)	3.12 (0.95)	3.05 (0.92)	2.89 (1.00)
Self-efficacy	.91	3.82 (0.82)	3.93 (0.82)	3.73 (0.81)	4.06 (0.81)	3.51 (0.93)	3.93 (0.74)	3.88 (0.80)	3.77 (0.83)
Self-regulation	.80	3.67 (0.64)	3.82 (0.63)	3.66 (0.65)	3.54 (0.60)	3.63 (0.64)	3.68 (0.65)	3.69 (0.64)	3.66 (0.65)

Note. HS = high school. α = Cronbach's alpha for the subscale. Int Alg = Intermediate Algebra; Coll Alg = College Algebra; Calc I = Calculus I. Mindset = mathematical mindset subscale; Identity = mathematical identity subscale; Self-efficacy = mathematical self-efficacy subscale; Self-regulation = use of self-regulated learning strategies subscale. Standard deviations are given in parentheses below the mean scores.

[a]The total number of participants included in the computations is less than the total number of identified participants due to individuals who did not respond to a minimum number of subscale items.

Students enrolled in Calculus I had higher mathematical mindset, mathematical identity, and mathematical self-efficacy scores than the other two mathematics courses on average, but also identified lower use of self-regulated learning strategies in mathematics courses. The students enrolled in Intermediate Algebra identified the most frequent use of self-regulated learning strategies for mathematics courses on average. Students who had taken advanced mathematics courses in high school were more likely to exhibit higher mathematical mindset, mathematical identity, and mathematical self-efficacy scores as compared to others who had not taken coursework beyond Algebra 2. On average, there was minimal difference in students' use of self-regulated learning strategies for mathematics courses between students who took advanced mathematics courses in high school and those who had not. Males reported higher scores on average for mathematical mindset, mathematical identity, and mathematical self-efficacy compared to females in the study; however, there was little difference in males' and females' reported use of self-regulated learning strategies for mathematics courses.

Items 13, 14a, and 14b. Participants responded with reasons why they chose to enroll in their current mathematics course, whether or not they anticipated taking another mathematics course in the future, and if so, the reasons why. Participants chose one or more responses from a fixed list of options, but were also offered the opportunity to include "another reason" as an open-ended response. Responses to these items are organized by mathematical course enrollment and gender in Table 7 and by course enrollment and high school mathematics course experience in Table 8.

Table 7

Current and Future Mathematics Course Enrollment Rationale for MEPS1 Participants by Mathematics Course Enrollment and Gender

		Intermediate Algebra		College Algebra		Calculus I	
	Total *n*=299[a]	Male *n*=18	Female *n*=33	Male *n*=74	Female *n*=129	Male *n*=27	Female *n*=17
Item 13: Reasons for taking the current mathematics course							
This course was required, or it fills a requirement. [b]	243	14	22	66	109	20	11
This course was recommended by an advisor, parent, or former teacher. [c]	104	6	8	27	47	13	2
This course is a prerequisite for a future course. [d]	99	4	7	21	39	18	9
I was placed into the course by a mathematics placement score.	89	4	17	15	45	3	5
I will need this course for my future career.	81	3	5	14	29	18	11
I really enjoy math or like to be challenged. [e]	49	2	4	4	17	12	10
Another reason: I took this course in high school, and am retaking it to earn credit or get a better grade.	2	0	0	0	1	0	1
Another reason: I don’t know that I can take higher math.	1	0	0	0	0	0	1
Another reason: I needed to start out slow so I can retain as much as I can before I jump into harder math because it’s been a couple years.	1	1	0	0	0	0	0
Item 14a: Expectation for taking a future mathematics course							
Yes, I plan to enroll in another math course before I complete my degree.	226	17	29	54	82	26	17
Item 14b: Reasons for taking a future mathematics course							
Taking an additional math course is required for my degree. [f]	186	13	24	50	59	25	14
I will need more math courses for my future career.	116	7	11	22	45	14	16
I enjoy doing math, and will be able to fulfill KU Core Goals or elective credits with one or more math courses.	45	4	1	6	13	11	9
An additional math course was recommended by my parent(s), instructor, or university advisor.	43	5	5	12	11	6	3
I am good at math.	37	1	2	5	15	7	7
I do not expect to pass this course.	2	0	0	0	2	0	0
Another reason: I want to be challenged.	1	1	0	0	0	0	0

Note. Participants were directed to mark all responses that applied, so more than one response was possible for each participant.

[a]One participant enrolled in Intermediate Algebra identified as neither female nor male, so was not included in the disaggregated counts. [b]Count included the total number of individual participants who marked one or both of the

responses, “It fulfills a requirement (such as the KU Goal 1.2 requirement)” and “I had no choice. I was required to enroll in this course.” [c]Count included the total number of individual participants who marked one or both of the responses, “My advisor recommended that I take it” and “My parent(s) or a former teacher encouraged me to take it.” [d]Count included one participant who included another reason, “Prerequisite for the School of Engineering.” [e]Count included the total number of individual participants who marked one or both of the responses, “I really enjoy math” and “I like to be challenged,” as well as one male Intermediate Algebra participant who included another reason, “I want to enter a mathematics class that really tests my intellect at some point.” [f]Count included one participant who included another reason, “It may be required when I decide on a major,” and a second participant who included, “Math is one of the main subjects I need to study well and understand in my major.”

Table 8

Current and Future Mathematics Course Enrollment Rationale for MEPS1 Participants by Mathematics Course Enrollment and High School Mathematics Course Experience

	Total	Intermediate Algebra		College Algebra		Calculus I	
		No adv math	Adv math	No adv math	Adv math	No adv math	Adv math
	n=299	*n*=20	*n*=32	*n*=60	*n*=143	*n*=3	*n*=41
Item 13: Reasons for taking the current mathematics course							
This course was required, or it fills a requirement. [a]	243	16	21	49	126	1	30
This course was recommended by an advisor, parent, or former teacher. [b]	104	6	9	21	53	2	13
This course is a prerequisite for a future course. [c]	99	7	5	19	41	1	26
I was placed into the course by a mathematics placement score.	89	7	15	13	46	1	7
I will need this course for my future career.	81	4	5	16	27	1	28
I really enjoy math or like to be challenged. [d]	49	3	3	5	16	1	21
Another reason: I took this course in high school, and am retaking it to earn credit or get a better grade.	2	0	0	1	0	0	1
Another reason: I don't know that I can take higher math.	1	0	0	0	0	0	1
Another reason: I needed to start out slow so I can retain as much as I can before I jump into harder math because it's been a couple years.	1	1	0	0	0	0	0
Item 14a: Expectation for taking a future mathematics course							
Yes, I plan to enroll in another math course before I complete my degree.	226	18	29	38	98	3	40
Item 14b: Reasons for taking a future mathematics course							
Taking an additional math course is required for my degree. [e]	186	13	25	32	77	3	36
I will need more math courses for my future career.	116	7	12	15	52	1	29
I enjoy doing math, and will be able to fulfill KU Core Goals or elective credits with one or more math courses.	45	4	2	4	15	0	20
An additional math course was recommended by my parent(s), instructor, or university advisor.	43	4	7	6	17	1	8
I am good at math.	37	1	2	4	16	0	14
I do not expect to pass this course.	2	0	0	0	2	0	0
Another reason: I want to be challenged.	1	1	0	0	0	0	0

Note. Participants were directed to mark all responses that applied, so more than one response was possible for each participant. No adv math = students who had not taken advanced mathematics courses in high school; Adv math = students who had taken advanced mathematics courses in high school.

[a]Count included the total number of individual participants who marked one or both of the responses, “It fulfills a requirement (such as the KU Goal 1.2 requirement)” and “I had no choice. I was required to enroll in this course.” [b]Count included the total number of individual participants who marked one or both of the responses, “My advisor recommended that I take it” and “My parent(s) or a former teacher encouraged me to take it.” [c]Count included one participant who included another reason, “Prerequisite for the School of Engineering.” [d]Count included the total number of individual participants who marked one or both of the responses, “I really enjoy math” and “I like to be challenged,” as well as one male Intermediate Algebra participant who included another reason, “I want to enter a mathematics class that really tests my intellect at some point.” [e]Count included one participant who included another reason, “It may be required when I decide on a major,” and a second participant who included, “Math is one of the main subjects I need to study well and understand in my major.”

Regarding why students had enrolled in a particular mathematics course in Fall 2018, the most common reason cited by participants (73%) was that it fulfilled a requirement such as a university core goal. A third of the students recognized that the course was a prerequisite for a future course. For 30% of the participants, enrollment in the course was due to their score from a placement test or standardized test. Some participants (16%) acknowledged that they really enjoy math or like to be challenged, and that contributed to the reason they enrolled in the course. Two participants, one in College Algebra and one in Calculus I, were retaking the course in order to receive credit or improve a grade, and one participant was taking Intermediate Algebra in order to “start out slow…before I jump into harder math.”

Other than the most common response that the current mathematics course fulfills a degree requirement, Calculus I students tended to respond that they enrolled in their current mathematics course also because it was necessary for their future career (66%) or they enjoy mathematics (45%). Second to taking the course because it fulfilled a degree requirement, Intermediate Algebra and College Algebra students cited they were advised to take the course (35%), or were placed into their class by a mathematics placement score (32%), or responded that they were required to take it and had no choice (31%).

After the most common reason of fulfilling a degree requirement, males most frequently reported that they took their current mathematics course because they were advised to do so

(39%) or because it was a prerequisite for a future course (36%). Females also most commonly cited fulfillment of a degree requirement as a reason, but were also likely to report that they had been placed into a course by a placement score (37%), had been advised to take the course (32%), had no choice (31%), or enrolled because the course was a prerequisite for a future course (31%). About the same proportion of males and females cited taking their current mathematics course because they enjoyed mathematics (15% and 13%, respectively).

For students who had taken advanced mathematics coursework in high school, about three-quarters reported that they took their current mathematics course because it fulfilled a degree requirement, and around a third of the participants reported they had been advised to take the course (34%), enrolled because the course was a prerequisite for a future course (33%), or they had been placed into the course by a mathematics placement score (31%). Similarly, about 70% of those who had not taken advanced mathematics coursework in high school took their current mathematics course because it fulfilled a degree requirement, 35% said they had been advised to take the course, 33% reported that they enrolled because the course was a prerequisite for a future course, and a quarter said that they had been placed into the course by a mathematics placement score. Of those who had not taken advanced mathematics coursework in high school, 10% reported that they enjoyed mathematics or liked to be challenged as opposed to 19% of those who had taken advanced mathematics in high school.

A little over three-quarters of the participants anticipated taking another mathematics course in the future. Most of the Intermediate Algebra and Calculus I students planned to take additional mathematics courses (90% and 98%, respectively), and about two-thirds of the College Algebra students planned to do so as well (67%). The most commonly cited reason for taking additional mathematics courses was that they would be required for an intended degree plan (62%) and secondarily, that more mathematics courses would be required for participants' future careers (39%). Some participants (15%) stated they would take more courses because they were good at mathematics; this included almost a third of the Calculus I students, 10% of the College Algebra students, and 7% of the Intermediate Algebra students. There were two female College Algebra students who had advanced mathematics course experience in high school who reported that they expected to take another mathematics course after this semester because they were concerned about passing the current course.

Statistical Analysis

Several inferential statistical procedures were completed to investigate the relationship of first-time college freshmen's mathematics course enrollment, gender, and high school mathematics course experience to their mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses at the beginning of the semester. These investigations were completed on the data gathered from the four subscale measures in the MEPS1. Assumptions underlying each of the analyses were checked prior to conducting these statistical analyses.

Multivariate analysis of variance. A three-way multivariate analysis of variance was conducted to determine whether any statistically significant relationships existed at the beginning of the semester among first-time freshmen's mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies when considering their mathematics course enrollment, their gender, and whether or not they took high school advanced mathematics courses. The multivariate analysis of variance tested the hypothesis that the means for participants' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies subscale scores were the same across all mathematics courses, across both genders, and across the groups with and without high school advanced mathematics course experience.

Underlying assumptions. Before completing the multivariate analysis of variance, three underlying assumptions were tested (Green & Salkind, 2014): the multivariate normality of the dependent variables across factor groups, the homogeneity of variance across factor groups, and independence of observations. The normality of each of the dependent variables was examined on each level of each of the independent variables using the Shapiro-Wilk test of normality (Ghasemi & Zahediasl, 2012). The test indicated that not all of the subscales were normally distributed across all levels of the factors (α = .01). Statistically significant results indicated that there was some level of non-normality of the mathematical self-efficacy subscale across every factor at every level, and therefore results should be interpreted with caution. The homogeneity of variance across factor groups for each of the dependent variables was checked using Levene's Test of Equality of Variances (α = .01). Levene's Test confirmed the homogeneity of variance of all four subscale measures across all factor levels. Independence among participants was assumed since each participant was associated with only one set of responses for MEPS1 and since no participant was included in more than one group for any of the three independent variables (i.e., no participant is enrolled in more than one of the courses, no participant is both genders, and no participant is in both groups of high school advanced mathematics course experience).

Multivariate analysis of variance results. Statistically significant differences (α = .05) were found for two of the factors, mathematics course enrollment and high school mathematics course experience. For the mathematics course enrollment factor, Wilks's Λ = .920, $F(8,556)$ = 2.96, p < .01. The multivariate η^2 based on Wilks's Λ was .041, suggesting that about 4% of the proportion of variance of the dependent variables could be attributed to which mathematics course a participant was enrolled in at the beginning of the first semester of college.

Participants' high school mathematics course experience also yielded a significant difference, with a Wilks's Λ = .958, $F(4,278) = 3.07$, $p < .05$. The multivariate η^2 was .042, indicating that another 4% of the proportion of variability among the dependent variables could be attributed to participants' experiences taking advanced mathematics courses in high school. No significant effects were indicated for gender groups on any of the dependent variables, and the multivariate analysis of variance did not identify any statistically significant interaction effects.

Following the multivariate analysis of variance, analyses of variance were conducted in order to identify over which of the dependent variables the significant differences of mathematics course enrollment and high school mathematics course experience existed. The tests of between-subjects effects indicated that there were statistically significant differences among students enrolled in different mathematics courses when measuring mathematical identity, with $F(2,281) = 3.34$, $p < .05$, partial $\eta^2 = .02$, indicating that about 2% of the variance in mathematical identity scores can be attributed to participants' mathematics course enrollment. There were also statistically significant differences between those who had taken advanced mathematics courses in high school and those who had not when measuring both mathematical identity and mathematical self-efficacy. For mathematical identity, $F(1,281) = 8.00$, $p < .01$, partial $\eta^2 = .03$, and for mathematical self-efficacy, $F(1,281) = 7.69$, $p < .01$, partial $\eta^2 = .03$. These values suggest that about 3% of the variance in each of the mathematical identity and mathematical self-efficacy subscales can be associated with participants' high school mathematics course experience.

Neither mathematical mindset nor use of self-regulated learning strategies varied significantly across mathematics course enrollment groups nor high school mathematics course experience groups. Since neither gender nor any factor interactions were identified in the multivariate analysis of variance to have significant effects, follow-up analyses of variance for those were not included in the examination of significant differences.

Pairwise comparisons of the estimated marginal means for the high school mathematics course experience groups were examined for both the mathematical identity and mathematical self-efficacy subscales. Post hoc *t* test analyses using the Bonferroni method included conducting multiple pairwise comparisons among the three mathematics course enrollment levels to identify which mathematics course enrollment group had stronger or weaker mathematical identity scores on average. The estimated marginal means and standard deviations for the mathematical identity and mathematical self-efficacy subscales and the two independent variables of interest are shown in Table 9.

Table 9
MEPS1 Dependent Variable Estimated Marginal Means and Standard Deviations for Independent Variable Groups

	Mathematical identity subscale		Mathematical self-efficacy subscale	
	M	*SD*	*M*	*SD*
High school mathematics course experience				
Not advanced	2.58	.20	3.47	.18
Advanced	3.18	.08	4.00	.07
Mathematics course enrollment				
Intermediate Algebra	2.54	.13		
College Algebra	2.77	.07		
Calculus I	3.32	.28		

Note. M = estimated marginal mean; SD = standard deviation.

An examination of the pairwise comparisons of estimated marginal means for students who had taken advanced mathematics in high school and those who had not revealed that those who had taken advanced mathematics courses reported significantly higher mathematical identity and mathematical self-efficacy than those who had not. The estimate marginal mean difference of mathematical identity scores was .60, $p < .01$, and the estimated marginal mean difference of mathematical self-efficacy scores was .53, $p < .01$.

The post hoc multiple pairwise comparisons of the mathematical identity subscale means revealed that the students who were enrolled in Calculus I reported significantly higher mathematical identity scores than did those who were enrolled in Intermediate Algebra, with an estimated marginal mean difference of .776, $p < .01$. There was not a statistically significant difference in mathematical identity scores reported between those enrolled in College Algebra and those enrolled in either Intermediate Algebra or Calculus I.

Multiple linear regression analyses. Multiple linear regression analyses were conducted to evaluate the extent to which mathematics course enrollment, gender, and high school mathematics course experience predicted participants' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies for mathematics courses at the beginning of the semester. Additionally, the analyses identified the relative weight of each of the three predictor variables. Statistical significance was set at $\alpha = .05$.

Predictor variables were coded dichotomously as equal to 0 or 1 for the regression analysis. For gender, males = 0 and females = 1. For the high school mathematics course experience, no advanced mathematics = 0 and advanced mathematics = 1. Since there were three levels, mathematics course enrollment included two dummy variables, with Intermediate Algebra as the reference group = 0, and College Algebra = 1 in one dummy variable and Calculus I = 1 in the second dummy variable.

In order to indicate the relative strength of each of the individual predictor variables for each dependent variable, the bivariate and partial correlations were computed. The partial correlations are the correlations between each predictor and each dependent measure after partialling out the effects of all other predictor variables (Green & Salkind, 2014). Statistically significant partial correlations indicated how much of the variance of an individual dependent variable could be explained by a single predictor variable.

Six hierarchical multiple regression analyses were conducted for each dependent variable. Each analysis included three models; model one included an initial predictor variable, model two added a second predictor variable, and model three included all three predictor variables. Two of the six analyses included mathematics course enrollment as an initial predictor, two included high school mathematics course experience as an initial predictor, and two included gender as an initial predictor. The change in R^2 was computed for each model in order to determine the change in the percent of the variance accounted for when additional predictors were added into the regression equation.

Underlying assumptions. Two underlying assumptions were relevant to the multiple linear regression analysis. The Shapiro-Wilk test of normality indicated that not all of the subscales were normally distributed across all levels of the factors at a significance level $\alpha = .01$. Statistically significant results indicated that there was some level of non-normality of the mathematical self-efficacy subscale across every factor at every level, and therefore results should be interpreted with caution. Independence among participants was assumed since each participant was associated with only one set of responses for the survey and since no participant was included in more than one group for any of the three independent variables.

Mathematical mindset. The linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with mathematical mindset, $F(4,292) = 4.39$, $p < .01$. The sample multiple correlation coefficient was $R = .24$, so $R^2 = .06$, indicating that approximately 6% of the variance of mathematical mindset scores among the participants at the beginning of the semester can be accounted for by the linear combination of independent predictor variables.

Hierarchical multiple regression analyses identified that of the three predictor variables, only mathematics course enrollment contributed significantly to the measure of mathematical mindset. The regression equations that included gender as the only predictor variable, high school mathematics course experience as the only predictor variable, or a linear combination of those two predictor variables were not statistically significant, with R^2 values ranging from .01 to .02, $p > .05$. The mathematics course enrollment variable predicted significantly ($p < .01$) over and above both the high school mathematics course experience variable and the gender variable, with R^2 change ranging from .04 when added into the model last to .05 when added as the second predictor. The regression equation with mathematics course enrollment as the only predictor was statistically significant, with $R^2 = .05$, adjusted $R^2 = .05$, $F(2,294) = 7.98$, $p < .001$, indicating that mathematics course enrollment alone accounted for about 5% of the variance of mathematical mindset scores among the participants.

More specifically, mathematics course enrollment was a statistically significant predictor of mathematical mindset scores when comparing participants' scores in Intermediate Algebra to those enrolled in Calculus I. That mathematics course enrollment factor was twice as influential as the mathematics course enrollment factor comparing participants in Intermediate Algebra to those enrolled in College Algebra. Equation 1 shows the regression equation with mathematics course enrollment as the only included predictor variable.

$$\text{Mathematical mindset} = .14(\text{CollAlg}) + .28(\text{CalcI}) + 2.57 \quad (1)$$

When mathematics course enrollment was the only predictor variable included, the predicted mathematical mindset score for students enrolled in Intermediate Algebra was 2.57, the score for students enrolled in College Algebra was 2.71, and the score for students enrolled in Calculus I was 2.85.

Whether or not a student had taken advanced mathematics in high school had minimal impact on a student's mathematical mindset score, and was not statistically significant. Gender was about twice as influential on mathematical mindset scores as high school mathematics course experience, although still not statistically significant. Gender was negatively correlated to mathematical mindset, indicating that females had lower mathematical mindset scores than males on average. Equation 2 shows the relative contributions of the predictor variables when all three were included.

$$\text{Mathematical mindset} = .13(\text{CollAlg}) + .26(\text{CalcI}) + .03(\text{AdvMath}) - .07(\text{Gender}) + 2.60 \quad (2)$$

According to the model, a male enrolled in Calculus I who had taken advanced mathematics courses in high school was likely to have higher mathematical mindset (predicted score 2.89) as opposed to a female enrolled in Intermediate Algebra who had not taken courses beyond Algebra 2 in high school (predicted score 2.53).

The bivariate and partial correlations are presented in Table 10 and are consistent with the multiple regression results. Two of the bivariate correlations were significant, but only one partial correlation was statistically significant. The mathematics course variable accounting for the difference in scores between students enrolled in Intermediate Algebra and those enrolled in

Calculus I was statistically significant, with partial correlation $R = .20$, so $R^2 = .04$ indicates this predictor variable alone accounted for about 4% of the variance of mathematical mindset scores.

Table 10

MEPS1 Bivariate and Partial Correlations of Predictor Variables with Mathematical Mindset

Predictors	Bivariate correlation between each predictor and mathematical mindset	Partial correlation between each predictor and mathematical mindset
Mathematics course: IntAlg/CollAlg	-.03	.11
Mathematics course: IntAlg/CalcI	.20***	.20***
High school advanced mathematics	-.10	-.07
Gender	.07*	.03

Note. IntAlg/CollAlg = dummy variable of Intermediate Algebra versus College Algebra; IntAlg/CalcI = dummy variable of Intermediate Algebra versus Calculus I.
*$p < .05$. **$p < .01$. ***$p < .001$

Mathematical identity. The linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with mathematical identity, $F(4,292) = 18.10$, $p < .001$. The sample multiple correlation coefficient was $R = .45$, so $R^2 = .199$, indicating that approximately 20% of the variance of mathematical identity scores among the participants at the beginning of the semester can be accounted for by the linear combination of independent predictor variables.

Hierarchical multiple regression analyses identified that two of the three predictor variables, mathematics course enrollment and high school mathematics course experience, contributed significantly to the measure of mathematical identity. The regression equation that included gender as the only predictor variable was not statistically significant, with $R^2 = .01$, adjusted $R^2 = .004$, $p > .05$. The high school mathematics course experience variable predicted significantly ($p < .001$) over and above the gender variable, with R^2 change = .05 when added into the model after gender. The regression equation with high school mathematics course experience as the only predictor was statistically significant, with R^2=.09, adjusted R^2=.08,

$F(1,295) = 27.80$, $p < .001$, indicating that high school mathematics course experience alone accounted for about 8% of the variance of mathematical identity scores among the participants.

The mathematics course enrollment variable predicted mathematical identity significantly ($p < .001$) over and above both the gender and the high school mathematics course experience variables, with R^2 change = .11 when added into the model after high school mathematics course experience, R^2 change = .14 when added into the model after gender, and R^2 change = .10 when added into the model after both. The regression equation with mathematics course enrollment as the only predictor was statistically significant, with R^2=.15, adjusted R^2=.14, $F(2,294) = 25.50$, $p < .001$, indicating that mathematics course enrollment alone accounted for about 14% of the variance of mathematical identity scores among the participants.

More specifically, mathematics course enrollment was a statistically significant predictor of mathematical identity scores when comparing participants' scores in Intermediate Algebra to those enrolled in Calculus I. That mathematics course enrollment factor was almost three times as influential as the mathematics course enrollment factor comparing participants in Intermediate Algebra to those enrolled in College Algebra. Equation 3 shows the regression equation with mathematics course enrollment as the only included predictor variable.

$$\text{Mathematical identity} = .17(\text{CollAlg}) + .46(\text{CalcI}) + 2.53 \quad (3)$$

When mathematics course enrollment was the only predictor variable included, the predicted mathematical identity score for students enrolled in Intermediate Algebra was 2.53, the score for students enrolled in College Algebra was 2.70, and the score for students enrolled in Calculus I was 2.99.

