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Attitudes Towards Mathematics of Developmental Mathematics Students in a Community College

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ATTITUDES TOWARDS MATHEMATICS OF DEVELOPMENTAL STUDENTS IN A COMMUNITY COLLEGE

A Thesis

by

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ABSTRACT

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Reformations to developmental mathematics aim to remove barriers for students entering higher education. Challenges like costly multi-course sequences and high failure rates prohibit students' access to college-level math courses and prevent degree or certification completion. Understanding factors that foster student success is critical to increase student success. This study focuses on students' attitudes towards mathematics, utilizing the novice-expert continuum through Code et al.'s Mathematical Attitude and Perceptions Survey (MAPS) instrument. Student expertise scores, including all MAPS dimensions and specific dimension scores, were assigned. Kruskal-Wallis Rank-Sum tests identified differences in student populations by course and attitude dimension. Wilcoxon Rank-Sum tests pinpointed specific course differences. Supplemental survey responses and student interviews, analyzed qualitatively through thematic analysis, highlighted factors like positive attitude, self-confidence, and motivation. Students also emphasized course aspects contributing to various attitude dimensions, such as real-world applications.

DEDICATION

First and foremost, this work is dedicated to my parents, Joe and Linda Ortiz. Dad, thank you for showing me that education is possible at any age. Mom, thank you for always believing that higher education was always meant to be my journey. To my brothers, Joseph and Joshua Ortiz, and all of the Ortiz clan: Maylene, Connie, Christopher, Anastazia, Damian, Michael, Alyssa, Joseph, Lola, Caleb, Myles and Mateo, I strive to succeed because of you. Remember that if Tio Ben can do this, so can you. To the faculty of Midland College: Alma Brannan, I can never repay you for your kindness and support. Dr. Paul Mangum, thank you for being my mentor. To Dr. Krista Cohlmia, Sarah Hildebrand and Jaime Kneisley, thank you for your guidance and friendship. I don't know what I would do without you. To Dr. Sonia Ford Petch, Joey Severino, Lori Thomas, Dr. Michael Dixon, and Anansa Green: my time with you was pivotal in my academic journey. Thank you for believing in me. To Dr. Angela Brown, you have my eternal gratitude. To Connie Sanchez, the first person who recognized my mathematical ability: Your guidance, encouragement, and support are invaluable, and I am honored to call you friend. To my three cats: RuPaw, Darth Kittius, and Obi-Cat Kenobi, you have been my sanity, and I do this to give you the best life I can. Finally, to the most important person in my life, Pete Liles: Words are not enough, so I won't even try. You are everything.

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CHAPTER I

INTRODUCTION

Students enrolling in community colleges and universities often find that they are not ready for the demands of college-level courses. In Texas, these standards are established by the Texas Success Initiative (Texas Higher Education Coordinating Board, 2023). The state of Texas estimates that approximately 40% of enrolling in higher education will be placed into developmental education (Texas Higher Education Coordinating Board, 2018). However, at community colleges this proportion tends to be higher, typically around 60% (Ryu, et al., 2022). Developmental education is intended to provide equity of opportunity for education, social mobility, and economic stability (Bahr, 2008; Bahr, 2010). Academic research in developmental education shows that the traditional model of developmental mathematics has created barriers to student success (Alkhateeb, 2022). Multiple course sequences, high rates of failure, and increasing costs on students are all barriers to students gaining access to courses that contribute to their degree/certification programs (Alkhateeb, 2022; Fong & Zientek, 2019; Logue et al., 2019; Hennessey et al., 2021).

Current reformations to developmental mathematics courses are meant to alleviate these barriers and provide equitable access to college-level courses. In an effort to minimize the time a student spends in developmental mathematics and increase student success, the 60x30TX plan states that developmental math courses should transition to the co-requisite model. The co-requisite model allows a student to enroll in a credit-granting course with an additional support course designed to increase student success (Texas Higher Education Coordinating Board, 2018). To promote students' success in these co-requisite courses, researchers need to address how these courses can foster positive student attitudes toward mathematics.

A key factor of student performance in mathematics courses is attitude (Mazana et al., 2019). Many students enrolled in developmental mathematics courses have a previously established negative attitude towards mathematics which should be taken into consideration when developing interventions (Dogbey, 2010). The nature of the co-requisite model allows for the development of interventions designed to improve students' attitudes towards mathematics. The goal of this study is to investigate students' attitudes toward mathematics under the co-requisite model in comparison to students in a traditional developmental algebra course.

CHAPTER II

LITERATURE REVIEW

2.1 Developmental Education

Many students enrolling in college for the first time find themselves unprepared academically for college-level coursework. In Texas, the criterion that determines if a student is ready for the rigor of college-level coursework is established by the Texas Success Initiative (TSI) (Texas Higher Education Coordinating Board, 2023). Those students who do not meet the guidelines established by the TSI are placed into developmental education courses in order to allow students to build the skill sets that are necessary to be successful in higher education. The content in these courses is often high school level or below, and these courses do not grant credit towards a degree or certification (Texas Higher Education Coordinating Board, 2018). For the students who are not ready for college-level mathematics courses, this content runs the span from arithmetic to Intermediate Algebra (Cafarella, 2021).

Developmental education could provide equity of opportunity for education and social mobility and economic stability (Bahr, 2008; Bahr, 2010). In Texas, economic disadvantage is the most successful measure in predicting if an individual will continue past a high school education (Texas Higher Education Coordinating Board, 2015). In addition to economic disadvantages, developmental education can help rectify disparities developed due to race and gender (Bahr, 2008). In Texas, as of 2020, approximately 20.7% of African American students who took the SAT or ACT met the TSI criteria for mathematics. Also, only 25.1% of Hispanic students and 35.5% of female students were considered to have met this criteria.

Historically, developmental courses tended to be a sequence of courses that took place over several semesters, with some students taking three to four semesters to complete them before placement into a college-level mathematics course (Brathwaite et al., 2020). These courses typically involved some combination of arithmetic, pre-algebra, elementary and intermediate algebra with the intention of preparing students for College Algebra and eventually, Calculus (Howell & Walkington, 2022; Cullinane & Treisman, 2010; Fitzpatrick & Sovde, 2017). Research is now showing that this developmental model has created a barrier to student success (Alkhateeb, 2022). Developmental mathematics courses have high rates of failure and have the highest drop out rates in comparison with other developmental courses (Alkhateeb, 2022; Fong & Zientek, 2019; Logue et al., 2019). Since traditional models of developmental mathematics included multiple courses, this provided more opportunities for students to fail before being allowed to take a credit-granting course, which prevented students from achieving their academic goals (Logue et al., 2019). Brathwaite et al. (2020) explain that underrepresented groups in higher education are more likely to be placed into developmental education, which research findings show is preventing access to credit-bearing courses. In addition to academic barriers, the cost of developmental education for the student is an additional barrier placed upon the student paying for multiple courses that do not grant college credit, which delays their successful completion of their academic goals (Hennessey et al., 2021). These barriers are disproportionately placed in front of students of color and other marginalized groups because of the increased likelihood of their placement into developmental mathematics (Brathwaite et al., 2020).

Because of these barriers to equitable student success, there currently is a reformation of developmental mathematics courses in the state of Texas. Two changes to developmental models are the use of mathematical pathways and accelerated course models (Ryu et al., 2022). A majority of college students do not need College Algebra for their academic majors; however, it has become the default math course for a majority of degree plans (Fitzpatrick & Sovde, 2017). Mathematical pathways allow students to enroll in courses such as Statistics and Quantitative Reasoning in order to fulfill their math requirements for their degree or certification program. Accelerated models are meant to allow a student to become college ready with fewer courses. One such accelerated model is the co-requisite model in which a student enrolls in a credit-granting course with an additional support course designed to increase student success (Texas Higher Education Coordinating Board, 2018).

Early research of the co-requisite model indicates increased student success and is an effective and efficient method to approach developmental mathematics education (Ryu et al., 2022). However, these reforms have been inadequate in resolving the inequities of placement into developmental mathematics and successful course completion rates of underrepresented populations (Brathwaite et al., 2020).