Equation 4 shows the regression equation with high school mathematics course experience as the only included predictor variable.

$$\text{Mathematical identity} = .29(\text{AdvMath}) + 2.49 \tag{4}$$

When high school mathematics course experience was the only predictor variable included, the predicted mathematical identity score for students who had not taken courses beyond Algebra 2 in high school was 2.49 and the score for students who had was 2.78.

Gender was minimally negatively correlated to mathematical identity, indicating that females had lower mathematical identity scores than males on average, although the contribution of gender was not statistically significant. While high school mathematics course experience was a significant contributor to participants' mathematical identity scores, the relative weight of that contribution depended on which mathematics course a participant was enrolled in. It played a larger role in the prediction of mathematical identity for participants enrolled in Intermediate Algebra or College Algebra than it did for participants enrolled in Calculus I. Equation 5 shows the relative contributions of the predictor variables when all three were included.

$$\text{Mathematical identity} = .15(\text{CollAlg}) + .40(\text{CalcI}) + .23(\text{AdvMath}) - .05(\text{Gender}) + 2.28 \tag{5}$$

According to the model, a male enrolled in Calculus I who had taken advanced mathematics courses in high school was likely to have higher mathematical identity (predicted score 2.91) as opposed to a female enrolled in Intermediate Algebra who had not taken coursework beyond Algebra 2 in high school (predicted score 2.23).

The bivariate and partial correlations are presented in Table 11 and are consistent with the multiple regression results. All of the bivariate and partial correlations between the predictor variables and mathematical identity were statistically significant except gender. Partialling out other predictors, mathematics course enrollment (combined R^2 = 0.12) accounted for about 12% of the variance of mathematical identity scores, and high school mathematics course experience (R^2 = .06) accounted for about 6%.

Table 11

MEPS1 Bivariate and Partial Correlations of Predictor Variables with Mathematical Identity

Predictors	Correlation between each predictor and mathematical identity	Partial correlation between each predictor and mathematical identity
Mathematics course: IntAlg/CollAlg	-.11*	.13*
Mathematics course: IntAlg/CalcI	.36***	.32***
High school advanced mathematics	.29***	.24***
Gender	-.09	-.06

Note. IntAlg/CollAlg = dummy variable of Intermediate Algebra versus College Algebra; IntAlg/CalcI = dummy variable of Intermediate Algebra versus Calculus I.
*p < .05. **p < .01. ***p < .001.

Mathematical self-efficacy. The linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with mathematical self-efficacy, $F(4,288) = 5.80$, $p < .001$. The sample multiple correlation coefficient was $R = .27$, so $R^2 = .075$, indicating that approximately 8% of the variance of mathematical self-efficacy scores among the participants at the beginning of the semester can be accounted for by the linear combination of independent predictor variables.

Hierarchical multiple regression analyses identified that of the three predictor variables, only high school mathematics course experience contributed significantly to the measure of mathematical self-efficacy. The regression equation that included gender as the only predictor variable was not statistically significant, with $R^2 = .01$, adjusted $R^2 = .002$, $p > .05$, accounting for almost none of the variance of mathematical self-efficacy scores. The mathematics course enrollment variable did not contribute significantly to any of the mathematical self-efficacy regression equations, although the regression equation with mathematics course enrollment as the only predictor was statistically significant, with R^2=.02, adjusted R^2=.02, $F(2,290) = 3.44$, $p <$ .05, indicating that mathematics course enrollment alone accounted for about 2% of the variance of mathematical self-efficacy scores among the participants.

The high school mathematics course experience variable predicted mathematical self-efficacy significantly ($p < .001$) over and above both the gender and the mathematics course enrollment variables, with R^2 change = .05 when added into the model after mathematics course enrollment, R^2 change = .06 when added into the model after gender, and R^2 change = .05 when added into the model after both. The regression equation with high school mathematics course experience as the only predictor of mathematical self-efficacy scores was statistically significant, with R^2=.05, adjusted R^2=.05, $F(1,291) = 15.62$, $p < .001$, indicating that high school mathematics course experience alone accounted for about 5% of the variance of mathematical self-efficacy scores among the participants.

Equation 6 shows the regression equation with high school mathematics course experience as the only included predictor variable.

$$\text{Mathematical self-efficacy} = .23(\text{AdvMath}) + 3.51 \tag{6}$$

When high school mathematics course experience was the only predictor variable included, the predicted mathematical self-efficacy score for students who had not taken courses beyond Algebra 2 in high school was 3.51 and the score for students who had was 3.74.

Gender was minimally negatively correlated to mathematical self-efficacy, indicating that females had lower mathematical self-efficacy scores than males on average, although the contribution of gender was not statistically significant. Mathematics course enrollment in College Algebra was also negatively correlated with mathematical self-efficacy, as was enrollment in Calculus I, although minimally weighted. Gender played a larger role in the prediction of mathematical self-efficacy scores for students enrolled in Intermediate Algebra or Calculus I. High school mathematics course experience contributed about three times as much weight as gender to the prediction of mathematical self-efficacy. Equation 7 shows the relative contributions of the predictor variables when all three were included.

$$\text{Mathematical self-efficacy} = -.13(\text{CollAlg}) - .01(\text{CalcI}) + .23(\text{AdvMath}) - .08(\text{Gender}) + 3.75 \quad (7)$$

According to the regression equation, a male student enrolled in Intermediate Algebra who had taken advanced mathematics in high school was likely to score higher on mathematical self-efficacy (predicted score 3.98), as opposed to a female student who was enrolled in College Algebra who had not taken courses beyond Algebra 2 in high school (predicted score 3.54).

The bivariate and partial correlations are presented in Table 12 and are consistent with the multiple regression results. All of the bivariate correlations between the predictor variables and mathematical self-efficacy scores were statistically significant except gender. The only predictor with a significant partial correlation with mathematical self-efficacy was high school mathematics course experience, which alone accounted for about 5% of the variability in mathematical self-efficacy scores ($R = .22$, $R^2 = .050$).

Table 12
MEPS1 Bivariate and Partial Correlations of Predictor Variables with Mathematical Self-efficacy

Predictors	Correlation between each predictor and mathematical self-efficacy	Partial correlation between each predictor and mathematical self-efficacy
Mathematics course: IntAlg/CollAlg	-.15**	-.11
Mathematics course: IntAlg/CalcI	.12*	-.01
High school advanced mathematics	.23***	.22***
Gender	-.07	-.08

Note. IntAlg/CollAlg = dummy variable of Intermediate Algebra versus College Algebra; IntAlg/CalcI = dummy variable of Intermediate Algebra versus Calculus I.
**p* < .05. ***p* < .01. ****p* < .001.

Use of self-regulated learning strategies. The linear combination of gender, high school mathematics course experience, and mathematics course enrollment was not significantly associated with the use of self-regulated learning strategies for mathematics courses, $F(4,292)$ =

1.36, p = .25. The sample multiple correlation coefficient was R = .14, so R^2 = .020 indicating that approximately 2% of the variance of scores for use of self-regulated learning strategies among the participants at the beginning of the semester can be accounted for by the linear combination of independent predictor variables.

Hierarchical multiple regression analyses identified that of the three predictor variables, only mathematics course enrollment contributed significantly ($p < .05$) to the measure of use of self-regulated learning strategies when all three variables were included, although the regression equation with mathematics course enrollment as the only predictor was not statistically significant, with R^2=.01, adjusted R^2=.01, $F(2,294) = 1.95$, $p > .05$.

Mathematics course enrollment was only a statistically significant predictor of self-regulated learning strategies use when comparing participants' scores in Intermediate Algebra to those enrolled in Calculus I. That mathematics course enrollment factor was only slightly more influential than the mathematics course enrollment factor comparing participants in Intermediate Algebra to those enrolled in College Algebra. Equation 8 shows the regression equation with mathematics course enrollment as the only included factor.

$$\text{Use of self-regulated learning strategies} = -.12(\text{CollAlg}) - .14(\text{CalcI}) + 3.83 \qquad (8)$$

When mathematics course enrollment was the only predictor variable included, the predicted use of self-regulated learning strategies score for students enrolled in Intermediate Algebra was 3.83, the score for students enrolled in College Algebra was 3.71, and the score for students enrolled in Calculus I was 3.69.

Both gender and mathematics course enrollment were negatively correlated with the use of self-regulated learning strategies scores, indicating that females or students enrolled in College Algebra or Calculus I had lower reported use of self-regulated learning strategies on average. Whether or not students had taken advanced mathematics in high school had almost twice as much influence on students' reported use of self-regulated learning strategies than did gender, although it was not statistically significant. Equation 9 shows the relative contributions of the predictor variables when all three were included.

Self-regulated strategy use = -.13(CollAlg) - .16(CalcI) + .07(AdvMath) - .04(Gender) + 2.60 (9)

According to the model, a male enrolled in Intermediate Algebra who had taken advanced mathematics courses in high school was likely to have higher reported use of self-regulated learning strategies (predicted score 2.67) as opposed to a female enrolled in Calculus I who had not taken courses beyond Algebra 2 in high school (predicted score 2.40).

The bivariate and partial correlations are presented in Table 13 and are consistent with the multiple regression results. None of the bivariate correlations were significant, and only one partial correlation was statistically significant. The mathematics course enrollment factor accounting for the difference in students' reported use of self-regulated learning strategies between students enrolled in Intermediate Algebra and those enrolled in Calculus I was statistically significant, with partial correlation $R = -.12$, so $R^2 = .014$, indicating that this factor accounted for about 1% of the variance of students' reported use of self-regulated learning strategies.

Table 13

MEPS1 Bivariate and Partial Correlations of Predictor Variables with Use of Self-regulated Learning Strategies for Mathematics Coursework

Predictors	Correlation between each predictor and use of self-regulated learning strategies	Partial correlation between each predictor and use of self-regulated learning strategies
Mathematics course: IntAlg/CollAlg	-.04	-.10
Mathematics course: IntAlg/CalcI	-.06	-.12*
High school advanced mathematics	.04	.06
Gender	-.02	-.04

Note. IntAlg/CollAlg = dummy variable of Intermediate Algebra versus College Algebra; IntAlg/CalcI = dummy variable of Intermediate Algebra versus Calculus I.

*$p < .05$.

Group 2: End of Semester

Of the 1,844 students included on the combined rosters of Intermediate Algebra, College Algebra, and Calculus I at the beginning of the semester and invited to participate in the MEPS2 at the end of the semester, there were 275 student responses, which was a 14.9% survey response rate. Students who were enrolled in College Algebra comprised almost half (45%) of the responses, and almost a third (29%) of the responses were from students enrolled in Calculus I. The remaining responses were split approximately equally between students enrolled in Intermediate Algebra (13%) and students who began the survey, but quit (13%) before responding to the item identifying their current mathematics course enrollment.

The MEPS2 data were examined and cleaned in preparation for analyses in a similar fashion to the MEPS1 data by eliminating incomplete responses as well as responses from students who could not be identified as first-time freshmen. After cleaning, there were 176 survey responses available for analysis.

Descriptive Statistics

Descriptive statistics were computed for each demographic variable, each independent variable, and MEPS2 items that related to participants' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses. Demographic data is reported in Appendix E. Additionally, items 13, 14a, and 14b gathered data related to participants' mathematical identity and mathematical self-efficacy.

Dependent variable construct subscales. The mean and standard deviation for each of the dependent variables are presented in Table 14 for all participants, as well as for each mathematics course, both groups of high school mathematics course experience, and both gender groups. Values were calculated by computing the mean and standard deviation of participants' subscale mean scores. All subscale items used the same 5-point Likert scale, and the eight negatively-worded items were reverse-scaled. Therefore, mean subscale values close to 1 correspond to a low score on the subscale, and mean values close to 5 correspond to a high score on the subscale.

Table 14

Means and Standard Deviations of MEPS2 Construct Subscale Scores

			Mathematics course enrollment			HS mathematics course experience		Gender	
Subscale	α	Total *n*=171[a]	Int Alg *n*=23	Coll Alg *n*=87	Calc I *n*=61	Not advanced *n*=37	Advanced *n*=134	Male *n*=66	Female *n* =105
Mindset	.77	2.71 (0.74)	2.46 (0.59)	2.50 (0.67)	3.10 (0.73)	2.45 (0.71)	2.78 (0.73)	2.80 (0.82)	2.65 (0.67)
Identity	.93	3.01 (1.11)	2.57 (1.04)	2.59 (1.08)	3.78 (0.72)	2.47 (1.09)	3.16 (1.07)	3.17 (1.05)	2.92 (1.14)
Self-efficacy	.93	3.43 (1.07)	3.49 (1.21)	3.24 (1.10)	3.69 (0.92)	2.95 (1.05)	3.57 (1.03)	3.51 (0.94)	3.39 (1.14)
Self-regulation	.79	3.50 (0.68)	3.71 (0.86)	3.61 (0.64)	3.27 (0.61)	3.60 (0.69)	3.47 (0.68)	3.34 (0.65)	3.60 (0.68)

Note. HS = high school. α = Cronbach's alpha for the subscale. Int Alg = Intermediate Algebra; Coll Alg = College Algebra; Calc I = Calculus I. Mindset = mathematical mindset subscale; Identity = mathematical identity subscale; Self-efficacy = mathematical self-efficacy subscale; Self-regulation = use of self-regulated learning strategies subscale. Standard deviations are given in parentheses below the mean scores.

[a]The total number of participants included in the computations is less than the total number of identified participants due to individuals who did not respond to a minimum number of subscale items.

Similar to MEPS1 participants, students enrolled in Calculus I had higher mathematical mindset, mathematical identity, and mathematical self-efficacy scores than the other two mathematics courses on average, but also identified lower use of self-regulated learning strategies in mathematics courses. The students enrolled in Intermediate Algebra identified the most frequent use of self-regulated learning strategies for mathematics courses on average. Also similar to MEPS1 participants, students who had taken advanced mathematics courses in high school were more likely to exhibit higher mathematical mindset, mathematical identity, and mathematical self-efficacy scores as compared to others who had not taken coursework beyond

Algebra 2. Students who had not taken advanced mathematics coursework in high school reported that they used self-regulated learning strategies for mathematics courses more often on average than those who had, which differed from the MEPS1 data. Males reported higher scores on average for mathematical mindset, mathematical identity, and mathematical self-efficacy compared to females in the study, but a lower use of self-regulated learning strategies in mathematics courses than females on average.

Items 13, 14a, and 14b. Participants responded with reasons why they chose to enroll in their current mathematics course, whether or not they anticipated taking another mathematics course in the future, and if so, the reasons why. Participants chose one or more responses from a fixed list of options, but were also offered the opportunity to include "another reason" as an open-ended response. Responses to these items are organized by mathematical course enrollment and gender in Table 15 and by course enrollment and high school mathematics course experience in Table 16.

Table 15

Current and Future Mathematics Course Enrollment Rationale for MEPS2 Participants by Mathematics Course Enrollment and Gender

		Intermediate Algebra		College Algebra		Calculus I	
	Total *n*=176	Male *n*=6	Female *n*=18	Male *n*=24	Female *n*=67	Male *n*=37	Female *n*=24
Item 13: Reasons for taking the current mathematics course							
This course was required, or it fills a requirement. [a]	143	5	10	23	58	29	18
This course is a prerequisite for a future course.	61	1	4	6	18	21	11
I was placed into the course by a mathematics placement score. [b]	52	1	13	6	18	7	7
This course was recommended by an advisor, parent, or former teacher. [c]	48	1	2	7	16	12	10
I will need this course for my future career.	45	1	2	1	8	20	13
I really enjoy math or like to be challenged. [d]	27	1	0	2	4	11	9
Another reason: I failed the first time I took it and I wanted to do better.	1	0	0	0	0	0	1
Another reason: I was placed in another class for my high ACT score but I am not confident in my math abilities so I wanted to take the course again.	1	0	0	0	1	0	0
Another reason: Skipping the course was an option due to AP credit but since my major is such a math heavy one I thought it'd be best to retake it and build a stronger foundation.	1	0	0	0	0	1	0
Item 14a: Expectation for taking a future mathematics course							
Yes, I plan to enroll in another math course before I complete my degree.	129	4	16	14	40	34	21
Item 14b: Reasons for taking a future mathematics course							
Taking an additional math course is required for my degree.	115	2	14	14	33	32	20
I will need more math courses for my future career.	60	1	4	5	13	25	12
I am good at math.	23	0	0	0	5	9	9
I enjoy doing math, and will be able to fulfill KU Core Goals or elective credits with one or more math courses.	19	0	2	0	8	8	1
An additional math course was recommended by my parent(s), instructor, or university advisor.	18	1	1	0	5	6	5

I dropped my math course this semester or I do not expect to pass this course. [e]	8	0	2	0	3	2	1

Note. Participants were directed to mark all responses that applied, so more than one response was possible for each participant.
[a]Count included the total number of individual participants who marked one or both of the responses, "It fulfills a requirement (such as the KU Goal 1.2 requirement)" and "I had no choice. I was required to enroll in this course."
[b]Count included one participant who included another reason, "[Name] put me in because I had a 25 on the ACT and the requirement for getting out of this class is 26 but to get into the Architecture School it's a 25 required so I was doomed from the start!" [c]Count included the total number of individual participants who marked one or both of the responses, "My advisor recommended that I take it" and "My parent(s) or a former teacher encouraged me to take it." [d]Count included the total number of individual participants who marked one or both of the responses, "I really enjoy math" and "I like to be challenged," [e]Count included the total number of individual participants who marked one or both of the responses, "I dropped my math course this semester, so I will need to retake a math course" and "I do not expect to pass this course this semester and will need to retake the course."

Table 16

Current and Future Mathematics Course Enrollment Rationale for MEPS2 Participants by Mathematics Course Enrollment and High School Mathematics Course Experience

	Total	Intermediate Algebra		College Algebra		Calculus I	
		No adv math	Adv math	No adv math	Adv math	No adv math	Adv math
	n=176	n=10	n=14	n=28	n=63	n=1	n=60
Item 13: Reasons for taking the current mathematics course							
This course was required, or it fills a requirement. [a]	143	5	10	25	56	1	46
This course is a prerequisite for a future course.	61	1	4	6	18	0	32
I was placed into the course by a mathematics placement score. [b]	52	5	9	3	21	0	14
This course was recommended by an advisor, parent, or former teacher. [c]	48	2	1	4	19	0	22
I will need this course for my future career.	45	1	2	2	7	0	33
I really enjoy math or like to be challenged. [d]	27	1	0	1	5	0	20
Another reason: I failed the first time I took it and I wanted to do better.	1	0	0	0	0	0	1
Another reason: I was placed in another class for my high ACT score but I am not confident in my math abilities so I wanted to take the course again.	1	0	0	0	1	0	0
Another reason: Skipping the course was an option due to AP credit but since my major is such a math heavy one I thought it'd be best to retake it and build a stronger foundation.	1	0	0	0	0	0	1
Item 14a: Expectation for taking a future mathematics course							
Yes, I plan to enroll in another math course before I complete my degree.	129	8	12	15	39	1	54
Item 14b: Reasons for taking a future mathematics course							
Taking an additional math course is required for my degree.	115	6	10	13	34	0	52
I will need more math courses for my future career.	60	3	2	6	12	0	37
I am good at math.	23	0	0	2	3	0	18
I enjoy doing math, and will be able to fulfill KU Core Goals or elective credits with one or more math courses.	19	0	2	3	5	0	9
An additional math course was recommended by my parent(s), instructor, or university advisor.	18	0	2	3	2	0	11

I dropped my math course this semester or I do not expect to pass this course. [e]	8	1	1	0	3	1	2

Note. Participants were directed to mark all responses that applied, so more than one response was possible for each participant. No adv math = students who had not taken advanced mathematics courses in high school; Adv math = students who had taken advanced mathematics courses in high school.
[a]Count included the total number of individual participants who marked one or both of the responses, “It fulfills a requirement (such as the KU Goal 1.2 requirement)” and “I had no choice. I was required to enroll in this course.” [b]Count included one participant who included another reason, “[Name] put me in because I had a 25 on the ACT and the requirement for getting out of this class is 26 but to get into the Architecture School it’s a 25 required so I was doomed from the start!” [c]Count included the total number of individual participants who marked one or both of the responses, “My advisor recommended that I take it” and “My parent(s) or a former teacher encouraged me to take it.” [d]Count included the total number of individual participants who marked one or both of the responses, “I really enjoy math” and “I like to be challenged,” [e]Count included the total number of individual participants who marked one or both of the responses, “I dropped my math course this semester, so I will need to retake a math course” and “I do not expect to pass this course this semester and will need to retake the course.”

The most common reason cited by participants (81%) for having enrolled in a particular mathematics course in Fall 2018 was that it fulfilled a requirement such as a university core goal. About a third (35%) of the students recognized that the course was a prerequisite for a future course. For 30% of the participants, enrollment in the course was due to their score from a placement test or standardized test. About a quarter (27%) of the participants enrolled in the course because of an advisor’s, parent’s, or former teacher’s recommendation, and about the same number (26%) did so because it would be needed for their future career. Some participants (15%) acknowledge that they really enjoy math or like to be challenged, and that contributed to the reason they enrolled in the course. There were three participants who had chosen to retake a mathematics course, one because of having failed it previously, one because of a desire to boost mathematical confidence, and one because of a desire to build a strong mathematical foundation in preparation for a “mathematically heavy” major.

Other than the most common response that the current mathematics course fulfills a degree requirement, Calculus I students tended to respond that they enrolled in their current mathematics course because it was necessary for their future career (54%) or it was a prerequisite for another course (52%). Second to taking the course because it fulfilled a degree requirement, College Algebra students cited they had been placed in the course due to a mathematics placement test score (26%), or it was a prerequisite for another course (26%), or they had been advised to take the course (25%). Intermediate Algebra students reported that they had been placed in the course due to a mathematics placement test score (58%) about as often as they cited having enrolled in the course in order to fulfill a degree requirement (63%). Students in Intermediate Algebra, College Algebra, and Calculus I responded approximately equally that they had no choice but to enroll in a particular course because it was required, with response rates of 42%, 46%, and 46%, respectively.

After the most common reason of fulfilling a degree requirement, males most frequently reported that they took their current mathematics course because it was a prerequisite for a future course (42%) or because it will be needed for their future career (33%). Females also most commonly cited fulfillment of a degree requirement as a reason, but were also likely to report that they had been placed into a course by a mathematics placement exam score (35%) or had enrolled because the course was a prerequisite for a future course (30%). Although it was a less common response, males (21%) reported having enrolled in a mathematics course because they enjoyed mathematics or liked to be challenged more often than did females (12%).

After the most common reason of fulfilling a degree requirement, students who had taken advanced mathematics coursework in high school reported that they had been advised to take the course (39%), enrolled because the course was a prerequisite for a future course (32%), they had been placed into the course by a mathematics placement score (31%), or they needed it for their future career (31%). However, after fulfilling a degree requirement, those who had not taken advanced mathematics coursework in high school took their current mathematics course because it was a prerequisite for a future course (21%), they had been advised to take the course (18%), or they had been placed into the course by a mathematics placement score (15%). Of those who had not taken advanced mathematics coursework in high school, 5% reported that they enjoyed mathematics or liked to be challenged as opposed to 18% of those who had taken advanced mathematics in high school.

Most participants (73%) anticipated taking another mathematics course in the future. Most of the Intermediate Algebra and Calculus I students planned to take additional mathematics courses (83% and 90%, respectively), and over half (59%) of the College Algebra students planned to do so. The most commonly cited reason for taking additional mathematics coursework was that more courses would be required for participants' intended degree (89%) and secondarily, that more mathematics classes would be required for a future career (47%). Some participants stated they would take additional mathematics courses because they are good at mathematics (18%); these numbers included almost a third of the Calculus I students (30%), but only 5% of the College Algebra students, and none of the Intermediate Algebra students. There were eight students who expected to retake their current mathematics course, either because they had dropped it this semester or because they were concerned they were likely to fail it.

Statistical Analysis

Several inferential statistical procedures were completed to investigate the relationship of first-time college freshmen's mathematics course enrollment, gender, and high school mathematics course experience to their mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses at the end of the semester. These investigations were completed on the data gathered from the four subscale measures in the MEPS2. Assumptions underlying each of the analyses were checked prior to conducting these statistical analyses.

Multivariate analysis of variance. A three-way multivariate analysis of variance was conducted to determine whether any statistically significant relationships existed at the end of the semester among first-time freshmen's mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies when considering their mathematics course enrollment, their gender, and whether or not they took high school advanced mathematics courses. The multivariate analysis of variance tested the hypothesis that the means for participants' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies subscale scores were the same across all mathematics courses, across both genders, and across the groups with and without high school advanced mathematics course experience.

Underlying assumptions. Before completing the multivariate analysis of variance, three underlying assumptions were tested (Green & Salkind, 2014): the multivariate normality of the dependent variables across factor groups, the homogeneity of variance across factor groups, and independence of observations. The normality of each of the dependent variables was examined on each level of each of the independent variables using the Shapiro-Wilk test of normality (Ghasemi & Zahediasl, 2012). The test indicated that not all of the subscales were normally distributed across all levels of the factors ($\alpha = .01$). Statistically significant results indicated that there was some level of non-normality of the mathematical identity subscale across College Algebra, Calculus I, females, and advanced mathematics course experience; and non-normality of the mathematical self-efficacy subscale across all three course levels, females, and advanced mathematics course experience. The homogeneity of variance across factor groups for each of the dependent variables was checked using Levene's Test of Equality of Variances (α = .01). Levene's Test confirmed the homogeneity of variance of the mathematical mindset subscale across all factor levels, the mathematical identity across gender and high school mathematics course experience, the mathematical self-efficacy subscale across all factor levels, and the use of self-regulated strategies subscale across all factor levels. However, statistically significant results indicated that there were unequal variances across mathematics course enrollment for the mathematical identity subscale, $F(2,168) = 8.06$, $p < .01$. Due to statistically significant results across some factor groups for both the normality and the homogeneity of variance tests, results should be interpreted with caution. Independence among participants was assumed since each participant was associated with only one set of responses for MEPS2 and since no participant was included in more than one group for any of the three independent variables (i.e., no participant is enrolled in more than one of the courses, no participant is both genders, and no participant is in both groups of high school mathematics experience).

Multivariate analysis of variance results. Statistically significant differences (α = .05) were not found among any of the factors on any of the dependent variables, although mathematics course enrollment showed marginal significance with Wilks's Λ = .908, $F(8,314)$ = 1.95, p = .053. The multivariate η^2 based on Wilks's Λ was .047, suggesting that about 5% of the proportion of variance of the dependent variables could be attributed to which mathematics course a participant was enrolled in at the end of the first semester of college. No significant effects were indicated for gender groups or high school mathematics course experience groups on any of the dependent variables. The multivariate analysis of variance did not indicate there were any statistically significant interaction effects.

Following the multivariate analysis of variance, analyses of variance were conducted in order to identify over which of the dependent variables the marginally significant differences of mathematics course enrollment existed. The tests of between-subjects effects indicated that there were statistically significant differences among students enrolled in different mathematics courses when measuring mathematical identity, with $F(2,160) = 3.78$, $p < .05$ partial $\eta^2 = .045$.

The analyses of variance did not identify any statistically significant differences across the mathematics course enrollment groups for mathematical mindset, mathematical self-efficacy, or the use of self-regulated learning strategies. Since neither gender nor the high school mathematics course experience factor were identified in the multivariate analysis of variance to have significant or marginally significant effects, follow-up analyses of variance for those were not included in the examination of significant differences. No follow-up analyses were conducted for interactions either, given that the results of the multivariate analysis of variance did not show significant interaction effects.

Post hoc analyses using the Bonferroni method included conducting multiple pairwise comparisons among the three mathematics course enrollment levels to identify which specific mathematics course enrollment group had stronger or weaker mathematical identity scores on average. The estimated marginal means and standard deviations for the mathematical identity subscale and mathematics course enrollment variable are shown in Table 17.

Table 17

MEPS2 Mathematical Identity Estimated Marginal Means and Standard Deviations for Mathematics Course Enrollment Groups

	Mathematical identity	
	M	*SD*
Intermediate Algebra	2.61	.23
College Algebra	2.46	.13
Calculus I	3.64	.33

Note. M = estimated marginal mean; SD = standard deviation.

The post hoc multiple pairwise comparisons of the mathematical identity subscale means revealed that the students who were enrolled in Calculus I reported significantly higher mathematical identity scores than the students enrolled in Intermediate Algebra (mean difference = 1.21, $p < .0125$) and those enrolled in College Algebra (mean difference = 1.19, $p < .0125$). There was not a statistically significant difference in mathematical identity scores reported between those enrolled in College Algebra and those enrolled in Intermediate Algebra.

Multiple linear regression analyses. Multiple linear regression analyses were conducted to evaluate the extent to which mathematics course enrollment, gender, and high school mathematics course experience predicted participants' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies for mathematics courses at the end of the semester. Additionally, the analyses identified the relative weight of each of the three predictor variables. Statistical significance was set at $\alpha = .05$.

Predictor variables were coded dichotomously as equal to 0 or 1 for the regression analysis. For gender, males = 0 and females = 1. For the high school mathematics course experience, no advanced mathematics = 0 and advanced mathematics = 1. Since there were three levels, mathematics course enrollment included two dummy variables, with Intermediate Algebra as the reference group = 0, and College Algebra = 1 in one dummy variable and Calculus I = 1 in the second dummy variable.

In order to indicate the relative strength of each of the individual predictor variables for each dependent variable, the bivariate and partial correlations were computed. The partial correlations are the correlations between each predictor and each dependent measure after partialling out the effects of all other predictor variables (Green & Salkind, 2014). Statistically significant partial correlations indicated how much of the variance of an individual dependent variable could be explained by a single predictor variable.

Six hierarchical multiple regression analyses were conducted for each dependent variable. Each analysis included three models; model one included an initial predictor variable, model two added a second predictor variable, and model three included all three predictor variables. Two of the six analyses included mathematics course enrollment as an initial predictor, two included high school mathematics course experience as an initial predictor, and two included gender as an initial predictor. The change in R^2 was computed for each model in order to determine the change in the percent of the variance accounted for when additional predictors were added into the regression equation.

Underlying assumptions. Two underlying assumptions were relevant to the multiple linear regression analysis. The Shapiro-Wilk test of normality indicated that not all of the subscales were normally distributed across all levels of the factors ($\alpha = .01$). Statistically significant results indicated that there was some level of non-normality of the mathematical identity subscale across College Algebra, Calculus I, females, and advanced mathematics; and non-normality of the mathematical self-efficacy subscale across all three courses, females, and advanced mathematics, and therefore results should be interpreted with caution. Independence among participants was assumed since each participant was associated with only one set of responses for the survey and since no participant was included in more than one group for any of the three independent variables.

Mathematical mindset. The linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with mathematical mindset scores, $F(4,171) = 5.99$, $p < .001$. The sample multiple correlation coefficient was R = .35, so R^2 = .12, indicating that about 12% of the variance of mathematical mindset scores among the participants at the end of the semester can be accounted for by the linear combination of independent predictor variables.

Hierarchical multiple regression analyses identified that of the three predictor variables, only mathematics course enrollment contributed significantly to the measure of mathematical mindset. The regression equations that included gender as the only predictor variable, high school mathematics course experience as the only predictor variable, or a linear combination of those two predictor variables were not statistically significant, with R^2 values ranging from .01 to .02, $p > .05$. The mathematics course enrollment variable predicted significantly ($p < .001$) over and above both the high school mathematics variable and the gender variable, with R^2 change ranging from .10 when added into the model last to .12 when added as the second predictor. The regression equation with mathematics course enrollment as the only predictor was statistically significant, with R^2=.12, adjusted R^2=.11, $F(2,173) = 11.82$, $p < .001$, indicating that mathematics course enrollment alone accounted for about 11% of the variance of mathematical mindset scores among the participants.

More specifically, mathematics course enrollment was a statistically significant predictor of mathematical mindset scores when comparing participants' scores in Intermediate Algebra to those enrolled in Calculus I. The mathematics course enrollment factor comparing participants in Intermediate Algebra to those enrolled in College Algebra was minimally influential in the prediction of mathematical mindset. Equation 10 shows the regression equation with mathematics course enrollment as the only included predictor variable.

$$\text{Mathematical mindset} = -.02(\text{CollAlg}) + .34(\text{CalcI}) + 2.56 \tag{10}$$

When mathematics course enrollment was the only predictor variable included, the predicted mathematical mindset score for students enrolled in Intermediate Algebra was 2.56, the score for students enrolled in College Algebra was 2.54, and the score for students enrolled in Calculus I was 2.90.

Whether or not a student had taken advanced mathematics courses in high school had minimal impact on a student's predicted mathematical mindset score, and was not statistically significant. Gender carried twice as much weight as high school mathematics course experience when predicting mathematical mindset scores, but was not statistically significant. Gender was positively correlated to mathematical mindset, indicating that females had higher mathematical mindset scores than males on average. Equation 11 shows the relative contributions of the predictor variables when all three were included.

$$\text{Mathematical mindset} = -.02(\text{CollAlg}) + .35(\text{CalcI}) + .02(\text{AdvMath}) + .05(\text{Gender}) + 2.48 \quad (11)$$

According to the model, a female enrolled in Calculus I who had taken advanced mathematics courses in high school was likely to have higher mathematical mindset (predicted score 2.90) as opposed to a male enrolled in College Algebra who had not taken courses beyond Algebra 2 in high school (predicted score 2.46).

The bivariate and partial correlations are presented in Table 18 and are consistent with the multiple regression results. Three of the bivariate correlations were significant, but only one partial correlation was statistically significant. The mathematics course enrollment factor accounting for the difference in scores between students enrolled in Intermediate Algebra and those enrolled in Calculus I was statistically significant, with partial correlation $R = .22$, so $R^2 = .05$ indicates this predictor variable alone accounted for about 5% of the variance of mathematical mindset scores.

Table 18

MEPS2 Bivariate and Partial Correlations of Predictor Variables with Mathematical Mindset

Predictors	Bivariate correlation between each predictor and mathematical mindset	Partial correlation between each predictor and mathematical mindset
Mathematics course: IntAlg/CollAlg	-.27***	-.01
Mathematics course: IntAlg/CalcI	.35***	.22**
High school advanced mathematics	.14*	.05
Gender	-.07	.02

Note. IntAlg/CollAlg = dummy variable of Intermediate Algebra versus College Algebra; IntAlg/CalcI = dummy variable of Intermediate Algebra versus Calculus I.
*$p < .05$. **$p < .01$. ***$p < .001$

Mathematical identity. The linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with mathematical identity, $F(4,171) = 16.87$, $p < .001$. The sample multiple correlation coefficient was $R = .53$, so $R^2 = .28$, indicating that approximately 28% of the variance of mathematical identity scores among the participants at the end of the semester can be accounted for by the linear combination of independent predictor variables.

Hierarchical multiple regression analyses identified that two of the three predictor variables, mathematics course enrollment and high school mathematics experience, contributed significantly to the measure of mathematical identity. The regression equation that included gender as the only predictor variable was not statistically significant, with $R^2 = .01$, adjusted $R^2 = .007$, $p > .05$. The high school mathematics course experience variable predicted significantly ($p < .01$) over and above the gender variable, with R^2 change = .06 when added into the model after gender, but did not contribute significantly when added into the equation after both gender and mathematics course enrollment, with R^2 change = .01, $p > .05$. The regression equation with high school mathematics course experience as the only predictor was statistically significant, with R^2=.07, adjusted R^2=.06, $F(1,174) = 12.97$, $p < .001$, indicating that high school mathematics course experience alone accounted for about 6% of the variance of mathematical identity scores among the participants.

The mathematics course enrollment variable predicted mathematical identity significantly ($p < .001$) over and above both the gender and the high school mathematics course experience variables, with R^2 change = .21 when added into the model after high school mathematics course experience, R^2 change = .26 when added into the model after gender, and R^2 change = .21 when added into the model after both. The regression equation with mathematics course enrollment as the only predictor was statistically significant, with R^2=.27, adjusted R^2=.26, $F(2,173) = 32.10$, $p < .001$, indicating that mathematics course enrollment alone accounted for about 26% of the variance of mathematical identity scores among the participants.

More specifically, mathematics course enrollment was a statistically significant predictor of mathematical identity scores when comparing participants' scores in Intermediate Algebra to those enrolled in Calculus I. The mathematics course enrollment factor comparing participants in Intermediate Algebra to those enrolled in College Algebra was minimally influential in the prediction of mathematical identity. Equation 12 shows the regression equation with mathematics course enrollment as the only included factor.

$$\text{Mathematical identity} = -.02(\text{CollAlg}) + .50(\text{CalcI}) + 2.60 \qquad (12)$$

When mathematics course enrollment was the only predictor variable included, the predicted mathematical identity score for students enrolled in Intermediate Algebra was 2.60, the score for students enrolled in College Algebra was 2.58, and the score for students enrolled in Calculus I was 3.10.

Equation 13 shows the regression equation with high school mathematics course experience as the only included predictor variable.

$$\text{Mathematical identity} = .26(\text{AdvMath}) + 2.44 \tag{13}$$

When high school mathematics course experience was the only predictor variable included, the predicted mathematical identity score for students who had not taken courses beyond Algebra 2 in high school was 2.44 and the score for students who had was 2.70.

Gender contributed about the same weight to the predicted mathematical identity score as high school mathematics course experience did, although the contribution of gender was not statistically significant. While high school mathematics course experience was a significant contributor to participants' mathematical identity scores, the relative weight of that contribution depended on which mathematics course a participant was enrolled in. It played a larger role for participants enrolled in Calculus I than it did for participants enrolled in Intermediate Algebra or College Algebra. Equation 14 shows the relative contributions of the predictor variables when all three were included.

$$\text{Mathematical identity} = -.03(\text{CollAlg}) + .49(\text{CalcI}) + .09(\text{AdvMath}) + .08(\text{Gender}) + 2.32 \tag{14}$$

According to the equation, a female enrolled in Calculus I who had taken advanced mathematics courses in high school was likely to have higher mathematical identity (predicted score 2.98) as opposed to a male enrolled in College Algebra who had not taken coursework beyond Algebra 2 in high school (predicted score 2.29).

The bivariate and partial correlations are presented in Table 19 and are consistent with the multiple regression results. All of the bivariate correlations between the predictor variables and mathematical identity were statistically significant except gender. The only partial correlation that was significant was the mathematics course enrollment factor accounting for the difference in mathematical identity scores between students enrolled in Intermediate Algebra and those enrolled in Calculus I, with partial correlation $R = .33$ ($R^2 = .11$). Partialling out other predictors, mathematics course enrollment accounted for about 11% of the variance of mathematical identity scores.

Table 19

MEPS2 Bivariate and Partial Correlations of Predictor Variables with Mathematical Identity

Predictors	Correlation between each predictor and mathematical identity	Partial correlation between each predictor and mathematical identity
Mathematics course: IntAlg/CollAlg	-.40***	-.03
Mathematics course: IntAlg/CalcI	.52***	.33***
High school advanced mathematics	.26***	.10
Gender	-.11	.09

Note. IntAlg/CollAlg = dummy variable of Intermediate Algebra versus College Algebra; IntAlg/CalcI = dummy variable of Intermediate Algebra versus Calculus I.
*$p < .05$. **$p < .01$. ***$p < .001$.

Mathematical self-efficacy. The linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with mathematical self-efficacy, $F(4,166) = 3.47$, $p < .01$. The sample multiple correlation coefficient was $R = .28$, so $R^2 = .077$, indicating that approximately 8% of the variance of mathematical self-efficacy scores among the participants at the end of the semester can be accounted for by the linear combination of independent predictor variables.

Hierarchical multiple regression analyses identified that of the three predictor variables, only high school mathematics course experience contributed significantly to the measure of mathematical self-efficacy. The regression equation that included gender as the only predictor variable was not statistically significant, with $R^2 = .003$, adjusted $R^2 = -.003$, $p > .05$, accounting for almost none of the variance of mathematical self-efficacy scores. The mathematics course enrollment variable did not contribute significantly to any of the mathematical self-efficacy regression equations, although the regression equation with mathematics course enrollment as the only predictor was statistically significant, with R^2=.04, adjusted R^2=.03, $F(2,168) = 3.27$, p <

.05, indicating that mathematics course enrollment alone accounted for about 3% of the variance of mathematical self-efficacy scores among the participants.

The high school mathematics course experience variable predicted mathematical self-efficacy significantly ($p < .01$) over and above both the gender and the mathematics course enrollment variables, with R^2 change = .04 when added into the model after mathematics course enrollment, R^2 change = .06 when added into the model after gender, and R^2 change = .04 when added into the model after both. The regression equation with high school mathematics course experience as the only predictor of mathematical self-efficacy scores was statistically significant, with R^2=.06, adjusted R^2=.05, $F(1,169) = 10.38$, $p < .01$, indicating that high school mathematics course experience alone accounted for about 5% of the variance of mathematical self-efficacy scores among the participants.

Equation 15 shows the regression equation with high school mathematics course experience as the only included predictor variable.

$$\text{Mathematical self-efficacy} = .24(\text{AdvMath}) + 2.95 \tag{15}$$

When high school mathematics course experience was the only predictor variable included, the predicted mathematical self-efficacy score for students who had not taken courses beyond Algebra 2 in high school was 2.95 and the score for students who had was 3.19.

Gender contributed minimally to the prediction of mathematical self-efficacy scores, and was not statistically significant. Mathematics course enrollment in College Algebra or Calculus I was negatively correlated with mathematical self-efficacy, with varying weights. High school mathematics course experience contributed more weight to the predicted mathematical self-efficacy score than any other variable. Equation 16 shows the relative contributions of the predictor variables when all three were included.

$$\text{Math self-efficacy} = -.15(\text{CollAlg}) - .01(\text{CalcI}) + .22(\text{AdvMath}) + .01(\text{Gender}) + 3.15 \quad (16)$$

According to the model, a female student enrolled in Intermediate Algebra who had taken advanced mathematics courses in high school was likely to score higher on mathematical self-efficacy (predicted score 3.38), as opposed to a male student who was enrolled in College Algebra who had not taken courses in high school beyond Algebra 2 (predicted score 3.00).

The bivariate and partial correlations are presented in Table 20 and are consistent with the multiple regression results. All of the bivariate correlations between the predictor variables and mathematical self-efficacy scores were statistically significant except gender. The only predictor with a significant partial correlation with mathematical self-efficacy was high school mathematics course experience, which alone accounted for about 4% of the variability in mathematical self-efficacy scores ($R = .20$, $R^2 = .04$).

Table 20

MEPS2 Bivariate and Partial Correlations of Predictor Variables with Mathematical Self-efficacy

Predictors	Correlation between each predictor and mathematical self-efficacy	Partial correlation between each predictor and mathematical self-efficacy
Mathematics course: IntAlg/CollAlg	-.18**	-.10
Mathematics course: IntAlg/CalcI	.18*	-.01
High school advanced mathematics	.24**	.20**
Gender	-.05	.01

Note. IntAlg/CollAlg = dummy variable of Intermediate Algebra versus College Algebra; IntAlg/CalcI = dummy variable of Intermediate Algebra versus Calculus I.
**p* < .05. ***p* < .01. ****p* < .001.

Use of self-regulated learning strategies. The linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with the use of self-regulated learning strategies for mathematics courses, $F(4,171) = 3.79$, $p < .01$. The sample multiple correlation coefficient was $R = .29$, so $R^2 = .08$ indicating that about 8% of the variance of use of self-regulated learning strategies scores among the participants at the end of the semester can be accounted for by the linear combination of independent predictor variables.

Hierarchical multiple regression analyses identified that of the three predictor variables, only mathematics course enrollment contributed significantly ($p < .05$) to the measure of use of self-regulated learning strategies. The regression equation with high school mathematics course experience as the only predictor was not significant, with R^2=.01, adjusted R^2=.003, $F(1,174)$ = 1.544, $p > .05$, indicating that high school mathematics course experience accounted for little to none of the variance of use of self-regulated learning strategies scores among the participants. Gender significantly predicted use of self-regulated learning strategies scores only when entered into the regression equation without the mathematics course enrollment factor. The regression equation that included gender as the only predictor variable was statistically significant, with R^2 = .04, adjusted R^2 = .03, $p < .01$, accounting for about 3% of the variance of use of self-regulated learning strategies scores.

In all equations, the mathematics course enrollment variable predicted use of self-regulated learning strategies scores significantly ($p < .05$) over and above both the high school mathematics course experience and gender variables, with R^2 change = .06 when added into the model after the high school mathematics course experience variable, R^2 change = .04 when added into the model after the gender variable, and R^2 change = .04 when added into the model after both. The regression equation with mathematics course enrollment as the only predictor was statistically significant, with R^2=.07, adjusted R^2=.06, $F(2,173)$ = 6.33, $p < .01$, indicating that mathematics course enrollment alone accounted for about 6% of the variance of use of self-regulated learning strategies scores among the participants.

Mathematics course enrollment was a statistically significant predictor of use of self-regulated learning strategies scores when comparing participants' scores in Intermediate Algebra to those enrolled in Calculus I. The mathematics course enrollment factor comparing participants in Intermediate Algebra to those enrolled in College Algebra was minimally influential in the prediction of a participant's use of self-regulated learning strategies scores. Equation 17 shows the regression equation with mathematics course enrollment as the only included predictor variable.

$$\text{Use of self-regulated learning strategies} = -.06(\text{CollAlg}) - .30(\text{CalcI}) + 3.70 \tag{17}$$

When mathematics course enrollment was the only predictor variable included, the predicted use of self-regulated learning strategies score for students enrolled in Intermediate Algebra was 3.70, the score for students enrolled in College Algebra was 3.64, and the score for students enrolled in Calculus I was 3.40.

Mathematics course enrollment was negatively correlated with the use of self-regulated learning strategies scores, indicating that students enrolled in College Algebra and Calculus I had lower reported use of self-regulated learning strategies on average compared to Intermediate Algebra students. Whether or not students had taken advanced mathematics in high school had minimal influence on students' predicted use of self-regulated learning strategies scores. Equation 18 shows the relative contributions of the predictor variables when all three were included.

$$\text{Self-reg strategy use} = -.06(\text{CollAlg}) - .26(\text{CalcI}) + .01(\text{AdvMath}) + .12(\text{Gender}) + 3.56 \tag{18}$$

According to the model, a female enrolled in Intermediate Algebra who had taken advanced mathematics courses in high school was likely to have higher reported use of self-regulated learning strategies (predicted score 3.69) as opposed to a male enrolled in Calculus I who had not taken courses beyond Algebra 2 in high school (predicted score 3.30).

The bivariate and partial correlations are presented in Table 21 and are consistent with the multiple regression results. All of the bivariate correlations were significant except for high school mathematics course experience, but only one partial correlation was statistically significant. The mathematics course enrollment factor accounting for the difference in students' reported use of self-regulated learning strategies between students enrolled in Intermediate Algebra and those enrolled in Calculus I was statistically significant, with partial correlation R = -.17, so $R^2 = .03$, indicating that this predictor accounts for about 3% of the variance of students' use of self-regulated learning strategies scores.

Table 21
MEPS2 Bivariate and Partial Correlations of Predictor Variables with Use of Self-regulated Learning Strategies for Mathematics Coursework

Predictors	Correlation between each predictor and use of self-regulated learning strategies	Partial correlation between each predictor and use of self-regulated learning strategies
Mathematics course: IntAlg/CollAlg	.17*	-.04
Mathematics course: IntAlg/CalcI	-.26***	-.17*
High school advanced mathematics	-.09	.01
Gender	.20**	.12

*p < .05. **p < .01. ***p < .001.

Groups 1 and 2: Two-Time Participants

Of the 299 participants in Group 1 and the 176 participants in Group 2, there were 68 first-time freshmen who completed both the MEPS1 and MEPS2. The majority (60%) of these two-time participants were students enrolled in College Algebra, and the remaining participants were split approximately equally between students enrolled in Intermediate Algebra (18%) and Calculus I (22%).

Descriptive Statistics

Descriptive statistics were computed for each demographic variable, each independent variable, and MEPS1 and MEPS2 items that related to the two-time participants' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses. Demographic data is reported in Appendix E. The data gathered from the two-time participants in response to items 13, 14a, and 14b were compiled.

Dependent variable construct subscales. The mean and standard deviation for each of the dependent variables are presented for all participants and for each mathematics course (Table 22), for both groups of high school mathematics course experience (Table 23), and for each gender group (Table 24). Values were calculated by computing the mean and standard deviation of participants' subscale mean scores. All subscale items used the same 5-point Likert scale, and the eight negatively-worded items were reverse-scaled. Therefore, mean subscale values close to 1 correspond to a low score on the subscale, and mean values close to 5 correspond to a high score on the subscale.