2.2 Placement into Developmental Education

The Texas Success Initiative Assessment (TSIA) was designed by the Texas Success Initiative program in order to determine whether a student enrolling in a higher education institution is ready for college level coursework (Texas Higher Education Coordinating Board, 2023). Students must make a minimum of 950 or a 950 with a diagnostic level 6 in order to be considered ready for college level mathematics (Texas Education Agency, 2022). Not all students enrolling in higher education are required to take the TSIA upon enrollment. For mathematics specifically, if a student has a composite score of 23 with a minimum of 19 on the mathematics portion of the ACT test, they are considered exempt from the TSIA, meaning they are ready for college-level mathematics (Texas Education Agency, 2022). Also, for a student taking the SAT, those who earn a minimum of 530 in the mathematics portion are considered as ready for college-level coursework (Texas Education Agency, 2022). There are other possibilities for a student to be exempt from the TSIA. For example, if a student has served at least three years in the military, is a veteran, or is on active duty or reserves, they are TSIA exempt. Also, a student transferring from one institution to another, who has already completed a college-level math course is also exempt from taking the TSIA (Texas Education Agency, 2022).

The Texas Education Agency estimated that approximately 62% of graduating high school seniors did not meet the Texas Success Initiative, or TSI, criteria for mathematics based on student SAT scores. For the students taking the ACT, 69.8% did not meet TSI criteria (Texas Education Agency, 2021). Additionally, the Texas Higher Education Coordinating Board estimates that nearly 40% of students enrolling in a public institution of higher education in Texas are not TSI ready to enroll in college-level courses (Texas Higher Education Coordinating Board, 2018).

The SAT, ACT, and TSIA are not the only tools used to determine whether a student is ready for college-level courses according to TSI criteria. Institutions also use other factors such as high school grade point average, STAAR exam scores, and GED scores. Also, if an enrolling student has already attained an associate degree or higher, they will also be TSI exempt (Texas Higher Education Coordinating Board, 2018). Those students who are not ready for college-level coursework, according to TSI criteria, are placed into developmental education.

Developmental courses are meant to allow a student to prepare for college-level courses and do not grant a student credit towards their degree or certification (Campbell, 2015; McAnally, 2019; Texas Higher Education Coordinating Board, 2018). In an effort to minimize the time a student spends in developmental mathematics and increase student success, the 60x30TX plan states that developmental math courses should transition to the co-requisite model (Texas Higher Education Coordinating Board, 2018).

Given the commonly documented low retention and pass rates of students in developmental mathematics courses, there is need for research in factors that inhibit student success. Students who are unsuccessful in remediation often have lower academic performance in their overall college educational experience (Cafarella, 2021). Further, Hennessey et al. (2021) explain that students who fail or withdraw from their first developmental mathematics course were more likely to withdraw from their degree or program. However, students who successfully complete developmental math through the co-requisite model have college outcomes similar to those students who did not take developmental mathematics (Mcanally, 2019) One longitudinal study compared student retention for students in traditional models and co-requisite models showing that co-requisite students had higher retention rates for their first through third years of their undergraduate education. However, this study also indicated that retention from the third to fourth years switched with those students who took traditional developmental models staying at a higher rate than the co-requisite students (Petillo & Anuszkiewicz, 2023). The study further explains that the graduation rates of students in co-requisite courses was approximately equal to that of those students who did not require remediation, and was higher than those students who took traditional developmental models (Petillo & Anuszkiewicz, 2023).

In order to increase student success and retention of developmental mathematics students, further research is necessary to identify key factors that contribute and inhibit students from achieving their academic goals. Research indicates that a key factor of student performance is attitude (Mazana et al, 2019). Dogbey (2010) explains that many developmental students have negative attitudes towards mathematics established before enrolling in higher education. Dogbey (2010) continues by explaining that taking these attitudes into consideration is important in the development of interventions. Hwang and Son (2021) expand on this by explaining that students with different attitudes towards mathematics need various types and levels of support in order to develop a positive attitude towards mathematics.