Table 22

Means and Standard Deviations of Two-time Participants' MEPS1 and MEPS2 Construct Subscale Scores by Mathematics Course Enrollment

	α		Total *n* = 68		Mathematics course enrollment Intermediate Algebra *n* = 12		College Algebra *n* = 41		Calculus I *n* = 15	
Subscale	MEPS1	MEPS2	MEPS1	MEPS2	MEPS1	MEPS2	MEPS1	MEPS2	MEPS1	MEPS2
Mindset	.73	.75	2.83 (0.71)	2.74 (0.79)	2.75 (0.80)	2.72 (0.97)	2.77 (0.61)	2.61 (0.63)	3.07 (0.88)	3.11 (0.95)
Identity	.93	.95	2.93 (1.10)	2.95 (1.17)	2.42 (1.08)	2.43 (1.17)	2.69 (1.00)	2.83 (1.13)	4.01 (0.66)	3.70 (0.96)
Self-efficacy	.92	.94	3.86 (0.83)	3.48 (1.11)	4.17 (0.43)	3.19[a] (1.33)	3.62 (0.85)	3.43[b] (1.06)	4.25 (0.80)	3.82 (1.04)
Self-regulation	.75	.79	3.58 (0.59)	3.53 (0.68)	3.68 (0.49)	3.54 (0.70)	3.54 (0.60)	3.60 (0.69)	3.59 (0.64)	3.30 (0.61)

Note. α = Cronbach's alpha for the subscale. Mindset = mathematical mindset subscale; Identity = mathematical identity subscale; Self-efficacy = mathematical self-efficacy subscale; Self-regulation = use of self-regulated learning strategies subscale. Standard deviations are given in parentheses below the mean scores.
[a]One participant did not respond to a minimum number of subscale items, so *n* = 11 for this subgroup. [b]Two participants did not respond to a minimum number of subscale items, so *n* = 39 for this subgroup.

The two-time participants enrolled in Calculus I had higher mathematical mindset, mathematical identity, and mathematical self-efficacy scores than the other two mathematics courses on average for both the MEPS1 and MEPS2, but identified lower use of self-regulated learning strategies in mathematics courses than Intermediate Algebra participants on the MEPS1, and both Intermediate Algebra and College Algebra participants on the MEPS2. The two-time participants enrolled in Intermediate Algebra and College Algebra reported declining mathematical mindset scores on average over the course of the semester whereas those enrolled in Calculus I reported improved scores. Mathematical identity scores decreased for Calculus I two-time participants but not for those in Intermediate Algebra or College Algebra. On average, mathematical self-efficacy scores dropped for all students, with the largest decrease for those enrolled in Intermediate Algebra, and the smallest decrease for those enrolled in College Algebra. Students' reported use of self-regulated learning strategies decreased on average for two-time participants in Intermediate Algebra and Calculus I, but increased for those in College

Algebra. Overall, mathematical identity scores and reported use of self-regulated learning strategies stayed about the same on average for the group of two-time participants over the semester, whereas mathematical mindset scores decreased some and mathematical self-efficacy scores decreased more.

Table 23

Means and Standard Deviations of Two-time Participants' MEPS1 and MEPS2 Construct Subscale Scores by High School Mathematics Course Experience

	α		Total n = 68		HS mathematics course experience			
					Not advanced mathematics n = 15		Advanced mathematics n = 53	
Subscale	MEPS1	MEPS2	MEPS1	MEPS2	MEPS1	MEPS2	MEPS1	MEPS2
Mindset	.73	.75	2.83 (0.71)	2.74 (0.79)	2.80 (0.80)	2.54 (0.76)	2.84 (0.69)	2.79 (0.80)
Identity	.93	.95	2.93 (1.10)	2.95 (1.17)	2.52 (1.00)	2.52 (1.09)	3.05 (1.12)	3.08 (1.17)
Self-efficacy	.92	.94	3.86 (0.83)	3.48 (1.11)	3.53 (1.02)	3.05 [a] (0.98)	3.95 (0.75)	3.60 [b] (1.12)
Self-regulation	.75	.79	3.58 (0.59)	3.53 (0.68)	3.47 (0.55)	3.63 (0.68)	3.61 (0.60)	3.50 (0.68)

Note. α = Cronbach's alpha for the subscale. HS = high school; Mindset = mathematical mindset subscale; Identity = mathematical identity subscale; Self-efficacy = mathematical self-efficacy subscale; Self-regulation = use of self-regulated learning strategies subscale. Standard deviations are given in parentheses below the mean scores.
[a]One participant did not respond to a minimum number of subscale items, so n = 14 for this subgroup. [b]Two participants did not respond to a minimum number of subscale items, so n = 51 for this subgroup.

The two-time participants who had taken advanced mathematics courses in high school had higher mathematical mindset, mathematical identity, and mathematical self-efficacy scores on average than those who had not for both the MEPS1 and MEPS2, but identified a more frequent use of self-regulated learning strategies in mathematics courses on the MEPS1, and less frequent use on the MEPS2. Mathematical mindset scores for two-time participants with advanced mathematics course experience decreased some over the course of the semester, but those without advanced mathematics course experience demonstrated a larger decrease on average. Mathematical identity scores did not change substantially from the beginning to the end of the semester for either group, with students who had taken advanced mathematics courses in high school consistently reporting higher scores on average than those who had not. On average, two-time participants who had not taken advanced mathematics courses in high school reported increased use of self-regulated learning strategies over the course of the semester and those with advanced mathematics course experience reported decreased use of self-regulated learning strategies. Self-efficacy scores decreased markedly for both subgroups on average.

Table 24
Means and Standard Deviations of Two-time Participants' MEPS1 and MEPS2 Construct Subscale Scores by Gender

	α		Total *n* = 68		Gender: Male *n* = 20		Gender: Female *n* = 48	
Subscale	MEPS1	MEPS2	MEPS1	MEPS2	MEPS1	MEPS2	MEPS1	MEPS2
Mindset	.73	.75	2.83 (0.71)	2.74 (0.79)	2.99 (0.82)	2.86 (0.99)	2.76 (0.65)	2.69 (0.69)
Identity	.93	.95	2.93 (1.10)	2.95 (1.17)	3.37 (1.09)	3.17 (1.09)	2.75 (1.07)	2.86 (1.20)
Self-efficacy	.92	.94	3.86 (0.83)	3.48 (1.11)	4.10 (0.77)	3.72 [a] (0.95)	3.75 (0.84)	3.39 [b] (1.16)
Self-regulation	.75	.79	3.58 (0.59)	3.53 (0.68)	3.50 (0.54)	3.33 (0.57)	3.61 (0.61)	3.61 (0.71)

Note. α = Cronbach's alpha for the subscale. Mindset = mathematical mindset subscale; Identity = mathematical identity subscale; Self-efficacy = mathematical self-efficacy subscale; Self-regulation = use of self-regulated learning strategies subscale. Standard deviations are given in parentheses below the mean scores.
[a]One participant did not respond to a minimum number of subscale items, so $n = 19$ for this subgroup. [b]Two participants did not respond to a minimum number of subscale items, so $n = 46$ for this subgroup.

Male two-time participants had higher mathematical mindset, mathematical identity, and mathematical self-efficacy scores on average than females for both the MEPS1 and MEPS2, but identified less frequent use of self-regulated learning strategies in mathematics courses. Over the course of the semester, males had decreased scores in mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies on average. Female two-time participants had increased scores in mathematical identity, reported similar scores for the use of self-regulated learning strategies, and had decreased scores in both mathematical mindset and mathematics self-efficacy on average. Both males and females experienced a similarly large drop in mathematical self-efficacy scores from the beginning of the semester to the end on average.

Items 13, 14a, and 14b. The two-time participants' reasons why they chose to enroll in their current mathematics course, whether or not they anticipated taking another mathematics course in the future, and if so, the reasons why were compiled. The responses from the two-time participants are organized by mathematical course enrollment and gender in Table 25 and by course enrollment and high school mathematics course experience in Table 26. The data reported for Item 13 were from the MEPS1 survey, and the data reported for Items 14a and 14b were from the MEPS2 survey.

Table 25

Current and Future Mathematics Course Enrollment Rationale for Two-Time Participants by Mathematics Course Enrollment and Gender

		Intermediate Algebra		College Algebra		Calculus I	
	Total	Male	Female	Male	Female	Male	Female
	n = 68[a]	*n* = 3	*n* = 8 [a] *n* = 9	*n* = 9	*n* = 32	*n* = 8	*n* = 7
Item 13: Reasons for taking the current mathematics course [b]							
This course was required, or it fills a requirement. [c]	55	3	6	7	26	8	4
This course was recommended by an advisor, parent, or former teacher. [d]	26	2	3	3	13	3	1
This course is a prerequisite for a future course.	25	1	1	2	10	5	5
I was placed into the course by a mathematics placement score.	23	0	5	2	11	2	2
I will need this course for my future career.	19	1	0	2	7	5	3
I really enjoy math or like to be challenged. [e]	14	1	2	1	3	4	3
Another reason: I took this course in high school, and am retaking it to earn credit.	1	0	0	0	0	0	1
Item 14a: Expectation for taking a future mathematics course [f]							
Yes, I plan to enroll in another math course before I complete my degree.	50	2	9	7	19	8	5
Item 14b: Reasons for taking a future mathematics course [f]							
Taking an additional math course is required for my degree.	47	1	9	7	17	8	5
I will need more math courses for my future career.	25	1	3	3	9	6	3
I enjoy doing math, and will be able to fulfill KU Core Goals or elective credits with one or more math courses.	10	0	1	0	5	4	0
I am good at math.	7	0	0	0	3	4	0
An additional math course was recommended by my parent(s), instructor, or university advisor.	4	0	0	0	3	1	0
I dropped my math course this semester or I do not expect to pass this course. [g]	2	0	1	0	0	1	0

Note. Participants were directed to mark all responses that applied, so more than one response was possible for each participant.

[a]One participant enrolled in Intermediate Algebra identified as neither female nor male for MEPS1, so was not included in the disaggregated counts for MEPS1. This participant identified as female for MEPS2, so was included in the disaggregated counts for MEPS2. [b]The data reported for Item 13 were from the MEPS1 survey. [c]Count included the total number of individual participants who marked one or both of the responses, "It fulfills a requirement (such as the KU Goal 1.2 requirement)" and "I had no choice. I was required to enroll in this course." [d]Count included the total number of individual participants who marked one or both of the responses, "My advisor recommended that I take it" and "My parent(s) or a former teacher encouraged me to take it." [e]Count included the

total number of individual participants who marked one or both of the responses, “I really enjoy math” and “I like to be challenged,” as well as one male Intermediate Algebra participant who included another reason, “I want to enter a mathematics class that really tests my intellect at some point.” [f]The data reported for Items 14a and 14b were from the MEPS2 survey. [g]Count included the total number of individual participants who marked one or both of the responses, “I dropped my math course this semester, so I will need to retake a math course” and “I do not expect to pass this course this semester and will need to retake the course.”

Table 26

Current and Future Mathematics Course Enrollment Rationale for Two-Time Participants by Mathematics Course Enrollment and High School Mathematics Course Experience

	Total	Intermediate Algebra		College Algebra		Calculus I	
		No adv math	Adv math	No adv math	Adv math	No adv math	Adv math
	n = 68	*n* = 5	*n* = 7	*n* = 10	*n* = 31	*n* = 0	*n* = 15
Item 13: Reasons for taking the current mathematics course [a]							
This course was required, or it fills a requirement. [b]	55	5	5	7	26	0	12
This course was recommended by an advisor, parent, or former teacher. [c]	26	3	3	6	10	0	4
This course is a prerequisite for a future course.	25	2	1	2	10	0	10
I was placed into the course by a mathematics placement score.	23	3	3	2	11	0	4
I will need this course for my future career.	19	2	0	4	5	0	8
I really enjoy math or like to be challenged. [d]	14	2	1	1	3	0	7
Another reason: I took this course in high school, and am retaking it to earn credit.	1	0	0	0	0	0	1
Item 14a: Expectation for taking a future mathematics course [e]							
Yes, I plan to enroll in another math course before I complete my degree.	50	4	7	6	20	0	13
Item 14b: Reasons for taking a future mathematics course [e]							
Taking an additional math course is required for my degree.	47	3	7	6	18	0	13
I will need more math courses for my future career.	25	2	2	4	8	0	9
I enjoy doing math, and will be able to fulfill KU Core Goals or elective credits with one or more math courses.	10	0	1	0	5	0	4
I am good at math.	5	0	0	0	3	0	4
An additional math course was recommended by my parent(s), instructor, or university advisor.	4	0	0	2	1	0	1
I dropped my math course this semester or I do not expect to pass this course. [f]	2	1	0	0	0	0	1

Note. Participants were directed to mark all responses that applied, so more than one response was possible for each participant. No adv math = students who had not taken advanced mathematics courses in high school; Adv math = students who had taken advanced mathematics courses in high school.

[a]The data reported for Item 13 were from the MEPS1 survey. [b]Count included the total number of individual participants who marked one or both of the responses, "It fulfills a requirement (such as the KU Goal 1.2 requirement)" and "I had no choice. I was required to enroll in this course." [c]Count included the total number of individual participants who marked one or both of the responses, "My advisor recommended that I take it" and "My parent(s) or a former teacher encouraged me to take it." [d]Count included the total number of individual participants who marked one or both of the responses, "I really enjoy math" and "I like to be challenged," as well as one male

Intermediate Algebra participant who included another reason, "I want to enter a mathematics class that really tests my intellect at some point." [e]The data reported for Items 14a and 14b were from the MEPS2 survey. [f]Count included the total number of individual participants who marked one or both of the responses, "I dropped my math course this semester, so I will need to retake a math course" and "I do not expect to pass this course this semester and will need to retake the course."

Regarding why two-time participants had enrolled in a particular mathematics course in Fall 2018, the most common reason cited by Calculus I students (80%) was that they had no choice but to enroll in a particular course because it was required, followed by 67% citing that it fulfilled a requirement such as a university core goal. For College Algebra students, 78% said that it fulfilled a requirement, and 41% said they had no choice. For Intermediate Algebra students, responses were equal (33% and 33%) for those two reasons. The recommendation to take a particular course by a parent, teacher, or advisor influenced about 38% of the two-time participants. Just over a third (35%) recognized that the course was a prerequisite for a future course and about the same number (34%) reported that their enrollment in the course was due to their score from a placement test or standardized test. One two-time participant in Calculus I was retaking the course in order to receive credit. About a third of students (34%) who had taken advanced mathematics courses in high school said they had enrolled in the course because of a placement test score, and about a fifth (21%) of those students said they enrolled because they enjoyed mathematics or liked to be challenged. The numbers were about the same for students who had not taken advanced mathematics courses in high school (33% and 20%, respectively).

About three-quarters of the two-time participants (74%) anticipated taking another mathematics course in the future. Most of the Intermediate Algebra and Calculus I students planned to take additional mathematics courses (92% and 87%, respectively), and almost two-thirds of the College Algebra students planned to do so as well (63%). The most commonly cited reason for taking additional mathematics courses among the two-time participants was that more mathematics courses would be required for an intended degree plan (94%) and secondarily, that more mathematics courses would be required for participants' future careers (50%). Two students reported that they expected to retake the mathematics course they had enrolled in; one female Intermediate Algebra student had dropped her course and one male Calculus I student did not expect to pass his course that semester. None of the students who had not taken advanced mathematics courses in high school said they would take an additional mathematics course because they were good at math, whereas 13% of those who had taken advanced mathematics courses in high school chose this response.

Statistical Analysis Using Repeated Measures Analysis of Variance

Several statistical investigations were conducted on the data gathered from the four subscale measures on both the MEPS1 and MEPS2 for the 68 two-time participants. Repeated measures analyses of variance were conducted for all four of the dependent variables. Significant results from the repeated measures analyses were followed up with paired-samples *t* tests to determine which independent variable subgroups experienced significant change over the course of the semester. Due to the limited number of two-time participants ($n = 68$), paired-samples *t* tests were selected as the statistical analysis method to evaluate the differences in mean scores of subgroups. Underlying assumptions were checked prior to conducting these statistical analyses.

Four repeated measures analyses of variance were conducted to investigate the differences among first-time freshmen's mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses from the beginning of the semester to the end. The analyses tested the hypothesis that the means for two-time participants' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies subscale scores were the same at the two measurement time periods. Each repeated measures analysis included the three between-subjects factors of mathematics course enrollment, gender, and high school mathematics course experience, and a within-subjects factor of either mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies measured at two different times (beginning of the semester and end of the semester).

Underlying assumptions. Before completing the repeated measures analyses of variance, two underlying assumptions were tested for each analysis (Green & Salkind, 2014): the normality of each difference score for each within-subjects factor and the independence of observations. The normality of each difference score was examined by computing a difference variable (scores from the MEPS2 were subtracted from the MEPS1 on those subscale items), then the difference variables were examined for normality using the Shapiro-Wilk test of normality (Ghasemi & Zahediasl, 2012). The test indicated that not all of the subscales were normally distributed across all levels of the factors at a significance level .01. Statistically significant results indicated that there was a non-normal distribution of the mathematical identity repeated measures factor. A review of the difference variables showed that the distributions were not substantially nonnormal, however, results should be interpreted with caution. Independence among participants was assumed since each participant was associated with only one set of responses for each survey.

Repeated measures analyses of variance results. A statistically significant difference ($\alpha = .05$) was found for the time effect for mathematical self-efficacy scores for the two-time participants, but not for any of the other dependent variables tested. The repeated measures analysis of variance for mathematical self-efficacy computed a Wilks's $\Lambda = .904$, $F(1,64) = 6.79$,

$p < .05$. The multivariate η^2 based on Wilks's Λ was .096, indicating that about 10% of the variance in mathematical self-efficacy scores for the two-time participants could be accounted for by the factor of time. The mean scores of mathematical self-efficacy at the beginning of the semester were significantly greater than those at the end of the semester. The means and standard deviations for all four of the dependent variables are presented in Table 27.

Table 27
Means, Standard Deviations, and Differences of Means of Two-time Participants' Construct Subscale Scores

	MEPS1		MEPS2		MEPS1 – MEPS2	
	M	*SD*	*M*	*SD*	*M*	*SD*
Mindset	2.83	.71	2.74	.79	.09	.08
Identity	2.93	1.10	2.95	1.17	-.02	.10
Self-efficacy	3.86	.83	3.48	1.11	.37*	.14
Self-regulation	3.58	.59	3.53	.68	.05	.07

Note. Mindset = mathematical mindset subscale; Identity = mathematical identity subscale; Self-efficacy = mathematical self-efficacy subscale; Self-regulation = use of self-regulated learning strategies subscale.
*$p < .05$

Paired-samples *t* tests results. Paired-samples *t* tests were conducted as follow-up tests to the repeated measures analysis of variance for mathematical self-efficacy in order to identify which of the independent variable subgroups had significantly different scores from the beginning of the semester to the end. The results of the paired-samples *t* tests are shown in Table 28.

Table 28

Two-time Participants' Paired Differences of MEPS1 and MEPS2 Mathematical Self-Efficacy Scores Across Subgroups

		MEPS1 (time 1)		MEPS2 (time 2)		MEPS1 – MEPS2			95% CI		
	n	*M*	*SD*	*M*	*SD*	*M*	*SD*	*t*	*LL*	*UL*	*d*
Mathematics course enrollment											
Intermediate Algebra	11	4.13	.43	3.19	1.33	.94	1.14	2.73*	.17	1.70	.82
College Algebra	39	3.62	.88	3.43	1.06	.18	1.20	.94	-.21	.57	.15
Calculus I	15	4.25	.80	3.82	1.04	.43	.81	2.06	-.02	.88	.53
High school mathematics course experience											
Not advanced mathematics	14	3.51	1.05	3.05	.98	.46	.97	1.76	-.10	1.02	.47
Advanced mathematics	51	3.94	.76	3.60	1.12	.34	1.18	2.06*	.01	.67	.29
Gender											
Male	19	4.13	.78	3.72	.95	.41	.57	3.14**	.14	.69	.72
Female	46	3.73	.84	3.39	1.16	.35	1.30	1.81	-.04	.73	.27

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit; *d* = Cohen's *d.*
$^*p < .05$ $^{**}p < .01$

There were three subgroups who had a statistically significant decrease in mathematical self-efficacy over the course of the semester. The two-time participants enrolled in Intermediate Algebra had the largest mean difference of self-efficacy scores from the beginning to the end of the semester, with mean difference = .94, standard deviation = 1.14, $t(10) = 2.73$, $p < .05$. The distributions of Intermediate Algebra two-time participants' mean self-efficacy scores for the two surveys are shown in Figure 1.

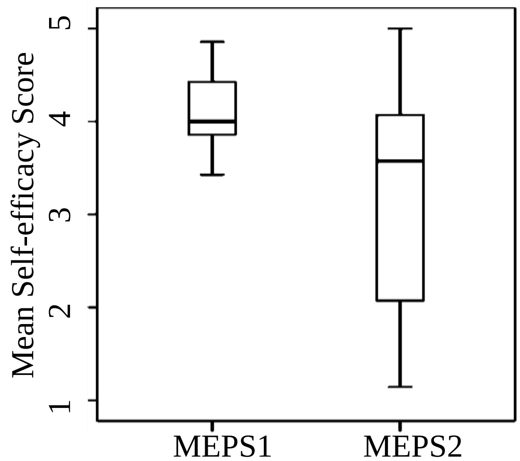

Figure 1. Boxplots of mean self-efficacy scores at the beginning of the semester and the end of the semester for Intermediate Algebra two-time participants.

The two-time participants who had taken advanced mathematics courses in high school had a significant difference in mean self-efficacy scores from the beginning to the end of the semester. For those who had taken advanced mathematics courses, the mean difference = .34, standard deviation = 1.18, $t(50) = 2.06$, $p < .05$. The distributions of self-efficacy mean scores for the two surveys for two-time participants who took advanced mathematics courses in high school are shown in Figure 2.

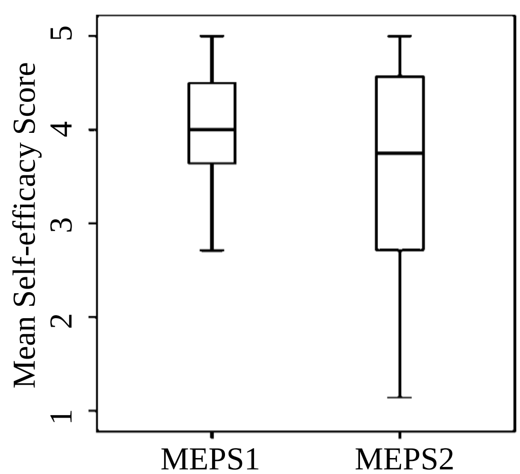

Figure 2. Boxplots of mean self-efficacy scores at the beginning and the end of the semester for two-time participants who had taken advanced mathematics courses in high school.

The male two-time participants' mean self-efficacy scores differed significantly from the beginning to the end of the semester. For male two-time participants, the mean difference = .41, standard deviation = .57, $t(18) = 3.14$, $p < .01$. The distributions of self-efficacy mean scores for the two surveys for male two-time participants are shown in Figure 3.

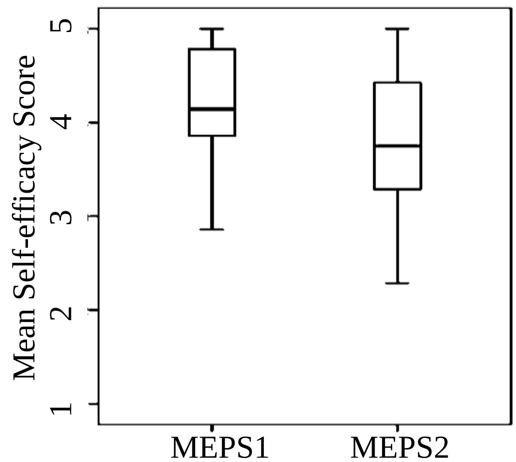

Figure 3. Boxplots of mean self-efficacy scores at the beginning of the semester and the end of the semester for male two-time participants.

CHAPTER 5

SUMMARY, CONCLUSIONS, & RECOMMENDATIONS

Summary

The freshman year of college is a period of significant transition, requiring adjustment to new social and academic demands (Clark, 2005; DeBerard et al., 2004; D'Lima et al., 2014; Gall, Evans, & Bellerose, 2000; Tinto & Goodsell, 1993; Turner & Thompson, 2014) and offering opportunities to discover new personal strengths, try out new identities, and develop independence (Clark, 2005; Terenzini et al., 1994). Freshmen differ in both their academic and psychological readiness for college (Komarraju et al., 2013). Underprepared students may differ not only in their level of high school academic preparation but also in their personal ability to structure learning opportunities, organize thinking, effectively evaluate understanding, and monitor progress toward success (Burrill, 2017; Corbishley & Truxaw, 2010; Ley & Young, 1998; The Research and Planning Group for California Community Colleges, 2010). A study of first year college students in 2016 found that more than a third of the students surveyed described difficulty in learning to "manage their time effectively, develop effective study skills, and understand what the professors expect" (Bates & Bourke, 2016, p. 1). Identifying the characteristics that differentiate students who drop out of college from those who persevere and graduate is essential for postsecondary institutions who wish to positively impact student success (Hurford, Ivy, Winders, & Eckstein, 2017).