Due to the reformation of developmental mathematics, particularly the co-requisite structure established by the 60x30TX strategic plan, further research into the mathematical attitudes of students is necessary. With the malleability of the course content in the co-requisite structure, these courses are in a unique position to develop specific interventions based on the needs of the students with the goal of increasing positive attitude towards mathematics. This forms the basis of this study. The goal of this research is to investigate students' attitudes towards mathematics in developmental courses, including both traditional developmental algebra and co-requisite support courses developed for various entry-level credit-bearing courses, such as Statistics, Quantitative Reasoning, Business Math, and College Algebra

2.3 Mathematical Attitude

Students' attitude is an important factor in learning mathematics, where both positive attitude and confidence contribute to student success (Farooq & Shah, 2008). Lin and Huang (2016) define attitude toward mathematics as "one's feelings toward mathematics, based on his/her beliefs about mathematics" (p. 194). Ma and Kishor (1997) explain that attitude towards mathematics and student achievement have a long assumed relation, with research indicating that this relationship may be statistically significant; however, results from various studies are often in contradiction. Research indicates that student effort towards mathematical coursework is influenced by the students' belief in their mathematical abilities, their opinion of the importance of mathematics, their enjoyment of their engagement with the subject, and their motivation to succeed (Lin & Huang, 2016). Beliefs about students' self-conceptualization about their mathematical abilities are more central to a students' identities than other beliefs that may affect their attitude and success (Di Martino & Zan, 2011).

Di Martino and Zan (2009) explain that generally the definition of mathematical attitude falls within three categories. The simple definition considers the degree of positive and negative emotions towards mathematics, while the tripartite recognizes emotions, beliefs, and behaviors associated with mathematics. When behavior is excluded, the definition is classified as bi-dimensional (Di Martino & Zan, 2009). For example, Mazana et al. (2019) use a tripartite model, the ABC Model of Attitude to define the basis for their study. They identify various aspects of attitude and place them into the categories of affect, behaviour, and cognition (Mazana et al., 2019). The affect category describes self-confidence, math anxiety, and enjoyment of mathematics. The behavior category describes the student motivation to learn, while the cognition category addresses the students' ideals of the usefulness of mathematics (Mazana et al., 2019).

While perceptions of the definition of mathematical attitude varies, Neale (1969) establishes that measurement instruments of mathematical attitudes generally contain similar components. These include variables such as like/dislike of mathematics, a willingness to engage in and with mathematics, belief in one's mathematical abilities, and a belief on the usefulness of mathematics (Neale, 1969). One such instrument is the Attitude Towards Mathematics Inventory (ATMI), which measures dimensions such as confidence, anxiety, value, enjoyment, and motivation (Tapia & Marsh, 2004).

2.3.1 The Mathematical Attitudes and Perceptions Survey

The instrument used in this study is the Mathematical Attitudes and Perceptions Survey (MAPS). MAPS is an instrument to measure student views about mathematics in comparison with expert-like views (Code et al., 2016). This survey was created to investigate student attitudes and perceptions and compare them with an arbitrary mathematician (Maciejewski et al., 2021). The *novice-expert continuum* basis for this survey is described as "what may be known, and what skills may be acquired, in a particular domain or subject area; sometimes in relation to the extent of the professional expertise which an instructor may possess" (Bryce & Blown, 2012, p. 2). Code et al. (2016), explain that one of the primary goals of undergraduate education is to transition students to domain-specific, expert-like ways of thinking and acquire appreciation for the field of study as an academic pursuit. Schoenfeld (2016) expands this by explaining that mathematics is a community of practice whose social and cultural norms are established by practicing mathematicians and mathematics educators. These practices influence students individual behavior in learning to think mathematically and that "a fundamental component of thinking mathematically is having a mathematical point of view, that is, seeing the world in the ways mathematicians do" (Schoenfeld, 2016, p.7). They further explain that if students develop a more positive attitude, their expert-like behavior in mathematics also improves (Schoenfeld, 2016). Additionally, this survey allows us to identify which aspects of mathematical attitude needs to be directed towards a more expert-like view.