Mathematics is of particular concern for freshmen, many of whom are required by postsecondary institutions to take a mathematics course within their first year of college (Barr & Wessell, 2018; Bryk & Treisman, 2010; Peters, 2013). For years, postsecondary institutions across the United States have faced high rates of failure and withdrawal for entry-level mathematics courses (Harper & Reddy, 2013; Ko et al., 2007; Norton et al., 2018; Stage, 2001; Stage & Kloosterman, 1995; Stevenson & Zweier, 2011). Students have expressed that in college there is an increased amount of work compared to high school, as well as higher expectations that students take responsibility for their own learning (Appleby, 2014; Barnes et al., 2004; Clark, 2005). College professors have reported that freshmen are not prepared for college-level mathematical thinking and responsibilities (Corbishley & Truxaw, 2010; Sadler & Sonnert, 2018; Sanoff, 2006).

Studies have found that students' first-year mathematics course success is predictive of college major selection and even future success in college more generally, including degree completion (Barr & Wessel, 2018; Callahan & Belcheir, 2017; Parker, 2005). When students are not ready to tackle the challenges presented in their first year of college, failure can form a barrier that prevents them from moving on to other classes, or even finishing a college degree (Barr & Wessel, 2018). "The readiness to take on, and pass, math – a subject matter typically considered difficult and less popular for most students" was identified by Herzog (2005, p. 911) as a primary factor heavily influencing one-year retention of freshmen. Fewer than half of the students enrolled in noncredit-bearing developmental mathematics courses ever complete the developmental pathway, and are subsequently barred from continuing to other required courses (Bahr, 2008; Jiminez et al., 2016; Rutschow, 2017). College Algebra, a required and terminal mathematics course for many majors, has a similarly detrimental effect for many students (Gordon, 2005; Small, 2002). Calculus has also been identified as a gatekeeper for some science, technology, engineering, and mathematics (STEM) degrees, such that if freshmen do not pass calculus, they are likely to extend their timetable to reach graduation (Ayebo et al., 2017; Sadler & Sonnert, 2017, 2018).

Looking to pre-college experiences, studies have shown that taking advanced mathematics courses in high school increases the likelihood of earning a bachelor's degree (Adelman, 1999, 2006; Callahan & Belcheir, 2017; Sadler & Sonnert, 2018). While the percentage of students taking advanced mathematics courses in high school has increased substantially over the past three decades (Sadler & Sonnert, 2018; Sonnert & Sadler, 2014), the number of students subsequently enrolling in mathematics courses below calculus in college has continued to increase as well, regardless of their high school preparation (Sonnert & Sadler, 2014). Students appear to be less confident about their mathematical abilities than their course preparation would otherwise suggest they should be (Benken et al., 2015). Their experiences in mathematics classrooms prior to high school graduation are likely to heavily influence their success in college mathematics courses (Rosin, 2012).

Personal mathematics learning experiences contribute heavily to students' mathematical identities, differentiating those who have experienced positive mathematical engagement from those who have experienced exclusionary mathematics teaching and damaging messaging from their parents, peers, and others (Boaler, 2002; Solomon, 2007). Students' mathematical identities are the deeply held beliefs that they have about their own ability to contribute to mathematical conversations, to achieve mathematically, and to use mathematics across other contexts in which they live (Aguirre et al., 2013). These beliefs can help or hinder students' progress in mathematics courses through their influence over students' choices to engage and participate as learners and doers of mathematics or to avoid valuable learning opportunities (Bishop, 2012).

Through interactions and experiences, people continually affirm or reject their position as part of a particular group (Aguirre et al., 2013; Gee, 2000), which can change based on their own successes and failures as well as the successes and failures of others considered "alike" or “different” (Beijaard et al., 2004; Bishop, 2012). Students’ identities do not exist just within one classroom; they integrate them into future classroom interactions as well as other parts of their lives (Benken et al., 2015; Gee, 2000; Rosin, 2012). Over time, as interactions and responses recur predictably, they “thicken” and more permanently establish that particular choice of identity (Wortham, 2004).

Mathematical mindsets begin to form as early as preschool and elementary school as students construct theories about their own and others’ mathematical abilities (Gunderson et al., 2012), and those theories guide their decisions and interactions within communities of mathematics learners (Murphy & Dweck, 2010). Students’ mathematical mindsets can impact their willingness to tackle challenging tasks in mathematics courses (Hong et al., 1999; Mangels et al., 2006), and make the difference between being successful and unsuccessful in mathematics (Boaler, 2016; Grant & Dweck, 2003).

When students hold an entity theory, or a fixed mindset, about mathematical ability, they see mathematical intelligence as static and limited, and therefore they often misinterpret mistakes as a lack of ability (Boaler, 2016). They view misunderstandings and gaps in knowledge as failure, and consequently feel incompetent, inadequate, and helpless (Dweck & Leggett, 1988; Elliott & Dweck, 1988). Alternatively, when students hold an incremental theory, a growth mindset about mathematical ability, they see mathematical intelligence as something that can grow with effort (Boaler, 2016). They view their mistakes as opportunities to engage in creative thinking and to develop strategies to revise and redirect efforts which allows them to complete even more difficult tasks (Boaler, 2013). Moser, Schroder, Heeter, Moran, and Lee (2011) found that each time a mistake occurs and is recognized, new connections form in the brain as people reflect about why something went wrong. Mistakes are integral to the development of mathematical understanding (Boaler, 2016). Nevertheless, mathematics educators have traditionally valued performance outcomes over learning objectives, and commonly measure mathematical ability by grading down for mistakes (Boaler, 2016). In such an environment, even students who previously believed that mathematical ability can increase with effort may begin to question their measure of mathematical ability to perform as expected (Good et al., 2012).

Parents, teachers, and peers send messages to students about mindsets as well (Dweck, 1999, 2008; Yeager & Dweck, 2012; Yeager, Walton, & Cohen, 2013). These unintended messages are communicated to students through praise for process or outcome (Dweck, 1999, 2007, 2008b; Mueller & Dweck 1998), comparisons to traditionally successful reference groups (Chestnut et al., 2018), and mathematical ability stereotypes that are inadvertently promoted (Dweck, 2006). Cultural gender stereotypes that teachers, parents, and others unwittingly continue to uphold have been found to influence mathematical mindsets (Boaler, 2013; Dweck, 2008a; Good et al., 2012; Gunderson et al., 2013; Mueller & Dweck, 1998; Rattan, Good, et al., 2012; Wang & Degol, 2017). Among those most damaged are fixed mindset high-achieving girls who have been praised for their intelligence, infer from mistakes that they are not as smart as they had been told previously (Boaler, 2013), and consequently may come to believe that they are unlikely to have the additional innate intelligence required for certain fields of study (Wang & Degol, 2017).

Self-efficacy beliefs are people's beliefs about their own ability to produce a certain outcome for tasks or events that will impact their lives (Bandura, 1997). These beliefs regulate human thinking and action through cognitive, motivational, affective, and selective processes (Bandura, 1993), and therefore impact how individuals think about themselves, respond when faced with difficulty, maintain their emotional well-being, and make critical choices (Bandura & Locke, 2003). Chemers et al. (2001) noted that optimism and self-efficacy are critical to students' successful navigation of the inevitable life transitions that occur during the first year of college. Students do well when they adopt robust academic self-efficacy beliefs that allow them to approach and persist in difficult academic tasks, even when they experience occasional set-backs (Brown et al., 2008).

Self-efficacy is about future actions, although it is influenced by prior performances and experiences (Bandura, 1977, 1986, 1997, 2006; Zimmerman, 1995). Judgements of one's skills, knowledge, experience, strategies, and effort all play a part in the formation of efficacy beliefs (Bandura, 1993; Zimmerman, 1995). Parents, peers, and teachers influence students' self-efficacy by communicating high or low expectations, expressing pride or dissatisfaction in performances, or encouraging risk-taking and exploration of new challenges (Zimmerman, 2000b). However, it is students' personal perceptions, ambitions, and experiences that drive their level of self-efficacy (Zimmerman et al., 1992). People regularly reflect on their own efficacy, revisiting their purpose, considering their strategies and actions, and making changes as necessary to stay focused on their vision (Bandura & Locke, 2003). Especially during periods of educational transition, students reflect on their own academic experiences and reassess their competence, frequently judging themselves unduly negatively due to their inexperience with new environments, expectations, and social reference groups (Midgley et al., 1989; Schunk & Pajares, 2001).

Those who experience mathematical tasks that they perceive to be overly difficult, who feel inferior to others due to mathematical performance or placement, or who perceive parental or instructor dissatisfaction tend to remember those experiences, and they are detrimental to mathematical self-efficacy (Valentine et al., 2004; Zimmerman, 1995). Conversely, success with complicated tasks positively influences students' feelings of competence, establishing the groundwork for increased self-efficacy (Campbell, 2015; Usher & Pajares, 2009). Students' mathematical self-efficacy influences what mathematical tasks they choose, how much effort they are willing to expend, how hard they will attempt to work at a task and for how long, and ultimately how well they actually perform (Bandura, 1997; Schunk & Pajares, 2001). Mathematical self-efficacy also influences students' decisions about taking future mathematics courses (Chen & Zimmerman, 2007; Champion & Mesa, 2016; Randhawa et al., 1993; Updegraff et al., 1996) and about choosing a college major (Hackett & Betz, 1989; Lent et al., 1984; Recber et al., 2018; Zeldin & Pajares, 2000; Zimmerman, 1995). Studies have also found that mathematical self-efficacy is associated with gender; females tend to report lower mathematical self-efficacy and are consistently more self-critical of their mathematical abilities than males, regardless of their actual mathematical abilities or performance (Ganley & Lubienski, 2016; Hackett, 1985; Jain & Dowson, 2009; Lent et al., 1991; Robinson-Cimpian et al., 2014).

Self-efficacy is closely partnered with self-regulation (Berger & Karabenick, 2011; Pintrich, 1999; Pintrich & De Groot, 1990; Zimmerman, 2008). Students with higher self-efficacy are more likely to be cognitively engaged (Pintrich, 1999), use self-regulated learning strategies (Cleary & Chen, 2009; Eccles & Wigfield, 2002; Zimmerman, 2000a), and exhibit self-regulatory characteristics such as effort and persistence (Zimmerman, 2002) which predict achievement (Pintrich & De Groot, 1990; Schunk & Pajares, 2001). Effective learners are aware of a purposeful relationship among their beliefs, actions, and associated social, academic, and environmental consequences (Zimmerman, 1986). Zimmerman (2008) described self-regulated learning as “the degree to which students are metacognitively, motivationally, and behaviorally active participants in their own learning process” (p. 167). Learning is a proactive activity that students do for themselves rather than a passive occurrence in response to teaching (Zimmerman, 2002). Self-regulated learners are aware of both their strengths and limitations (Zimmerman, 2002), and recognize when strategies need to change to reach their learning goals (Medina, 2011; Sanz de Acedo Lizarraga et al., 2003; Zimmerman, 2002, Zimmerman & Martinez-Pons, 1986).

A student’s ability to self-regulate has been linked to academic success (Briley et al., 2009; Cleary & Kitsantis, 2017; Ley & Young, 1998; Nota et al., 2004). When used effectively, self-regulated learning strategies support learners’ goals to obtain knowledge and proficiency (Medina, 2011; Nota et al., 2004). Such strategies may include goal-setting and planning, organizing and developing study schedules and settings, seeking information or help, keeping records and self-monitoring, finding methods to stay on task, reviewing notes or tests, or finding ways to make sense of material not easily recited from memory (Medina, 2011; Zimmerman & Martinez-Pons, 1986).

However, strategy use can be time consuming and require extra motivation and effort from students, so students who value mathematics are more likely to implement strategies that increase their probability for success in a mathematics course (Berger & Karabenich, 2011; Zimmerman, 2000a). Students who are not interested in mathematics are more likely to limit their learning strategy use to memorization, which they perceive to be less costly in terms of time and effort than other self-regulated learning strategies shown to be linked to achievement (Berger & Karabenich, 2011). On average, first year college students do not exhibit productive use of self-regulated learning skills (Thibodeaux et al., 2017). This is especially true for those who enroll in developmental courses (Ley & Young, 1998).

The beliefs that students develop about themselves are largely responsible for their success or failure in school, and for that matter, all life endeavors (Pajares & Schunk, 2002). In the Executive Summary of the *Principles and Standards for School Mathematics*, the National Council of Teachers of Mathematics (NCTM) (2000) stated "All students should have the opportunity and the support necessary to learn significant mathematics with depth and understanding" (p. 1). The present study contributes to the body of literature available to better understand the characteristics and needs of first-time freshmen enrolling in postsecondary mathematics courses, as well as how to support all students in their pathways to degree completion.

The present study was developed to investigate the relationship of first-time college freshmen's mathematics course enrollment, gender, and high school mathematics course experience to their mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses.

The study was designed to answer the following research questions:

1. Does mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies differ significantly among first-time freshmen, when considering their mathematics course enrollment, their high school mathematics course experience, or their gender, as measured at the beginning of the semester?
2. Does mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies differ significantly among first-time freshmen, when considering their mathematics course enrollment, their high school mathematics course experience, or their gender, as measured at the end of the semester?

3. What are the relative contributions of mathematics course enrollment, high school mathematics course experience, and gender to mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies?
4. Do first-time freshmen students' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies significantly differ between the beginning of the fall semester and the end of that semester, and do those differences vary significantly when gender, high school mathematics course experience, and mathematics course enrollment are considered?

To answer the research questions, the study used a quasi-experimental repeated measures design (Green & Salkind, 2014; Shadish et al., 2002).

The study was conducted at a large Midwestern 4-year public research university. The data were collected during the Fall 2018 semester from students enrolled in Intermediate Algebra, College Algebra, or Calculus I. These courses are often part of a degree requirement, and highly encouraged to be completed within the first year of undergraduate study at the university (College of Liberal Arts & Sciences, n.d.). Students in these courses were invited to participate in two online surveys through an email invitation, an in-class announcement, an announcement posted within the learning management system, or a combination of those. The first survey was available to students during the first two weeks of the fall semester, and the second survey was available to students during the last three weeks of the semester. Participants in the study included students who voluntarily chose to complete one or two online surveys and were subsequently identified as first-time freshmen at the university.

There were 299 first-time freshmen participants in Group 1 who completed the first survey and 176 first-time freshmen in Group 2 who completed the second survey. Of those participants, 68 took both surveys. Groups 1 and 2 had similar distributions across demographic factors such as gender, ethnicity and race, mathematics course enrollment, expected major, and high school mathematics course experience, as did the subset of two-time participants who took both surveys. At the beginning of the semester, there were 119 male participants, 179 female participants, and one participant who preferred to self-describe as fluid. Of those, 52 were enrolled in Intermediate Algebra, 203 in College Algebra, and 44 in Calculus I. There were 80 who had not taken mathematics courses above Algebra 2 in high school, and 216 who had. At the end of the semester, there were 67 male participants and 109 female participants. Of those, 24 were enrolled in Intermediate Algebra, 91 in College Algebra, and 61 in Calculus I. There were 39 who had not taken mathematics courses above Algebra 2 in high school, and 137 who had.

Two forms of a researcher-developed survey instrument were used to gather the data in this study. The Mathematics Experience and Perspectives Survey form 1 (MEPS1) was used at the beginning of the semester, with the expectation that participants' responses would be reflective of their past experiences in mathematics. The Mathematics Experience and Perspectives Survey form 2 (MEPS2) was used at the end of the semester, with the expectation that participants' responses would capture students' perspectives as first-time freshmen mathematics learners at the university. The wording and verb tense of some items on MEPS1 were adjusted for use on MEPS2 to reflect the end-of-semester timing of the second survey.

The MEPS1 and MEPS2 included a combination of items adapted from multiple survey instruments that formed four subscales to measure mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies in mathematics courses. Both surveys also included multiple items about participants' demographics, background experiences in mathematics, and anticipated major and future mathematics course enrollment. Prior to administering the MEPS1, survey items were field-tested with students who were not first-time freshmen to check for clarity and average response time. Revisions were made in response to the field test, and the revised items as well as the online survey delivery platform were tested in a pilot study during the Summer 2018 semester. Additionally, the construct measurement items were subjected to expert review between the Summer 2018 and Fall 2018 semesters. Revisions were made to identified items, and were included in both the MEPS1 and MEPS2. In response to an item analysis conducted on the data gathered from the MEPS1, one mathematical mindset subscale item and three use of self-regulated learning strategies items were excluded from data analysis.

Individual subscale scores were calculated by computing the mean value of participants' responses to the items included in each subscale measure. All subscale items used the same 5-point Likert scale, and all negatively-worded items were reverse-scaled for analysis. Univariate descriptive statistics were computed for the MEPS1 and MEPS2 subscale measures of mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies for mathematics. The means and standard deviations of participants' mean subscale scores were calculated both overall and for each independent variable subgroup for Group 1 participants, Group 2 participants, and the two-time participants in Groups 1 and 2. Frequencies were computed for participants' reasons for enrolling in their current mathematics course, whether or not they anticipated taking another mathematics course in the future, and if so, the reasons why.

Three-way multivariate analyses of variance were conducted on the mean subscale scores from the MEPS1 and MEPS2 at the $\alpha = .05$ significance level to determine whether there were any statistically significant differences in mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies among first-time freshmen in different mathematics courses, with different high school mathematics course experiences, or with different genders. Following the multivariate analyses on the MEPS1 and MEPS2 data, analyses of variance were conducted in order to identify over which of the dependent variables any significant differences existed. Finally, post hoc analyses to the significant analysis of variance were completed by examining pairwise comparisons of mean scores to identify which specific groups of students had significant differences. The pairwise comparisons of mean scores were tested at the α =.0125 level, after Bonferroni adjustment for multiple comparisons.

At the beginning of the semester, students enrolled in Calculus I, males, and students with advanced mathematics course experience in high school reported higher mean scores for mathematical mindset, mathematical identity, and mathematical self-efficacy than other students on average. Students enrolled in Intermediate Algebra, females, and students who did not take advanced mathematics courses in high school reported higher mean scores for use of self-regulated learning strategies in mathematics courses compared to other students on average. The multivariate analyses of variance confirmed that there were significant differences in one or more of the dependent variable scores when mathematics course enrollment and high school mathematics course experiences were considered. No statistically significant differences between genders were found among the dependent variables. The multivariate η^2 values indicated that about 4% of the variance in the values of the subscale scores could be accounted for by which course a student was enrolled in, and about 4% could be accounted for by whether or not a participant had taken advanced mathematics courses in high school.

The analyses of variance on the MEPS1 data revealed statistically significant differences for both mathematical identity and mathematical self-efficacy. Students who had taken advanced mathematics courses in high school had significantly higher mean mathematical identity and mathematical self-efficacy scores than did those students who had not. Whether or not a student had taken advanced mathematics in high school accounted for about 3% of the variability in students' reported mathematical identity scores, and 3% of the variability in students' reported mathematical self-efficacy scores. The mathematics course a student was enrolled in also contributed significantly to the variability in mean mathematical identity scores, accounting for about 2% of the variability in students' reported mathematical identity scores. Post hoc pairwise comparisons identified that the students who were enrolled in Calculus I reported significantly higher mathematical identity mean scores than did those who were enrolled in Intermediate Algebra, with an estimated marginal mean difference of .776. Although students enrolled in Calculus I and those with advanced mathematics course experience in high school had higher mean mathematical mindset scores and lower mean use of self-regulated learning strategies scores than other students, none of those differences were statistically significant at $\alpha = .05$.

At the end of the semester, students enrolled in Calculus I, males, and students with advanced mathematics course experience in high school reported higher mean scores for mathematical mindset, mathematical identity, and mathematical self-efficacy than other students on average. Students enrolled in Intermediate Algebra, females, and students who did not take advanced mathematics courses in high school reported higher mean scores for use of self-regulated learning strategies in mathematics courses compared to other students on average. The multivariate analyses of variance did not identify significant differences in any of the dependent variable scores for any of the independent variables, although it did detect a marginally significant difference in dependent variable values when mathematics course enrollment was considered. The multivariate η^2 values indicated that about 5% of the variance in the values of the subscale scores could be accounted for by course enrollment.

Follow-up analyses of variance revealed statistically significant differences for mathematical identity. The mathematics course a student was enrolled in was significant, accounting for about 5% of the variability in students' mathematical identity scores. Post hoc pairwise comparisons identified that the students who were enrolled in Calculus I reported significantly higher mathematical identity mean scores than did those who were enrolled in Intermediate Algebra or College Algebra, with estimated marginal mean differences of 1.21 and 1.19, respectively. Although students enrolled in Calculus I had higher mean mathematical mindset scores, higher mean self-efficacy scores, and lower mean use of self-regulated learning strategies scores, none of those differences were statistically significant at $\alpha = .05$.

Multiple linear regression analyses were conducted on the mean subscale scores from the MEPS1 and MEPS2 to evaluate the extent to which mathematics course enrollment, gender, and high school mathematics course experience predicted participants' mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies for mathematics courses at the beginning and end of the semester, respectively. The regression analyses also identified the relative weight of each of the three predictor variables of mathematics course enrollment, gender, and high school mathematics course experience. For each dependent variable, six hierarchical multiple regression analyses were conducted, and the change in R^2 was computed for each model in order to determine the change in the percent of the variance accounted for when additional predictors were added into the regression equation. The bivariate and partial correlations were computed and confirmed the relative strength of each of the individual predictor variables. Statistical significance was set at $\alpha = .05$.

The multiple regression analysis of participants' mean mathematical mindset scores at the beginning of the semester indicated that the linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with mathematical mindset, and that approximately 6% of the variance of participants' mathematical mindset scores could be accounted for by the linear combination of independent predictor variables. Mathematics course enrollment contributed significantly to the measure of mathematical mindset over and above the other two predictor variables, accounting for about 5% of the variance of mathematical mindset among the participants. Students enrolled in Calculus I had significantly higher mean mathematical mindset scores than those enrolled in Intermediate Algebra, but students enrolled in College Algebra did not. The mathematics course enrollment factor accounting for the difference in mean scores between those enrolled in Calculus I and Intermediate Algebra accounted for about 4% of the variance of mathematical mindset, and contributed twice as much weight to the mathematical mindset measure as the mathematics course enrollment factor accounting for the difference in mean scores between those enrolled in College Algebra and Intermediate Algebra.

The multiple regression analysis of participants' mean mathematical mindset scores at the end of the semester indicated that the linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with mathematical mindset, and that approximately 12% of the variance of participants' mathematical mindset scores could be accounted for by the linear combination of independent predictor variables. Mathematics course enrollment contributed significantly to the measure of mathematical mindset over and above the other two predictor variables accounting for about 11% of the variance of mathematical mindset among the participants. Students enrolled in Calculus I had significantly higher mean mathematical mindset scores than those enrolled in Intermediate Algebra, but students enrolled in College Algebra did not. The mathematics course enrollment factor accounting for the difference in mean scores between those enrolled in Calculus I and Intermediate Algebra accounted for about 5% of the variance of mathematical mindset, and contributed more than four times as much weight to the mathematical mindset measure as gender and more than 12 times as much weight as high school mathematics course experience.

The multiple regression analysis of participants' mean mathematical identity scores at the beginning of the semester indicated that the linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with mathematical identity, and that approximately 20% of the variance of participants' mathematical identity scores could be accounted for by the linear combination of independent predictor variables. Mathematics course enrollment and high school mathematics experience contributed significantly to the measure of mathematical identity over and above gender. High school mathematics course experience alone accounted for about 8% and mathematics course enrollment alone accounted for about 14% of the variance of mathematical identity scores among the participants. Students enrolled in either Calculus I or College Algebra had significantly higher mean mathematical identity scores than those enrolled in Intermediate Algebra. The mathematics course enrollment factor accounting for the difference in mean scores between those enrolled in Calculus I and Intermediate Algebra accounted for about 10% of the variance of mathematical identity, and contributed about three times as much weight to the mathematical identity measure as the mathematics course enrollment factor accounting for the difference in mean scores between those enrolled in College Algebra and Intermediate Algebra.

The multiple regression analysis of participants' mean mathematical identity scores at the end of the semester indicated that the linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with mathematical identity, and that approximately 28% of the variance of participants' mathematical identity scores could be accounted for by the linear combination of independent predictor variables. Mathematics course enrollment and high school mathematics experience contributed significantly to the measure of mathematical identity over and above gender. High school mathematics course experience alone accounted for about 6% and mathematics course enrollment alone accounted for about 26% of the variance of mathematical identity scores among the participants. Students enrolled in Calculus I had significantly higher mean mathematical identity scores than those enrolled in Intermediate Algebra, but students enrolled in College Algebra did not. The mathematics course enrollment factor accounting for the difference in mean scores between those enrolled in Calculus I and Intermediate Algebra accounted for about 11% of the variance of mathematical identity, and contributed over 15 times as much weight to the mathematical identity measure as the mathematics course enrollment factor accounting for the difference in mean scores between those enrolled in College Algebra and Intermediate Algebra, and over five times as much weight as the high school mathematics course experience factor.

The multiple regression analysis of participants' mean mathematical self-efficacy scores at the beginning of the semester indicated that the linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with mathematical self-efficacy, and that approximately 8% of the variance of participants' mathematical self-efficacy scores could be accounted for by the linear combination of independent predictor variables. High school mathematics course experience contributed significantly to the measure of mathematical self-efficacy over and above the other two predictor variables. High school mathematics course experience alone accounted for about 5% of the variance of mathematical self-efficacy among the participants. Gender played a more significant role in predicting mathematical self-efficacy scores for students who were enrolled in Intermediate Algebra or Calculus I, as opposed to those enrolled in College Algebra, but contributed only about a third as much to the mathematical self-efficacy scores as the high school mathematics course experience factor.

The multiple regression analysis of participants' mean mathematical self-efficacy scores at the end of the semester indicated that the linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with mathematical self-efficacy, and that approximately 8% of the variance of participants' mathematical self-efficacy scores could be accounted for by the linear combination of independent predictor variables. High school mathematics course experience contributed significantly to the measure of mathematical self-efficacy over and above the other two predictor variables. High school mathematics course experience alone accounted for about 5% of the variance of mathematical self-efficacy among the participants. Gender contributed minimally to mathematical self-efficacy. Although not statistically significant, the mathematics course enrollment factor negatively contributed about two-thirds as much weight as the high school mathematics course experience factor, indicating that that a student enrolled in College Algebra had lower mathematical self-efficacy scores on average than a student enrolled in Intermediate Algebra.

The multiple regression analysis of participants' mean use of self-regulated learning strategies scores at the beginning of the semester indicated that the linear combination of gender, high school mathematics course experience, and mathematics course enrollment was not significantly associated with use of self-regulated learning strategies. The mathematics course enrollment factor was a statistically significant predictor of self-regulated learning strategies use when comparing participants' scores in Intermediate Algebra to those enrolled in Calculus I, and was minimally more influential than the factor comparing participants in Intermediate Algebra to those enrolled in College Algebra.

The multiple regression analysis of participants' mean use of self-regulated learning strategies scores at the end of the semester indicated that the linear combination of gender, high school mathematics course experience, and mathematics course enrollment was significantly associated with use of self-regulated learning strategies, and that approximately 8% of the variance of participants' use of self-regulated learning strategies scores could be accounted for by the linear combination of independent predictor variables. Mathematics course enrollment and high school mathematics course experience contributed significantly to the use of self-regulated learning strategies measure over and above gender. Mathematics course enrollment alone accounted for about 6% of the variance of use of self-regulated learning strategies scores among the participants. The mathematics course enrollment factor accounting for the difference in mean scores between those enrolled in Calculus I and Intermediate Algebra was negatively correlated with use of self-regulated learning strategies and accounted for about 3% of the variance of use of self-regulated learning strategies scores. Students enrolled in Calculus I reported lower use of self-regulated learning strategies scores on average compared to those enrolled in both College Algebra and Intermediate Algebra.

The mean mathematical self-efficacy scores decreased for all two-time participants over the course of the semester, as well as for two-time participants in each individual mathematics course, gender group, and high school mathematics course experience group. A repeated measures analysis of variance at significance $\alpha = .05$ revealed that there was a statistically significant difference for the time effect on mathematical self-efficacy scores indicating that about 10% of the variance in mathematical self-efficacy scores for the two-time participants could be accounted for by the factor of time. Paired-samples *t* tests were conducted to follow up the mathematical self-efficacy repeated measures analysis of variance in order to identify which of the independent variable subgroups had significantly different scores from the beginning of the semester to the end. The results showed that the two-time participants enrolled in Intermediate Algebra had a statistically significant difference of .94 between their mean mathematical self-efficacy scores at the beginning of the semester and those at the end. Two-time participants who had taken advanced mathematics courses in high school also had a statistically significant drop in mean mathematical self-efficacy scores, with a .34 difference between their mean mathematical self-efficacy scores at the beginning of the semester and at the end. Males also experienced a statistically significant drop of .41 in mean mathematical self-efficacy scores over the course of the semester.

Mathematical mindset mean scores increased for two-time participants enrolled in Calculus I, and mathematical identity mean scores and use of self-regulated learning strategies mean scores increased for those enrolled in College Algebra over the course of the semester, but the differences were not statistically significant. Mathematical identity mean scores remained about the same over the course of the semester both for students with and without advanced mathematics course experience in high school. The mean scores for use of self-regulated learning strategies increased for those who had not taken advanced mathematics courses previously and decreased for those that had, but the differences were not statistically significant. Male two-time participants reported decreased mean scores on all four constructs from the beginning of the semester to the end, but only the mathematical self-efficacy score differences were statistically significant. Females reported increased mathematical identity mean scores, about the same use of self-regulated learning strategies mean scores, and decreased mathematical mindset and mathematical self-efficacy mean scores over the course of the semester, but none of the differences were statistically significant.

Conclusions

The following conclusions address the research questions for this study.

1. There were statistically significant differences among first-time freshmen's mathematical identity and mathematical self-efficacy scores at the beginning of the semester, but not their scores for mathematical mindset or use of self-regulated learning strategies in mathematics courses. Students who were enrolled in Calculus I reported significantly higher mathematical identity scores on average than students who were enrolled in Intermediate Algebra; College Algebra students' mathematical identity mean scores fell in between those two. These results align with a suggestion by Hall and Ponton (2005) that there is a stigma associated with enrollment in developmental mathematics courses, although few published studies have addressed the differences in mathematical identity among students of varying levels of mathematics courses.

Students who had taken mathematics courses above the level of Algebra 2 in high school had significantly higher mathematical identity and mathematical self-efficacy scores at the beginning of the semester. This result is related to Anderson’s (2007) findings that for college-bound students, advanced mathematics course-taking was associated with students’ mathematical identities because of an expectation that colleges require higher level mathematics for both admission and degree program requirements; it is also related to studies that have found that secondary students in advanced mathematics not only have stronger self-efficacy, but also more accurate self-perceptions of ability (Chen & Zimmerman, 2007; Pajares & Graham, 1999; Zimmerman, 1995). Few other studies exist that directly link high school mathematics course experience to mathematical identity or mathematical self-efficacy, although multiple studies have found that whether or not students take advanced mathematics courses in high school is predictive of students’ decisions to attend college and complete college degrees (Adelman, 1999, 2003; Burris, Heubert, & Levin, 2004; Horn & Nuñez, 2000; Ma & Wilkins, 2007).

No statistically significant differences were found for mathematical identity or mathematical self-efficacy scores with regard to gender, which is inconsistent with results from other studies (Cullen, Waters, & Sackett, 2006; Good et al., 2012; Lesko & Corpus, 2006; Nosek, Banaji, & Greenwalk, 2002; Recber et al., 2018; Steel, Spencer, & Aronson, 2002; Wang & Degol, 2017). Since this study gathered self-report data, the contradictory results could be explained by a recent study that found that college students were swayed by gender stereotypes when rating others, but did not manifest gender stereotypes when reporting about themselves (Barth, Kim, Eno, & Guadagno, 2018).

No statistically significant differences were found among any of the subgroups with regard to mathematical mindset or use of self-regulated learning strategies scores. Similarly, Cleary and Chen (2009) found that middle school adolescents in an advanced mathematics course did not significantly differ from those in a regular mathematics course with regard to their use of self-regulated learning strategies. When considering different mathematics courses, few other studies have focused on the differences among students' mathematical mindsets or the use of self-regulated learning strategies.

2. There were marginally statistically significant differences among first-time freshmen's mathematical identity scores at the end of the semester, but no statistically significant differences were found among their scores for mathematical mindset, mathematical self-efficacy, or use of self-regulated learning strategies in mathematics courses. Students who were enrolled in Calculus I reported higher mathematical identity scores on average than students who were enrolled in Intermediate Algebra and students who were enrolled in College Algebra; the mean mathematical identity scores of College Algebra students were similar to those enrolled in Intermediate Algebra. No statistically significant differences were found for first-time freshmen's mathematical identity scores with regard to high school mathematics course experience or gender, nor among any of the subgroups with regard to mathematical mindset, mathematical self-efficacy, or use of self-regulated learning strategies scores.
3. The relative contributions of mathematics course enrollment, high school mathematics course experience, and gender varied for each of the constructs of mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies for mathematics. At the beginning and the end of the semester, mathematics

course enrollment and high school mathematics course experience both contributed significantly to one or more of the constructs, but gender did not contribute statistically significantly to any of the constructs.

The variability of mathematical mindset scores at both the beginning and the end of the semester could be significantly attributed to mathematics course enrollment, with those enrolled in Calculus I having significantly higher mathematical mindset scores than those enrolled in Intermediate Algebra. Gender contributed less to the regression model than mathematics course enrollment. Whether or not a student had taken advanced mathematics courses in high school had minimal influence on the variability in mathematical mindset scores at both the beginning and the end of the semester. Neither high school mathematics course experience nor gender had statistically significant contributions to the prediction of mathematical mindset scores.

The variability of mathematical identity scores at both the beginning and the end of the semester could be significantly attributed to mathematics course enrollment and high school mathematics course experience. Gender did not have a statistically significant contribution to the prediction of mathematical identity scores. The majority of the variability could be explained by which mathematics course students were enrolled in, with those enrolled in Calculus I having significantly higher mathematical identity scores than those enrolled in Intermediate Algebra at both the beginning of the semester and at the end. Whether or not a student had taken advanced mathematics courses in high school contributed the second highest weight to the prediction of mathematical identity scores at both time periods, with those who had advanced mathematics course experience in high school reporting significantly higher mathematical identity scores on average than those who had not.

The variability of mathematical self-efficacy scores at both the beginning and the end of the semester could be significantly attributed to students' high school mathematics course experience, with those who had taken advanced mathematics coursework expressing higher mathematical self-efficacy scores at both the beginning of the semester and at the end. Although not statistically significant, whether or not a student was enrolled in College Algebra contributed the second most weight to the prediction of mathematical self-efficacy; whether or not a student was enrolled in Intermediate Algebra or Calculus I was minimally influential. Neither mathematics course enrollment nor gender had statistically significant contributions to the prediction of mathematical self-efficacy scores.

The variability of students' use of self-regulated learning strategies at both the beginning and the end of the semester could be significantly attributed to students' mathematics course enrollment, with those enrolled in Intermediate Algebra having significantly higher use of self-regulated learning strategies scores than those enrolled in Intermediate Algebra. Although not statistically significant, gender contributed the second most weight to the prediction of students' use of self-regulated learning strategies at the end of the semester. High school mathematics course experience was minimally influential at both the beginning and the end of the semester.

4. There were statistically significant differences in students' mathematical self-efficacy scores over the course of the fall semester for first-time freshmen who completed both surveys, but differences were not significant with regard to mathematical mindset,

mathematical identity, or use of self-regulated learning strategies scores. Although there were decreases in the mean scores of mathematical mindset and use of self-regulated learning strategies, and an increase in the mean scores of mathematical identity, none were statistically significant. Mathematical self-efficacy dropped significantly across the whole group. When gender, high school mathematics course experience, and mathematics course enrollment were considered, statistically significant differences in mathematical self-efficacy from the beginning of the semester to the end of the semester were found for males, those who had taken advanced mathematics coursework in high school, and those enrolled in Intermediate Algebra. It is not uncommon for students to have lower self-efficacy later in the semester after having experienced challenges (e.g., Bandura, 1997; Bressoud, 2015; Chen & Zimmerman, 2007; Lee et al., 2014; Tinto, 2017), which was also the case in the present study.

The following conclusions were drawn regarding observations made during the analysis and were supplemental to the conclusions related to the research questions.

5. Although not found to be statistically significant, students enrolled in Intermediate Algebra tended to report the highest use of self-regulated learning strategies scores, and students enrolled in Calculus I reported the lowest. Students enrolled in College Algebra reported mean scores for use of self-regulated learning strategies that were in between those reported by students enrolled in Intermediate Algebra and Calculus I. Use of self-regulated learning strategies for the students who participated at both the beginning and the end of the semester decreased over time for those enrolled in Intermediate Algebra and Calculus I, but they increased for those enrolled in College Algebra. Although there

are many studies supporting the strong positive relationship between the use of self-regulated learning strategies and mathematics achievement (e.g., Briley et al., 2009; Peters, 2013), there are few that offer insight into the relationship of the use of self-regulated learning strategies and mathematics course enrollment. One study by Ley and Young (1998) found that community college students placed in developmental courses used self-regulated learning strategies less than those placed in College Algebra, which is in contrast to the findings in this study.

6. Gender did not contribute significantly to any differences in mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies scores. This finding is similar to studies that did not find gender to be a significant moderator (e.g. D'Lima et al., 2014; Priess-Groben & Hyde, 2017; Talsma et al., 2018; Valentine et al., 2004) but is in contrast to studies that cited gender gaps for one or more of these constructs (e.g. Cavallo et al., 2004; Diseth et al., 2014; Huang, 2013).
7. Students' mathematical identity and mathematical self-efficacy appeared to be associated with students' reasoning for taking mathematics courses and their expectations for taking mathematics courses in the future. Anderson (2007) noted that the images students have of themselves in relation to the need for mathematics coursework in postsecondary education or the use of mathematics in a future career influence how students see themselves as learners of mathematics. Responses in this study indicative of stronger mathematical identity such as "I really enjoy math" or "I am good at math," and responses indicative of higher mathematical self-efficacy such as, "Taking an additional math course is required for my degree" or, "I will need more math courses for my future career" were selected more often by Calculus I students, who had higher mathematical

identity and mathematical self-efficacy scores. There were only a few students who anticipated needing to retake their mathematics course either because they dropped it or they anticipated a failing grade. These responses that indicate weak self-efficacy did not appear to be associated with mathematics course enrollment.

Recommendations

The following recommendations may be of interest to mathematics education researchers, postsecondary mathematics department leaders and instructors, administrators and instructors in postsecondary First Year Experience and summer bridge programs (programs designed to support students' transition to college and postsecondary success (U.S. Department of Education, 2016), and secondary mathematics department leaders and instructors. They could also be of interest to those influencing mathematics learners at all levels of preparation including leaders in mathematics education, mathematics education policy-makers, parents, teachers, community members, and mathematics learners themselves.

1. Other studies have found that all four of the constructs included in this study are highly related to mathematics achievement (e.g., Ayotola & Adedeji, 2009; Blackwell et al., 2007; Briley et al., 2009; Cohen & Garcia, 2008), but there is minimal research published that examines all four constructs together with mathematical achievement. Permission was not granted to use student achievement data during this study, but future research should investigate first-time freshmen's mathematics achievement in conjunction with mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies. Studies (e.g., Callahan & Belcheir, 2017; Herzog, 2005) show that the first semester mathematics course grade is one of the best predictors for college degree completion, and learning about how that is related to the four identified

constructs could give direction to university course leaders to better guide how to support students as they integrate into college academic life.

2. For this study, students identified the mathematics course in which they were enrolled, but not which mathematics instructor(s) they had. Different instructors' methods of pedagogy, mathematical mindsets for teaching, homework policies, time spent with students, and classroom environments are among the possible differences that could have impacted students' mathematical mindset, mathematical identity, mathematical self-efficacy, or use of self-regulated learning strategies over the course of the semester. Future research that examined those differences among students and their instructors could inform future mathematics educators about positively or negatively impactful policies and actions. For example, a recent study by Canning, Muenks, Green, and Murphy (2019) found that STEM faculty mindset predicted student achievement above and beyond any other faculty characteristic studied, including gender, race/ethnicity, age, teaching experience, or tenure status.
3. Although the present study did not focus on racial differences among students, and did not have adequate numbers of participants to do so, the demographic data gathered in this study showed that there were differences in the racial distribution across the three university mathematics courses. At the beginning of the semester, of the 52 Intermediate Algebra participants, there were three students who identified as Asian, eight as Black or African American, seven as two or more races or "Other", and 32 as White. However, of the 44 Calculus I students, 10 identified as Asian, two as two or more races or "Other", 32 as White, and none as Black or African American. A similar distribution existed across the mathematics courses at the end of the semester. Future research may

investigate whether or not there are also associated differences in the racial distribution of mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies.

4. This study utilized self-reported data from first-time freshmen. It is acknowledged that self-report data can be inaccurate (Paulhus & Vazire, 2007; Rosen et al., 2017), and also can cause issues due to missing data if students choose not to respond to items important to the analysis. Future research could replicate the current study, but include data gathered from student records where possible, such as high school course history, college course history, and date of first enrollment at the university. Students' high school grade point average and ACT/SAT mathematics scores could also be included from the student records and informative for future research. This could avoid the inaccuracies and missing data caused by student self-reporting that occurred in this study.
5. A larger study that incorporates all first-time freshmen at a college or university should be conducted. The three courses included in this study were representative of only about 50% of the first-time freshmen taking mathematics courses at the university. After College Algebra, the introductory mathematics course with the second highest enrollment at this university is the Calculus I usually taken by business, life science, and social science majors. There are others who enroll in Precalculus, a few who enroll in other upper level mathematics courses, and others who, for one reason or another, do not enroll in mathematics courses at all. A more inclusive study could reveal additional relationships that exist among first-time freshmen with regard to mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies.

6. The results of this study indicated that students who enroll in Intermediate Algebra tend to have lower mathematical identity scores. Developmental mathematics program leaders and instructors should incorporate teaching practices that strengthen mathematical learning and cultivate positive student mathematical identities, such as those proposed by Aguirre et al. (2013): developing a deep understanding of mathematics using high cognitive demand tasks, leveraging students' mathematical backgrounds and competencies, affirming mathematics learners' identities in order to promote student participation, implementing practices that embrace student competencies and value multiple contributions, and intentionally drawing on students' knowledge and experiences as resources for mathematics teaching and learning.
7. First Year Experience programs exist at many postsecondary institutions and serve to support students' academic and life skills as they transition into the collegiate community (Gore, 2006; Schrader & Brown, 2008). The present study found that there were significant differences among first-time freshmen with regard to their mathematical identity and mathematical self-efficacy as they began their fall semester at the university. Other studies have stated that both mathematical identity and mathematical self-efficacy are closely tied to mathematical achievement (e.g., Briggs, 2014; Cohen & Garcia, 2008; Komarraju & Nadler, 2013). Moreover, studies have noted that mathematical achievement in the first semester of college is closely tied to eventual degree completion (e.g., Callahan & Belcheir, 2017; Herzog, 2005). University First Year Experience program administrators and instructors should consider what interventions may be possible for first-time freshmen who are placed into developmental mathematics courses

or those who arrive at college without having completed any advanced mathematics courses in high school.

8. Use of self-regulated learning strategies has been found to be positively associated with academic achievement (e.g. Briley et al., 2009; Nota et al., 2004). Although not statistically significant, results from this study indicated that students reported using fewer self-regulated learning strategies in their mathematics courses when comparing the end to the beginning of the semester, particularly among those enrolled in Intermediate Algebra and Calculus I. Secondary mathematics department leaders and instructors should consider how to implement practices that encourage or require students to use self-regulated learning strategies habitually as part of their mathematical learning process. Students that incorporate the use of self-regulatory learning strategies into their regular routine are much more likely to sustain those practices as they engage in future learning opportunities (Nota et al., 2004).
9. The development of both mathematical identity and mathematical self-efficacy begins early in life, long before high school or college (Aguirre et al., 2013; Bandura, 1997). The results of the present study found that students who had not taken advanced mathematics courses in high school had significantly lower mathematical identity and mathematical self-efficacy scores. It is imperative that those who influence students' mathematical learning opportunities take intentional steps to remove obstacles that keep students from participating productively and confidently in mathematics courses. To accomplish this, mathematics education leaders and policy-makers must find a way to inform and support all teachers, parents, and community members who take part in the development of confident mathematical learners.

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Appendices

Appendix A:

Mathematics Experiences and Perspectives Survey form 1 (MEPS1)

Information Statement (MEPS1)

You are invited to complete a short online survey that should take 10 minutes or less. The purpose of this survey is to gain information from you regarding your views about being a math student, as well as a little about your background in mathematics. You will receive two invitations to complete the survey, once at the beginning of the semester and once at the end, in order to compare responses over the course of time. There are no risks to you or others participating in this survey and the items included should not cause you any discomfort. Participation will not affect the outcomes of your mathematics course, nor your relationship with the University of Kansas in any way.

The Department of Curriculum and Teaching at the University of Kansas supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You should be aware that even if you agree to participate and begin the survey, you may choose not to complete it and your responses will not be saved.

Although participation may not benefit you directly, we believe that the information obtained from this study will help us better understand students who are taking freshmen math courses at KU and may help instructors do a better job of meeting students' needs in math. Your participation is solicited, although strictly voluntary. We have requested your KU email address in order to link your survey responses from the beginning of the semester to your responses at the end of the semester. Your name will not be associated in any publication or presentation with the information collected about you, or with the research findings from this study. Participation in this study will not affect your grade in your KU math course. Your identifiable information will not be shared unless (a) it is required by law or university policy, or (b) you give written permission. It is possible, however, with internet communications, that through intent or accident someone other than the intended recipient may see your response. Data gathered from this survey will be maintained securely until the conclusion of the study, anticipated to be May 2019, at which point downloaded data will be deleted.

If you would like additional information concerning this study before or after it is completed, please feel free to contact us by phone or email. Our contact information is listed below.

Completion of the survey indicates your willingness to take part in this study and that you are at least 18 years old. If you have any additional questions about your rights as a research participant, you may call (785) 864-7429 or write the Human Research Protection Program (HRPP), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas 66045-7563, email irb@ku.edu.

We wish you well in your courses this semester! Click the right arrow to begin the survey.

Sincerely,

Katrina Rothrock, PhD Candidate, School of Education, Department of Curriculum & Teaching
rothrock@ku.edu; 785-864-8441
Dr. Susan Gay, Faculty Supervisor, Associate Professor of Mathematics Education
sgay@ku.edu; 785-864-9676

KU Lawrence IRB # STUDY00142674 | Approval Period 6/27/2018

Q1 ID	What is your KU online user ID (KU email address)? ______________________
Q2 Mclass	In which math course are you currently enrolled at KU? ○ MATH 002 ○ MATH 101 ○ MATH 125
Q3 Age	What is your age? ____
Q4 Gend	What is your gender? ○ Female ○ Male ○ Prefer to self-describe: ____
Q58 Intl	Are you an international student? ○ Yes ○ No
Q5 Ethn	Are you Hispanic/Latino? ○ Yes ○ No
Q6 Race	Are you: (Mark all that apply) ○ American Indian or Alaska Native ○ Asian ○ Black or African American ○ Native Hawaiian or Other Pacific Islander ○ White ○ Other: ____
Q7 HSGrad	In what year did you graduate from high school? ○ 2018 ○ 2017 ○ 2016 ○ 2015 or earlier ○ Passed GED or HSE exam instead. Year: ___________________________
Q8 HSLocat	Where did you last attend high school? City ____ State/Province ____ Country ____
Q9 KUSem	What semester was your first semester at KU? ○ Spring Semester, Year: ____ ○ Summer Semester, Year: ____ ○ Fall Semester, Year: ____
Q10a PSecYN	AFTER you completed high school, have you ever taken courses, whether for credit or not for credit, at any institution besides KU (university, 4- or 2-year college, technical, vocational, or business school)? *Do not include any course experience completed PRIOR to graduating from high school.* ○ No ○ Yes
Display Q10b: If Q10a = Yes	
Q10b PSecInfo	Please share information about your post-high school course experience(s). Name of institution(s): ____ Semester(s) & Year(s): ____

Q11a Calc Did you take calculus in high school?

- ○ Yes, AP Calculus
- ○ Yes, other Calculus: ____
- ○ No

Display Q11b: If Q11a = No

Q11b PCalc Did you take Precalculus or Trigonometry in high school?

- ○ Yes, Precalculus
- ○ Yes, Trigonometry
- ○ Yes, both Precalculus and Trigonometry
- ○ No

Display Q11c: If Q11b = No

Q11c Alg2 Did you take Algebra 2 or (Integrated) Math 3 in high school?

- ○ Yes, Algebra 2
- ○ Yes, (Integrated) Math 3
- ○ No

Display Q11d: If Q11c = No

Q11d Geom Did you take Geometry or (Integrated) Math 2 in high school?