MAPS measures several dimensions of students' mathematical attitudes. One dimension is self-confidence in mathematics, which is an important factor when studying mathematical attitudes because students with low confidence avoid mathematical activity, which affects their academic success (Mazana et al., 2019). *Self-Confidence* in mathematics is the self-identified ability to successfully learn and engage with mathematics (Code et al., 2016). Further, confidence in mathematics has shown to be a better indicator of a student continuing in further math courses, especially in fields which require multiple mathematics courses (Code et al., 2016).

Figure 2.1: MAPS Dimensions

Another factor of student attitude is *growth mindset*, which is the belief that intelligence is not static in nature, but is able to increase or grow, which contributes to student success (Dweck, 2006; Masterson & Koch, 2021). This includes the students' belief that their skill and ability in mathematics are not fixed (Bostwick et al., 2017). Students who have a growth mindset in mathematics have shown to have higher levels of engagement and achievement in mathematics (Masterson & Koch, 2021). Further, students who have a growth mindset set goals that are growth-oriented, focusing on their improvement of both mastery of the skill and understanding of the content (Bostwick et al., 2017).

Interest in mathematics is a reference to students' willingness to engage with mathematics (Code et al., 2016). Long-term studies show that students' interest in mathematics begins to decline in elementary school (Oppermann & Lazarides, 2021). However, students who are interested in mathematics often enjoy learning mathematics and are therefore more motivated to engage with mathematical content (Mazana et al., 2019). Additionally, students who are interested in learning mathematics have higher *persistence* while working with mathematical tasks (Oppermann & Lazarides, 2021). While not necessarily an indicator of student achievement, students with higher interest in mathematics tend to be more willing to take higher courses in mathematics (Code et al., 2016; Tapia & Marsh, 2004).

The relationship between mathematics and the real world, or the *usefulness* of mathematics, is also another factor that influences students' attitudes and motivation to study mathematics (Mazana et al., 2019). Students who understand the usefulness and importance of mathematics are more motivated to study and practice course material. This perception of the usefulness of mathematics is a positive predictor in student success (Mazana et al., 2019).

Sense making allows for the study of student perspectives on the nature and structure of their mathematical knowledge (Maciejewski et al., 2021). Student perspectives tend to be either *superficial*, which is memorization of the problem-solving process, or *deep*, which is an attempt to examine the ideals of the concept under study and relate them to their existing knowledge and skills (Code et al., 2016). These categories have shown positive correlation with course grade for deep knowledge and negatively for superficial knowledge (Code et al., 2016). Similar to sense making is *nature of answers*, which relates students' view on the absolutism of mathematically correct solutions which influences the student conception of and achievement in mathematics (Code et al., 2016). A *fragmented* view of mathematics is that it is a set of facts but the underlying structure is limited, which correlates to a superficial understanding in sense making and low grades, while the *cohesive* view relates to deep understanding and high grades (Code et al., 2016).

2.4 Conclusion and Purpose of the Study

Reformation of developmental mathematics education is a necessary endeavor in order to increase access to higher education for all students. The strategic 60x30TX plan implements the co-requisite course structure to support unprepared students (Texas Higher Education Coordinating Board, 2018). This model eliminates multiple exit points of the traditional model, where students previously have taken up to three developmental courses before gaining access to a credit-bearing mathematics course. This decreases the cost on both the institution and student. The co-requisite model allows an unprepared student to take a credit-bearing math course with additional support immediately. Further, current research in the success of the co-requisite model, while limited, indicates that this course model increases both student success and the number of developmental students who complete their degree or program. While eliminating barriers established by traditional models of developmental mathematics, further research into mathematical attitudes is necessary to help increase students' academic achievement in completing their educational goals. Attitudes towards mathematics has shown to be key factor in increasing student success, which directly influences student retention and academic achievement. Therefore, this study investigate students' attitude towards mathematics in various developmental courses, including a traditional lecture-based Intermediate Algebra and various co-requisite mathematics courses paired with credit-granting courses. Informed by the research on developmental mathematics courses and students' mathematical attitudes, I developed the following research questions to be addressed in this study:

1. What are the attitudes that developmental students have for learning mathematics?
2. Do the attitudes towards mathematics of developmental students differ based on course model and type of course they are enrolled in?
3. What aspects of the developmental course contribute to students developing a positive attitude toward mathematics?