- ○ Yes, Geometry
- ○ Yes, (Integrated) Math 2
- ○ No

Display Q11e: If Q11d = No

Q11e Alg1 Did you take Algebra 1 or (Integrated) Math 1 in high school?

- ○ Yes, Algebra 1
- ○ Yes, (Integrated) Math 1
- ○ No

Q12 Maj What is your major (or intended major)? ___________________________________

Q13 MWhy Why are you taking this math course? (Mark all that apply)

- ○ It fulfills a requirement (such as the KU Goal 1.2 requirement)
- ○ I really enjoy math.
- ○ I like to be challenged.
- ○ I had no choice. I was required to enroll in this course.
- ○ My advisor recommended that I take it.
- ○ My parent(s) or a former teacher encouraged me to take it.
- ○ It is a prerequisite for a future course.
- ○ I will need it for my future career.
- ○ I was placed in this course by my ACT/SAT/placement test score.
- ○ Another reason: ____

Q14a MFut After this semester, do you plan to enroll in another math course before you complete your degree?

- ○ No
- ○ Yes

Display Q14b: If Q14a = Yes

Q14b MFutWhy Reason(s) why I expect to take one or more math courses in the future: (Mark all that apply)

- ○ Taking an additional math course is required for my degree.
- ○ An additional math course was recommended by my parent(s), instructor, or university advisor.
- ○ I am good at math.
- ○ I will need more math courses for my future career.
- ○ I do not expect to pass this course this semester and will need to retake the course.
- ○ I enjoy doing math, and I will be able to fulfill KU Core Goals or elective credits with one or more math courses.
- ○ Another reason: ____

For the following statements, please select the response that best aligns with your perceptions about yourself and your experiences as a math student. Please respond honestly, as there are no right or wrong answers, and your responses will be confidential. We are interested in learning about your true experience as a math student.

Q15 SRTime When I study for math, I try to study a little every day instead of waiting until the test or until the work is due.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q16 SEAssign I am confident that I will do an excellent job on assignments in my math course this semester.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q17 IGood People think of me as someone who is good at math.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q18 MLearn No matter who you are, you can learn math.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q19 SRPlace I usually choose a location to study math where there are few distractions.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q20 SEMatrl I am certain I will be able to understand the material presented in my math course.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q21 MSkAb I can improve my math skills, but I can't change my basic math ability.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q22 IOut I often feel out of place in math classes.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q23 SRHelp When I need help with math, I find someone who is knowledgeable in math, or I go to a math help room or tutor.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q24 SRTGoal I set goals to help manage studying time for my math classes.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q25 IMPers I see myself as a math person.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q26 MTalent To be honest, you can't really change how much math talent you have.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q27 SRLocEff I know where I can study most efficiently for math classes.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q28 SRTSched I try to schedule the same time every day or every week to study for my math classes, and I stick to the schedule.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q29 SEClass I expect to do well in my math class this semester.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q30 MIntel It's possible to change even your basic level of math intelligence.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q31 IPrais I have been praised for my ability to do math.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q32 SRXProb In math classes, I usually work extra math problems in addition to the assigned ones to master the course content.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q33 SRInst I am persistent in asking for help from my math instructors.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q34 IMPeople I don't really fit in with "math people".

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q35 MGetIt In math, there will always be some students who just don't "get it" and others that do.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q36 SEGrade I believe that I will receive an excellent grade in my math course.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q37 SRQuest I ask myself a lot of questions about course material when studying for math courses.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q38 SRRead I read aloud math instructions and math problems to fight against distractions.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q39 INotGood Others think I'm not very good at math.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q40 SESkills I am certain that I can master the skills being taught in my math course this semester.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q41 SRGoals I set short-term (daily or weekly) goals as well as long-term (monthly or for the semester) goals for getting work done in my math classes.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q42 MFix Math ability is something that remains relatively fixed throughout a person's life.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q43 IChall I can imagine myself successfully solving challenging math problems.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q44 SRSum I summarize my learning in math to examine my understanding of what I have learned.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q45 IOthPers Others see me as a math person.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Q46 SETest I am confident that I can do an excellent job on tests in my math course.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q47 MKnack Some people just have a knack for math, and some just don't.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Appendix B:

Mathematics Experiences and Perspectives Survey form 2 (MEPS2)

Information Statement (MEPS2)

You are invited to complete a short online survey that should take 10 minutes or less. The purpose of this survey is to gain information from you regarding your views about being a math student, as well as a little about your background in mathematics. This is the second of two invitations to complete the survey. There are no risks to you or others participating in this survey and the items included should not cause you any discomfort. Participation will not affect the outcomes of your mathematics course, nor your relationship with the University of Kansas in any way.

The Department of Curriculum and Teaching at the University of Kansas supports the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You should be aware that even if you agree to participate and begin the survey, you may choose not to complete it and your responses will not be saved.

Although participation may not benefit you directly, we believe that the information obtained from this study will help us better understand students who are taking freshmen math courses at KU and may help instructors do a better job of meeting students' needs in math. Your participation is solicited, although strictly voluntary. We have requested your KU email address in order to link your survey responses from the beginning of the semester to your responses at the end of the semester. Your name will not be associated in any publication or presentation with the information collected about you, or with the research findings from this study. Participation in this study will not affect your grade in your KU math course. Your identifiable information will not be shared unless (a) it is required by law or university policy, or (b) you give written permission. It is possible, however, with internet communications, that through intent or accident someone other than the intended recipient may see your response. Data gathered from this survey will be maintained securely until the conclusion of the study, anticipated to be May 2019, at which point downloaded data will be deleted.

If you would like additional information concerning this study before or after it is completed, please feel free to contact us by phone or email. Our contact information is listed below.

Completion of the survey indicates your willingness to take part in this study and that you are at least 18 years old. If you have any additional questions about your rights as a research participant, you may call (785) 864-7429 or write the Human Research Protection Program (HRPP), University of Kansas, 2385 Irving Hill Road, Lawrence, Kansas 66045-7563, email irb@ku.edu.

We wish you well as you complete your courses this semester! Click the right arrow to begin the survey.

Sincerely,
Katrina Rothrock, PhD Candidate, School of Education, Department of Curriculum & Teaching
rothrock@ku.edu; 785-864-8441
Dr. Susan Gay, Faculty Supervisor, Associate Professor of Mathematics Education
sgay@ku.edu; 785-864-9676

KU Lawrence IRB # STUDY00142674 | Approval Period 6/27/2018

Q1 ID	What is your KU online user ID (KU email address)? ______________________
Q2 Mclass	In which math course are you currently enrolled at KU? ○ MATH 002 ○ MATH 101 ○ MATH 125 ○ I am no longer enrolled in math this semester. The course I was previously enrolled in was: ____
Q3 Age	What is your age? ____
Q4 Gend	What is your gender? ○ Female ○ Male ○ Prefer to self-describe: ____
Q58 Intl	Are you an international student? ○ Yes ○ No
Q5 Ethn	Are you Hispanic/Latino? ○ Yes ○ No
Q6 Race	Are you: (Mark all that apply) ○ American Indian or Alaska Native ○ Asian ○ Black or African American ○ Native Hawaiian or Other Pacific Islander ○ White ○ Other: ____
Q7 HSGrad	In what year did you graduate from high school? ○ 2018 ○ 2017 ○ 2016 ○ 2015 or earlier ○ Passed GED or HSE exam instead. Year: __________________________
Q8 HSLocat	Where did you last attend high school? City ____ State/Province ____ Country ____
Q9 KUSem	What semester was your first semester at KU? ○ Spring Semester, Year: ____ ○ Summer Semester, Year: ____ ○ Fall Semester, Year: ____
Q10a PSecYN	AFTER you completed high school, have you ever taken courses, whether for credit or not for credit, at any institution besides KU (university, 4- or 2-year college, technical, vocational, or business school)? *Do not include any course experience completed PRIOR to graduating from high school.* ○ No ○ Yes
Display Q10b: If Q10a = Yes	
Q10b PSecInfo	Please share information about your post-high school course experience(s). Name of institution(s): ____ Semester(s) & Year(s): ____

Q11a Calc Did you take calculus in high school?
- ○ Yes, AP Calculus
- ○ Yes, other Calculus: ____
- ○ No

Display Q11b: If Q11a = No

Q11b PCalc Did you take Precalculus or Trigonometry in high school?
- ○ Yes, Precalculus
- ○ Yes, Trigonometry
- ○ Yes, both Precalculus and Trigonometry
- ○ No

Display Q11c: If Q11b = No

Q11c Alg2 Did you take Algebra 2 or (Integrated) Math 3 in high school?
- ○ Yes, Algebra 2
- ○ Yes, (Integrated) Math 3
- ○ No

Display Q11d: If Q11c = No

Q11d Geom Did you take Geometry or (Integrated) Math 2 in high school?
- ○ Yes, Geometry
- ○ Yes, (Integrated) Math 2
- ○ No

Display Q11e: If Q11d = No

Q11e Alg1 Did you take Algebra 1 or (Integrated) Math 1 in high school?
- ○ Yes, Algebra 1
- ○ Yes, (Integrated) Math 1
- ○ No

Q12 Maj What is your major (or intended major)? _________________________________

Q13 MWhy Why did you take the math course you are (or were) enrolled in? (Mark all that apply)
- ○ It fulfills a requirement (such as the KU Goal 1.2 requirement)
- ○ I really enjoy math.
- ○ I like to be challenged.
- ○ I had no choice. I was required to enroll in this course.
- ○ My advisor recommended that I take it.
- ○ My parent(s) or a former teacher encouraged me to take it.
- ○ It is a prerequisite for a future course.
- ○ I will need it for my future career.
- ○ I was placed in this course by my ACT/SAT/placement test score.
- ○ Another reason: ____

Q14a MFut After this semester, do you plan to enroll in another math course before you complete your degree?
- ○ No
- ○ Yes

Display Q14b: If Q14a = Yes

Q14b MFutWhy Reason(s) why I expect to take one or more math courses in the future: (Mark all that apply)
- ○ Taking an additional math course is required for my degree.
- ○ An additional math course was recommended by my parent(s), instructor, or university advisor.
- ○ I am good at math.
- ○ I will need more math courses for my future career.
- ○ I do not expect to pass this course this semester and will need to retake the course.
- ○ I enjoy doing math, and I will be able to fulfill KU Core Goals or elective credits with one or more math courses.
- ○ I dropped my math course this semester, so I will need to retake a math course.
- ○ Another reason: ____

For the following statements, please select the response that best aligns with your perceptions about yourself and your experiences as a math student. Please respond honestly, as there are no right or wrong answers, and your responses will be confidential. We are interested in learning about your true experience as a math student.

Q15 SRTime — This semester, when I studied for math, I tried to study a little every day instead of waiting until the test or until the work was due.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q16 SEAssign — I am confident that I will do an excellent job on the remaining assignments in my math course this semester.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q17 IGood — People think of me as someone who is good at math.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q18 MLearn — No matter who you are, you can learn math.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q19 SRPlace — I usually choose a location to study math where there are few distractions.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q20 SEMatrl — I am certain I will be able to understand the remaining material presented in my math course this semester.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q21 MSkAb — I can improve my math skills, but I can't change my basic math ability.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q22 IOut — I often feel out of place in math classes.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q23 SRHelp — When I needed help with math this semester, I found someone who is knowledgeable in math, or I went to a math help room or tutor.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q24 SRTGoal — This semester, I set goals to help manage studying time for my math class.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q25 IMPers — I see myself as a math person.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q26 MTalent — To be honest, you can't really change how much math talent you have.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q27 SRLocEff — I know where I can study most efficiently for math classes.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q28 SRTSched — This semester, I tried to schedule the same time every day or every week to study for my math class, and I kept to the schedule.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q29 SEClass — I expect to do well in my math class this semester.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q30 MIntel It's possible to change even your basic level of math intelligence.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q31 IPrais I have been praised for my ability to do math.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q32 SRXProb This semester, I usually worked extra math problems in addition to the assigned ones in order to master the course content.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q33 SRInst I am persistent in asking for help from my math instructors.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q34 IMPeople I don't really fit in with "math people".
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q35 MGetIt In math, there will always be some students who just don't "get it" and others that do.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q36 SEGrade I believe that I will receive an excellent grade in my math course.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q37 SRQuest I ask myself a lot of questions about course material when studying for math courses.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q38 SRRead I read aloud math instructions and math problems to fight against distractions.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q39 INotGood Others think I’m not very good at math.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q40 SESkills I am certain that I can master the skills being taught in my math course the rest of this semester.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q41 SRGoals This semester, I set short-term (daily or weekly) goals as well as long-term (monthly or for the semester) goals for getting work done in my math class.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q42 MFix Math ability is something that remains relatively fixed throughout a person's life.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q43 IChall I can imagine myself successfully solving challenging math problems.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q44 SRSum I summarize my learning in math to examine my understanding of what I have learned.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q45 IOthPers Others see me as a math person.
- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q46 SETest I am confident that I can do an excellent job on the final exam in my math course.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Q47 MKnack Some people just have a knack for math, and some just don't.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

Appendix C:

Construct Subscales and Item Changes from MEPS1 to MEPS2

Construct Subscales and Item Changes from MEPS1 to MEPS2

The information statement and all demographic items on MEPS1 remained unchanged for MEPS2 other than a few items that were revised to incorporate additional options or a shift in verb tense to reflect the change in timing of the survey distribution from the beginning of the semester to the end.

No.	MEPS1 item	MEPS2 item (if revised)	Reason for revision
Information statement and demographic items			
Info. State.	…your background in mathematics. You will receive two invitations to complete the survey, once at the beginning of the semester and once at the end, in order to compare responses over the course of time. There are no risks… …We wish you well in your courses this semester! Click the…	…your background in mathematics. This is the second of two invitations to complete the survey. There are no risks… …We wish you well as you complete your courses this semester! Click the…	The language needed to reflect that MEPS1 had already been administered, and also that the semester was coming to a close.
1.		*(no revisions)*	
2.	In which math course are you currently enrolled at KU? • MATH 002 • MATH 101 • MATH 125	In which math course are you currently enrolled at KU? • MATH 002 • MATH 101 • MATH 125 • I am no longer enrolled in math this semester. The course I was previously enrolled in was:________	Identify the Fall 2018 math course enrollment of all survey participants, including those who dropped their math course.
3.-12.		*(no revisions)*	
13.	Why are you taking this math course? (Mark all that apply)…	Why did you take the math course you are (or were) enrolled in? (Mark all that apply)…	The language needed to reflect that the semester was coming to a close, and that a student may have dropped his/her math course during the Fall 2018 semester.
14a.		*(no revisions)*	
14b.	*If Yes:* Reason(s) why I expect to take one or more math courses in the future: (Mark all that apply)…	*If Yes:* Reason(s) why I expect to take one or more math courses in the future: (Mark all that apply)… • I dropped my math course this semester, so I will need to retake a math course.	An option was needed for students who dropped their math course.
Mathematical mindset			
18.[a]	No matter who you are, you can learn math.	*(no revision)*	
21.[b]	I can improve my math skills, but I can't change my basic math ability.	*(no revision)*	
26.[b]	To be honest, you can't really change how much math talent you have.	*(no revision)*	
30.	It's possible to change even your basic level of math intelligence.	*(no revision)*	

35.[b]	In math, there will always be some students who just don't "get it" and others that do.	*(no revision)*	
42.[b]	Math ability is something that remains relatively fixed throughout a person's life.	*(no revision)*	
47.[b]	Some people just have a knack for math, and some just don't.	*(no revision)*	
Mathematical identity			
17.	People think of me as someone who is good at math. *social mathematical identity*	*(no revision)*	
22.[b]	I often feel out of place in math classes. *personal mathematical identity*	*(no revision)*	
25.	I see myself as a math person. *personal mathematical identity*	*(no revision)*	
31.	I have been praised for my ability to do math. *social mathematical identity*	*(no revision)*	
34.[b]	I don't really fit in with "math people". *personal mathematical identity*	*(no revision)*	
39.[b]	Others think I'm not very good at math. *social mathematical identity*	*(no revision)*	
45.	Others see me as a math person. *social mathematical identity*	*(no revision)*	
Mathematical self-efficacy			
16.	I am confident that I will do an excellent job on assignments in my math course this semester.	I am confident that I will do an excellent job on the remaining assignments in my math course this semester.	Self-efficacy items must be anticipatory.
20.	I am certain I will be able to understand the material presented in my math course.	I am certain I will be able to understand the remaining material presented in my math course this semester.	Self-efficacy items must be anticipatory.
29.	I expect to do well in my math class this semester.	*(no revision)*	
36.	I believe that I will receive an excellent grade in my math course.	*(no revision)*	
40.	I am certain that I can master the skills being taught in my math course this semester.	I am certain that I can master the skills being taught in my math course the rest of this semester.	Self-efficacy items must be anticipatory.
43.	I can imagine myself successfully solving challenging math problems.	*(no revision)*	
46.	I am confident that I can do an excellent job on tests in my math course.	I am confident that I can do an excellent job on the final exam in my math course.	Self-efficacy items must be anticipatory.
Use of self-regulated learning strategies in mathematics courses			
15.	When I study for math, I try to study a little every day instead of waiting until the test or until the work is due.	This semester, when I studied for math, I tried to study a little every	Reflection of the end-of-semester timing of the MEPS2.

	time management [c]	day instead of waiting until the test or until the work was due.	
19.	I usually choose a location to study math where there are few distractions. *environment structuring* [c]	*(no revision)*	
23.	When I need help with math, I find someone who is knowledgeable in math, or I go to a math help room or tutor. *help seeking* [c]	When I needed help with math this semester, I found someone who is knowledgeable in math to help me, or I went to a math help room or tutor.	Reflection of the end-of-semester timing of the MEPS2.
24.	I set goals to help manage studying time for my math classes. *goal setting* [c]	This semester, I set goals to help manage my studying time for math class.	Reflection of the end-of-semester timing of the MEPS2.
27.	I know where I can study most efficiently for math classes. *environment structuring* [c]	*(no revision)*	
28.	I try to schedule the same time every day or every week to study for my math classes, and I stick to the schedule. *time management* [c]	This semester, I tried to schedule the same time every day or every week to study for my math class, and I kept to the schedule.	Reflection of the end-of-semester timing of the MEPS2.
32. [a]	In math classes, I usually work extra math problems in addition to the assigned ones to master the course content. *task strategies* [c]	This semester, I usually worked extra math problems in addition to the assigned ones in order to master the course content.	Reflection of the end-of-semester timing of the MEPS2.
33.	I am persistent in asking for help from my math instructors. *help seeking* [c]	*(no revision)*	
37. [a]	I ask myself a lot of questions about course material when studying for math courses. *self evaluation* [c]	*(no revision)*	
38. [a]	I read aloud math instructions and math problems to fight against distractions. *task strategies* [c]	*(no revision)*	
41.	I set short-term (daily or weekly) goals as well as long-term (monthly or for the semester) goals for getting work done in my math classes. *goal setting* [c]	This semester, I set short-term (daily or weekly) goals as well as long-term (monthly or for the semester) goals for getting work done in my math class.	Reflection of the end-of-semester timing of the MEPS2.
44.	I summarize my learning in math to examine my understanding of what I have learned. *self evaluation* [c]	*(no revision)*	

Note. Info. State. = Information Statement.
[a]Item was not included in study analyses due to inadequate factor loading during item analysis. [b]Item was reverse-scaled when computing the subscale score. [c]Self-regulatory subscale identified by Barnard et al. (2009).

Appendix D:

MEPS1 & MEPS2 Item Sources

Sources for MEPS1 and MEPS2 Survey Items

Items included in the mathematical mindset, mathematical identity, mathematical self-efficacy, and use of self-regulated learning strategies subscales were taken directly from or were modified from items on existing scales.
MSLQ: Motivated Strategies for Learning Questionnaire (Pintrich, 1991)
OSLQ: Online Self-regulated Learning Questionnaire (Barnard, Lan, To, Paton, & Lai, 2009)
HSLS: High School Longitudinal Study of 2009 (NCES, 2009)
SMSES: Sources of Middle School Mathematics Self-Efficacy Scale (Usher & Pajares, 2009)
OPCS: Openness to Pedagogical Change Survey (Williams, 2015)

MEPS1 Item		Source Item(s)	Source Scale (Item No.)
15.	When I study for math, I try to study a little every day instead of waiting until the test or until the work is due.	I make sure I keep up with the weekly readings and assignments for this course. Although we don't have to attend daily classes, I try to distribute my studying time evenly across days.	MSLQ (70.) OSLQ (16.)
16.	I am positive that I will do an excellent job on assignments in my math course this semester.	You are confident that you can do an excellent job on assignments in this course. I'm confident I can do an excellent job on the assignments and tests in this course. I do well on math assignments. I do well on even the most difficult math assignments.	HSLS (S1MAssExcl) MSLQ (20.) SMSES (5.) SMSES (6.)
17.	People think of me as someone who is good at math.	My math teachers have told me that I am good at learning math. Other students have told me that I'm good at learning math. My classmates like to work with me in math because they think I'm good at it.	SMSES (13.) SMSES (17.) SMSES (18.)
18.	No matter who you are, you can learn math. *(no revisions)*	No matter who you are, you can learn math.	OPCS (24.)
19.	I usually choose a location to study math where there are few distractions.	I usually study in a place where I can concentrate on my course work. I choose the location where I study to avoid too much distraction.	MSLQ (35.) OSLQ (6.)
20.	I am certain I will be able to understand the material presented in my math course.	You are certain that you can understand the most difficult material presented in the textbook used in this course. I'm certain I can understand the most difficult material presented in the readings for this course.	HSLS (S1MTextbook) MSLQ (6.)

		I'm confident I can understand the most complex material presented by the instructor in this course.	MSLQ (15.)
21.	I can improve my math skills but I can't change my basic math ability.	I can improve my math skills but I can't change my basic math ability. There isn't much you can do about how much math ability you have.	OPCS (23.) OPCS (27.)
22.	I often feel out of place in math classes.	I don't really feel like a member of the math teaching profession.	OPCS (32.)
23.	When I need help with math, I find someone who is knowledgeable in math, or I go to a math help room or tutor.	Even if I have trouble learning the material in this class, I try to do the work on my own, without help from anyone. When I can't understand the material in this course, I ask another student in this class for help. I find someone who is knowledgeable in course content so that I can consult with him or her when I need help.	MSLQ (40.) MSLQ (68.) OSLQ (17.)
24.	I set goals to help manage studying time for my math classes.	When I study for this class, I set goals for myself in order to direct my activities in each study period. I set goals to help manage studying time for my online courses.	MSLQ (78.) OSLQ (4.)
25.	I see myself as a math person. *(no revisions)*	I see myself as a math person.	HSLS (S1MPerson1)
26.	To be honest, you can't really change how much math talent you have. *(no revisions)*	To be honest, you can't really change how much math talent you have.	OPCS (19.)
27.	I know where I can study most efficiently for math classes.	I have a regular place set aside for studying. I know where I can study most efficiently for online courses.	MSLQ (65.) OSLQ (8.)
28.	I try to schedule the same time every day or every week to study for my math class, and I stick to the schedule.	I find it hard to stick to a study schedule. I try to schedule the same time everyday or every week to study for my online courses, and I observe the schedule.	MSLQ (52.) OSLQ (15.)
29.	I expect to do well in my math class this semester.	I expect to do well in this class. Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class. Even when I study very hard, I do poorly in math.	MSLQ (21.) MSLQ (31.) SMSES (3.)

30.	It's possible to change even your basic level of math intelligence. *(no revisions)*	It's possible to change even your basic level of math intelligence.	OPCS (25.)
31.	I have been praised for my ability to do math.	I have been praised for my ability in math. People have told me I have a talent for math.	SMSES (16.) SMSES (14.)
32.	In math classes, I usually work extra math problems in addition to the assigned ones to master the course content.	I work extra problems in my online courses in addition to the assigned ones to master the course content.	OSLQ (13.)
33.	I am persistent in asking for help from my math instructors.	I am persistent in getting help from the instructor through email.	OSLQ (20.)
34.	I don't really fit in with "math people."	I can identify positively with other math teachers. I don't really feel like a member of the math teaching profession.	OPCS (30.) OPCS (32.)
35.	In math, there will always be some students who just don't "get it" and others that do.	In math there will always be some students who simply won't "get it."	OPCS (26.)
36.	I believe that I will receive an excellent grade in my math course.	I believe I will receive an excellent grade in this class.	MSLQ (5.)
37.	I ask myself a lot of questions about course material when studying for math courses.	I ask myself questions to make sure I understand the material I have been studying in this class. I ask myself a lot of questions about the course material when studying for an online course.	MSLQ (55.) OSLQ (22.)
38.	I read aloud math instructions and math problems to fight against distractions.	I read aloud instructional materials posted online to fight against distractions.	OSLQ (11.)
39.	Others think I'm not very good at math.	My math teachers have told me that I am good at learning math. Other students have told me that I'm good at learning math. My classmates like to work with me in math because they think I'm good at it.	SMSES (13.) SMSES (17.) SMSES (18.)
40.	I am certain that I can master the skills being taught in my math course this semester.	You are certain that you can master the skills being taught in this course. I'm certain I can master the skills being taught in this class.	HSLS:09 (S1MSkills) MSLQ (29.)

41.	I set short-term (daily or weekly) goals as well as long-term (monthly or for the semester) goals for getting work done in my math classes.	When I study for this class, I set goals for myself in order to direct my activities in each study period. I set short-term (daily or weekly) goals as well as long-term goals (monthly or for the semester).	MSLQ (78.) OSLQ (2.)
42.	Math ability is something that remains relatively fixed throughout a person's life. *(no revisions)*	Math ability is something that remains relatively fixed throughout a person's life. There isn't much you can do about how much math ability you have.	OPCS (21.) OPCS (27.)
43.	I can imagine myself successfully solving challenging math problems.	I think of myself as very good at math. When I see how my math teacher solves a problem, I can picture myself solving the problem in the same way. I imagine myself working through challenging math problems successfully.	OPCS (33.) SMSES (8.) SMSES (11.)
44.	I summarize my learning in math to examine my understanding of what I have learned.	When studying for this course I try to determine which concepts I don't understand well. I summarize my learning in online courses to examine my understanding of what I have learned.	MSLQ (76.) OSLQ (21.)
45.	Others see me as a math person. *(no revisions)*	Others see me as a math person.	HSLS (S1MPerson2)
46.	I am confident that I can do an excellent job on tests in my math course.	You are confident that you can do an excellent job on tests in this course. I make excellent grades on math tests.	HSLS (S1MTests) SMSES (1.)
47.	Some people just have a knack for math, and some just don't. *(no revisions)*	Some people just have a knack for math and some just don't.	OPCS (20.)

Appendix E:

Demographic Data

Demographic Summary for Group 1 and Group 2 Participants

	Group 1								Group 2							
	Total (n=299[a])		Int Alg (n=52[a])		Coll Alg (n=203)		Calc I (n=44)		Total (n=176)		Int Alg (n=24)		Coll Alg (n=91)		Calc I (n=61)	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Total	119	179	18	33	74	129	27	17	67	109	6	18	24	67	37	24
HS mathematics course experience	(n=297[a,b])								(n=176)							
No advanced mathematics	38	42	8	11	28	30	2	1	9	30	3	7	6	22		1
Advanced mathematics	81	135	10	22	46	97	25	16	58	79	3	11	18	45	37	23
Age	(n=294[a,c])								(n=165[d])							
16 – 17	5	8	2	1	2	4	1	3		2		1				1
18 – 19	102	168	13	30	64	124	25	14	60	101	5	16	23	62	32	23
20+	8	2	3	1	4	1	1			2		1		1		
Ethnicity	(n=299[a])								(n=176)							
Hispanic	13	16	2	3	7	12	4	1	5	8			1	5	4	3
Race	(n=291[a,e])								(n=173[f])							
American Indian or Alaska Native	1				1					1						1
Asian	16	12	1	2	10	5	5	5	6	4	1		1	4	4	
Black or African American	6	13	3	5	3	8			1	1	1	1				
White	88	137	12	20	56	105	20	12	55	92	4	13	21	58	30	21
Two or more races	4	11	1	5	2	6	1		5	7		3	2	2	3	2
Other	1	1		1			1			1		1				
International students: HS country	(n=22)								(n=9)							
Canada										1		1				
China	2				1		1									
Colombia	1		1													
India	1	2	1	1				1	2		1				1	
Indonesia	1	2			1	1		1	1				1			
Kuwait		2		2												
New Zealand	1		1													
Nigeria	1	2	1	2					1	2	1	2				

South Korea	2				2											
Taiwan	1				1											
United States[g]	2				1		1		1						1	
Vietnam		2				1		1		1				1		
Domestic students: HS state	(*n*=277[a])								(*n*=167)							
Arkansas		2				2				1				1		
California		5		2		2		1		2		1		1		
Colorado	6	5		1	5	4	1		3	3		1	3	1		1
Florida	1	1		1	1											
Illinois	8	16		2	8	12		2	3	9		1	2	7	1	1
Indiana		1				1										
Iowa		4		1		3				2		1		1		
Kansas	63	88	9	18	36	62	18	8	39	51	2	8	10	32	27	11
Kentucky		1				1										
Massachusetts		2		1		1										
Michigan	2	1			2	1										
Minnesota	5	6		1	3	5	2		2	3	1	1	1	2		
Missouri	8	21	2		5	20	1	1	9	18			5	12	4	6
Nebraska	4	4	1		3	3		1	2	6		1	1	3	1	2
New Jersey										1				1		
North Carolina	1		1													
Ohio	1		1													
Oklahoma	1	2			1	2			1	2				2	1	
Pennsylvania	2	1			1	1	1		2				1		1	
South Dakota	1						1									
Tennessee										1		1				
Texas	3	6		1	2	4	1	1	1	2	1			1		1
Virginia	1				1					1						1
Washington		1				1										
Wisconsin		2				2				1				1		
American student in Stuttgart, Germany									1						1	
Did not identify		1				1				2				1		1

Expected major	(*n*=299[a])								(*n*=176)							
Arts & humanities[h]	7	6	3	1	3	5	1			6		1		5		
Business[i]	50	25	7	4	43	21			12	14	4	3	8	11		
Health & medicine[j]	6	49	1	10	5	38		1	3	21		3	2	18	1	
Public and social services[k]										1				1		
Social science[l]	11	48	3	9	8	38		1	9	31		7	8	23	1	1
STEM[m]	41	42	4	7	12	20	25	15	41	33	2	3	6	7	33	23
Undecided	4	9		2	3	7	1		2	3		1		2	2	

Note. Int Alg = Intermediate Algebra; Coll Alg = College Algebra; Calc I = Calculus I; M = male; F = female; HS = high school.

[a]One participant enrolled in Intermediate Algebra identified as neither female nor male, so was not included in the disaggregated counts. [b]Two female students in College Algebra did not respond to this item. [c]One female student in Intermediate Algebra and four male students in College Algebra did not respond to this item. [d]One male student in Intermediate Algebra, one male and four female students in College Algebra, and five male students in Calculus I did not respond to this item. [e]One male student in Intermediate Algebra and five female and two male students in College Algebra did not respond to this item. [f]Three female students in Intermediate Algebra did not respond to this item. [g]There were students who identified themselves as international students, but stated that they had completed high school in the United States. In Group 1, one was from New York and one was from Kansas. In Group 2, one was from Kansas. [h]Specific majors mentioned by students included dance, film, languages, linguistics, theater, and visual art. [i]Specific majors included accounting, business analytics, business administration, finance, management (business, sports, and supply chain), and marketing and sales. [j]Specific majors included behavioral science, community health, dance or music therapy, dentistry, exercise science, nursing, occupational therapy, pharmacy, physical therapy, premedicine, speech language audiology, and speech pathology. [k]The specific major was social welfare. [l]Specific majors included anthropology, applied behavioral science, communications and journalism, education, economics, global or international studies, history, political science, psychology, social work, and sociology. [m]Specific majors included architecture, computer science, engineering (aerospace, architectural, chemical, civil, computer, electrical, mechanical, and physics), information technology, mathematics, and physical sciences (atmospheric, biochemistry, biology, biotechnology, chemistry, and physics).

Demographic Summary for Two-Time Participants in Both Groups 1 and 2

	Groups 1 and 2 two-time participants							
	Total (*n*=68)		Intermediate Algebra (*n*=12)		College Algebra (*n*=41)		Calculus I (*n*=15)	
	Male	Female	Male	Female	Male	Female	Male	Female
Total	20	48	3	9	9	32	8	7
High school mathematics course experience (*n*=68)								
No advanced mathematics	4	11	2	3	2	8		
Advanced mathematics	16	37	1	6	7	24	8	7
Age[a] (*n*=68)								
16 – 17	3	2	1	1	2			1
18 – 19	17	46	2	8	7	32	8	6
Ethnicity (*n*=68)								
Hispanic	2	2			1	1	1	1
Race (*n*=68)								
American Indian or Alaska Native								
Asian	3	1			1	1	2	
Black or African American	1	1	1	1				
White	15	44	2	7	7	30	6	7
Two or more races	1	1			1	1		
Other		1		1				
International students: high schol country (*n*=6)								
Indonesia	1				1			
Nigeria	1	2	1	2				
United States[b]	1						1	
Vietnam		1				1		
Domestic students: high school state (*n*=62)								
Arkansas		1				1		
California		2		1		1		
Colorado	2	1			2	1		
Illinois		5				4		1
Iowa		1				1		
Kansas	9	20	2	5	2	12	5	3
Minnesota		2		1		1		

Missouri	3	9			2	8	1	1
Nebraska	1	1			1			1
Oklahoma		2				2		
Pennsylvania	2				1		1	
Texas		1						1
Expected major[a] (*n*=68)								
Arts & humanities[c]		1				1		
Business[d]	4	10	2	2	2/3[i]	8/7[i]		
Health & medicine[e]	1	10		2	1	8/7[i]		
Public and social service[f]						0/1[i]		
Social science[g]	2	11		2	2/3[i]	9/12[i]		
STEM[h]	13	13	1	2	4/2[i]	4/3[i]	8	7
Undecided		3		1		2/1[i]		

[a]Documented as of the beginning of the Fall 2018 semester. [b]One student identified as an international student, but stated that he had completed high school in Kansas. [c]The specific major was language. [d]Specific majors included accounting, business analytics, business administration, management (business and sports), and marketing and sales. [e]Specific majors included community health, exercise science, nursing, premedicine, and speech pathology. [f]The specific major was social welfare. [g]Specific majors included applied behavioral science, communications and journalism, education, economics, global or international studies, political science, and psychology. [h]Specific majors included architecture, computer science, engineering (aerospace, architectural, civil, electrical, and mechanical), information technology, mathematics, and physical sciences (atmospheric, biology, biotechnology, and physics). [i]Some two-time participants changed their expected major from the beginning of the semester to the end, so overall frequencies of participants are listed with two counts if the total changed: beginning of the semester/end of the semester.

Appendix F:

Expert Review of Construct Items

Instructions: Please categorize each of the statements (on the second page) as a statement of: Mathematical Identity (MI), Mathematical Mindset (MM), Mathematical self-efficacy (MSE), or Self-regulation in math classes (SRM). I have included the following definitions so that you know how I have defined each within my writing. Do not worry if you do not have experience with one or more of these constructs, simply do your best to categorize the statements as you see them with reference to these definitions.

Mathematical Identity	Identity is a self-created construct, developed both by how one perceives oneself and how one perceives his or her relationship to others (Kaasila, Hannula, & Laine, 2012). People develop multiple identities, depending on the context and the relationships they develop within any particular context (Boaler et al., 2000; Black et al., 2010; Gee, 2000; Kaasila, 2007; Lutovac & Kaasila, 2011). One uses mathematical identity to make sense of his or her position in relation to mathematics and others within mathematical communities (Cribbs et al., 2015; Kaasila et al., 2012), which may include classroom communities, professional communities, and social communities outside of mathematics (Solomon, 2007). A mathematical identity includes "the dispositions and deeply held beliefs that students develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics in powerful ways across the contexts of their lives" (Aguirre et al., 2013, p. 14).
Mathematical Mindset	Those who hold a growth mathematics mindset believe that intelligence and math ability is malleable, controllable, and thus increasable (Dweck & Leggett, 1988). It is something they can foster through learning opportunities and effort (Dweck, 1999). Individuals who hold a fixed mathematics mindset tend to believe that intelligence and math ability is a static and largely uncontrollable trait. It is viewed as an entity that exists within each individual in a fixed quantity that cannot be changed.
Mathematical Self-efficacy	Perceived mathematics self-efficacy is one's beliefs about their capabilities to attain designated levels of math performance. Perceived self-efficacy is about what people believe they are capable of achieving, rather than what they have achieved, or a personal characteristic, psychological trait, or how they feel about themselves (Bandura, 2006; Zimmerman, 1995, 2000b).
Self-regulation in math classes	Self-regulation in math classes is referring to "the degree to which students are metacognitively, motivationally, and behaviorally active participants in their own learning process" (Zimmerman, 2008, p.167) for mathematics. Metacognitively, self-regulated learners plan, organize, self-instruct, self-monitor, and self-evaluate (Zimmerman, 1986). Motivationally, self-regulated learners perceive themselves as competent, self-efficacious, and autonomous (Zimmerman, 1986). Behaviorally, self-regulated learners select, structure, and create environments that optimize learning (Zimmerman, 1986).

	Statements	MI, MM, MSE, or SRM
Q15	When I study for math, I try to study a little every day instead of waiting until the test or until the work is due.	
Q16	I am confident that I will do an excellent job on assignments in my math course this semester.	
Q17	People think of me as someone who is good at math.	
Q18	No matter who you are, you can learn math.	
Q19	I usually choose a location to study math where there are few distractions.	
Q20	I am certain I will be able to understand the material presented in my math course.	
Q21	I can improve my math skills, but I can't change my basic math ability.	
Q22	When I am learning math, I often find it difficult to understand what to do.	
Q23	When I need help with math, I find someone who is knowledgeable in math, or I go to a math help room or tutor.	
Q24	I set goals to help manage studying time for my math classes.	
Q25	I see myself as a math person.	
Q26	To be honest, you can't really change how much math talent you have.	
Q27	I know where I can study most efficiently for math classes.	
Q28	I try to schedule the same time every day or every week to study for my math classes, and I stick to the schedule.	
Q29	I expect to do well in my math class this semester.	
Q30	It's possible to change even your basic level of math intelligence.	
Q31	I have been praised for my ability to do math.	
Q32	In math classes, I usually work extra math problems in addition to the assigned ones to master the course content.	
Q33	I am persistent in asking for help from my math instructors.	
Q34	I don't really fit in with "math people".	
Q35	In math, there will always be some students who just don't "get it" and others that do.	
Q36	I believe that I will receive an excellent grade in my math course.	
Q37	I ask myself a lot of questions about course material when studying for math courses.	
Q38	I read aloud math instructions and math problems to fight against distractions.	
Q39	When my answer to a math problem doesn't match another person's answer, I usually assume my answer is wrong.	
Q40	I am certain that I can master the skills being taught in my math course this semester.	
Q41	I set short-term (daily or weekly) goals as well as long-term (monthly or for the semester) goals for getting work done in my math classes.	
Q42	Math ability is something that remains relatively fixed throughout a person's life.	
Q43	I can imagine myself successfully solving challenging math problems.	
Q44	I summarize my learning in math to examine my understanding of what I have learned.	
Q45	Others see me as a math person.	
Q46	I am confident that I can do an excellent job on tests in my math course.	
Q47	Some people just have a knack for math, and some just don't.	

Appendix G:

Initial Factor Loadings for MEPS1

MEPS1 Initial Factor Loadings for Maximum Likelihood Factor Analysis With Varimax Rotation of Construct Subscales

	Factors			
Item	Mindset	Identity	Self-eff	Self-reg
Mathematical mindset				
18. No matter who you are, you can learn math.	.349	.087	.387	.205
21. I can improve my math skills, but I can't change my basic math ability.	**.459**	.069	.015	-.058
26. To be honest, you can't really change how much math talent you have.	**.675**	.099	.236	.093
30. It's possible to change even your basic level of math intelligence.	**.429**	.051	.287	.226
35. In math, there will always be some students who just don't "get it" and others that do.	**.549**	.212	.055	.014
42. Math ability is something that remains relatively fixed throughout a person's life.	**.528**	.017	-.038	-.207
47. Some people just have a knack for math, and some just don't.	**.495**	.205	.031	.070
Mathematical identity				
17. People think of me as someone who is good at math.	.039	**.828**	.277	.077
22. I often feel out of place in math classes.	.243	**.472**	**.409**	-.028
25. I see myself as a math person.	.071	**.763**	.273	.127
31. I have been praised for my ability to do math.	.141	**.747**	.201	.094
34. I don't really fit in with "math people".	.287	**.520**	.259	.059
39. Others think I'm not very good at math.	.254	**.571**	.274	.010
45. Others see me as a math person.	.146	**.815**	.246	.027
Mathematical self-efficacy				
16. I am confident that I will do an excellent job on assignments in my math course this semester.	.004	.354	**.693**	.220
20. I am certain I will be able to understand the material presented in my math course.	.061	.304	**.675**	.167
29. I expect to do well in my math class this semester.	.034	.230	**.784**	.162
36. I believe that I will receive an excellent grade in my math course.	.061	.279	**.741**	.222
40. I am certain that I can master the skills being taught in my math course this semester.	.101	.239	**.755**	.178
43. I can imagine myself successfully solving challenging math problems.	.224	.364	**.483**	.169
46. I am confident that I can do an excellent job on tests in my math course.	.100	.250	**.745**	.142
Use of self-regulated learning strategies in mathematics courses				
15. When I study for math, I try to study a little every day instead of waiting until the test or until the work is due.	.075	.114	.147	**.455**
19. I usually choose a location to study math where there are few distractions.	.117	-.116	-.007	**.540**
23. When I need help with math, I find someone who is knowledgeable in math, or I go to a math help room or tutor.	.004	-.056	.118	**.465**
24. I set goals to help manage studying time for my math classes.	-.012	.164	.105	**.707**
27. I know where I can study most efficiently for math classes.	.064	-.033	.242	**.410**
28. I try to schedule the same time every day or every week to study for my math classes, and I stick to the schedule.	-.188	.096	.041	**.600**

32. In math classes, I usually work extra math problems in addition to the assigned ones to master the course content.	.050	.232	.055	.349
33. I am persistent in asking for help from my math instructors.	-.027	.084	.234	**.477**
37. I ask myself a lot of questions about course material when studying for math courses.	.027	-.014	-.020	.373
38. I read aloud math instructions and math problems to fight against distractions.	-.194	.038	.092	.309
41. I set short-term (daily or weekly) goals as well as long-term (monthly or for the semester) goals for getting work done in my math classes.	.006	.093	.141	**.680**
44. I summarize my learning in math to examine my understanding of what I have learned.	.045	.119	.324	**.427**

Note. Factor loadings > .40 are in boldface. Mindset = mathematical mindset subscale; Identity = mathematical identity subscale; Self-eff = mathematical self-efficacy subscale; Self-reg = use of self-regulated learning strategies subscale.

Appendix H:

Survey and Directions Used for the Field Test

Directions. Following a brief introduction, the researcher gave oral directions. The following is the script prepared prior to the administration of the survey, which formed the basis for the informal instructions shared.

> We have the rest of class to spend on this survey. Please respond to the best of your ability. If you encounter a statement or question that is confusing, uncomfortable, or incorrect, please mark the item and share a comment because that will help me improve that item. When you are finished with the survey, please place it in the folder at the front of the classroom as you leave. Because everyone's survey responses are anonymous, none of the information you share will be associated with you personally. If you are uncomfortable answering any of the questions, do not feel that you need to answer, but I would appreciate you marking the question to let me know. Thank you again for your willingness to participate in the preparation of my research study!

MATH 109 Field Test of the First Year Freshman Mathematics Survey

1. What is your age? __________

2. In what year did you graduate from high school? (Circle one)

2017 2016 2015 2014 or earlier Passed GED or HSE exam instead (Year:_______)

3. Where did you last attend high school?

City:____

State/Province:________________________________ Country:____________________

4. What is your gender?

Female Male Transgender Prefer to self-describe Prefer not to say

5. Are you Hispanic? (Circle one) Yes No

6. Are you: (Mark all that apply)

___ American Indian/Alaskan Native

___ Asian

___ Black

___ Native Hawaiian/Pacific Islander

___ White

___ Two or More Races

7. What semester was your first semester at KU? (Mark one)

___ Spring Semester, Year: _____________

___ Summer Semester, Year: ____________

___ Fall Semester, Year: ________________

8. Since leaving high school, have you ever taken courses, whether for credit or not for credit, anywhere besides KU (university, 4- or 2-year college, technical, vocational, or business school)?

___ No (move on to next question)

___ Yes. Institution: ____

Semester(s) (Spring/Summer/Fall) ________________________ Year(s): ________

Name or description of course(s): ______________________________________

COMMENTS

What was unclear, confusing, or awkward? Please share any suggestions for how to improve these questions.

9. Please mark which math courses you have taken previously, and circle when you took them: ***before high school (⬅), 9th grade, 10th grade, 11th grade, 12th grade, or after high school (➡)***

COMMENTS

Course						
Algebra I:	⬅	9th	10th	11th	12th	➡
Algebra II:	⬅	9th	10th	11th	12th	➡
Geometry:	⬅	9th	10th	11th	12th	➡
Integrated Math I:	⬅	9th	10th	11th	12th	➡
Integrated Math II:	⬅	9th	10th	11th	12th	➡
Integrated Math III:	⬅	9th	10th	11th	12th	➡
Precalculus/Trigonometry:	⬅	9th	10th	11th	12th	➡
Calculus:	⬅	9th	10th	11th	12th	➡
AP Calculus:	⬅	9th	10th	11th	12th	➡
Probability/Statistics:	⬅	9th	10th	11th	12th	➡
AP Statistics:	⬅	9th	10th	11th	12th	➡
Other:______________________	⬅	9th	10th	11th	12th	➡

Circle the best response that represents your opinion of the extent to which you agree or disagree with the following statements.
Strongly Agree (SA), Agree (A), Neither Agree Nor Disagree (N), Disagree (D), Strongly Disagree (SD)

10. When I study for math, I try to study a little every day instead of waiting until the test or until the work is due.	SA	A	N	D	SD
11. I am positive that I will do an excellent job on assignments in this course.	SA	A	N	D	SD
12. People think of me as someone who can help others do math.	SA	A	N	D	SD
13. No matter who you are, you can learn math.	SA	A	N	D	SD
14. I choose a location to study math where there are few distractions.	SA	A	N	D	SD
15. I am certain I will be able to understand the material presented in this course.	SA	A	N	D	SD
16. I can improve my math skills but I can't change my basic math ability.	SA	A	N	D	SD
17. When I am learning math, I often find it difficult to understand what to do.	SA	A	N	D	SD
18. When I need help, I find someone who is knowledgeable in math, or I go to a math help room or tutor.	SA	A	N	D	SD
19. I set goals to help manage studying time for my math classes.	SA	A	N	D	SD
20. I see myself as a math person.	SA	A	N	D	SD
21. To be honest, you can't really change how much math talent you have.	SA	A	N	D	SD

Circle the best response that represents your opinion of the extent to which you agree or disagree with the following statements.
Strongly Agree (SA), Agree (A), Neither Agree Nor Disagree (N), Disagree (D), Strongly Disagree (SD)

22. I know where I can study most efficiently for math classes.	SA	A	N	D	SD
23. I try to schedule the same time every day or every week to study for my math class, and I stick to the schedule.	SA	A	N	D	SD
24. I expect to do well in this class.	SA	A	N	D	SD
25. It's possible to change even your basic level of math intelligence.	SA	A	N	D	SD
26. I have been praised for my ability to do math.	SA	A	N	D	SD
27. I work extra math problems in addition to the assigned ones to master the course content.	SA	A	N	D	SD
28. I am persistent in asking for help from my instructor.	SA	A	N	D	SD
29. I don't really fit in with "math people".	SA	A	N	D	SD
30. In math there will always be some students who just don't "get it" and others that do.	SA	A	N	D	SD
31. I believe that I will receive an excellent grade in this course.	SA	A	N	D	SD
32. I ask myself a lot of questions about course material when studying for math courses.	SA	A	N	D	SD
33. I read aloud math instructions and math problems to fight against distractions.	SA	A	N	D	SD
34. When my answer to a math problem doesn't match another person's answer, I usually assume my answer is wrong.	SA	A	N	D	SD
35. I am confident that I can master the skills being taught in this course.	SA	A	N	D	SD
36. I set short-term (daily or weekly) goals as well as long-term goals (monthly or for the semester).	SA	A	N	D	SD
37. Math ability is something that remains relatively fixed throughout a person's life.	SA	A	N	D	SD
38. I can imagine myself successfully solving challenging math problems.	SA	A	N	D	SD
39. I summarize my learning in math to examine my understanding of what I have learned.	SA	A	N	D	SD
40. Others see me as a math person.	SA	A	N	D	SD
41. I am confident that I can do an excellent job on tests in this course.	SA	A	N	D	SD
42. Some people just have a knack for math and some just don't.	SA	A	N	D	SD

Thank you for taking time to take this survey. I greatly appreciate your assistance with my doctoral research!

COMMENTS