CHAPTER III

METHODOLOGY

3.1 Study Context

This study takes place in a small community college in West Texas. In 2020, the Texas Higher Education Coordinating Board estimates average enrollment of approximately five thousand students for Fall 2019 through Fall 2022 (Texas Higher Education Coordinating Board, 2023). Additionally, in 2020, approximately 53% of first-time enrolling students did not meet TSI criteria in mathematics, and approximately 72% of those students attempted developmental courses (The Texas Higher Education Coordinating Board, 2023).

This institution offers several co-requisite mathematics courses, as well as a stand-alone developmental course not linked to a credit-granting mathematics course. The stand-alone course, Math 0482, covers Intermediate Algebra. This course is the only course that upon successful completion satisfies TSI criteria and allows a student to enroll in any introductory transfer level course. This course is available online and face-to-face on campus. Math 0482 is a four-hour non-credit bearing course with the additional requirement of a math study skills lab. During the course of this study, the math lab component transitioned from a separately enrolled course Math 0180 to be integrated within Math 0482. In fact, Math 0180 was a required pairing of all developmental mathematics courses at this institution and has been incorporated into the structure of co-requisite courses, as well. This lab component requires students to attain thirteen attendance credits in the lab where they have access to tutors and instructors while the student works on homework or other instructor-assigned assignments. Also required for online courses, Math 0482 Intermediate Algebra, or the co-requisite model, the requirements of completion for math lab credits vary by instructor. Online, some instructors created additional assignments that students would complete week to week in lieu of physical or virtual attendance. These assignments could cover study skills, such as time management and preparing for examinations. Some instructors required attendance either physical or virtual online sessions. This method allowed for students to receive support of the course material in one-on-one or small group sessions with the instructor of the course. At this institution, failure to complete the requirements of the lab portion of the developmental course sequence may automatically fail the student in the developmental course, regardless of the student average. The overall goal of Math 0180 is that students develop study skills and regularly work on course material in an environment where they could receive clarification and support.

Each entry-level credit-granting math course has an associated co-requisite model course. Course structure and content for the developmental portion varies by the course itself and by the instructor of record. Because the developmental portion of the co-requisite model is meant to support students and not prevent student success in the credit-granting course, the nature of the content required for these courses is loosely defined by the Texas 60x30 plan. At this particular institution, these developmental courses have no influence on the grade of the credit course, but the examinations of the credit course constitute 60% of the overall grade for the developmental portion.

Math 0414 is the developmental component of Math 1314 College Algebra in the co-requisite model. Math 0414 is four hours plus the additional requirements of the lab. This course is available in person or online. Math 0424 is the support course for Math 1324 Mathematics for Business and Social Sciences, which was a four-hour course plus the additional requirements of the lab. Over the course of this study, this developmental course transitioned to Math 0324, reducing the amount of in-class time a student spent with the developmental portion of the course but retains the lab requirements. These courses are considered to be the most mathematically rigorous of the mathematics department at this particular institution, which is why the requirements of institutional hours for the developmental portion is greater than the institutional hours of the actual credit-granting course. This allows extra time for the instructors to focus on attention to the algebraic skill sets necessary to be successful in the credit-granting portions of these courses. Some instructors utilize skill building as an introduction to material covered in the credit-granting portion of the course. Other instructors use the additional time to cover developmental material in the beginning of the semester in order to build student mathematical skills and spend the remaining majority of the semester devoted to credit-bearing content.

Math 0242 is the developmental portion for Math 1342 Statistics, while Math 0232 is the developmental portion to Math 1332 Quantitative Reasoning. These courses are two institutional hours; however, both also require the lab component of the course. These courses are not considered algebraic and, therefore, less mathematically rigorous yet no less complex than their counterparts. In Math 0232, the course content is meant to introduce arithmetic and algebraic skills directly before the student needs them in Math 1332 Quantitative Reasoning. Some instructors handle Math 0242 in a similar manner while some use the additional time to slow down the speed of the lecture in Math 1342 Statistics, to allow students time to work with the course material.

3.2 Participants

Through institutional agreement, all students in a developmental mathematics course in the Fall semester of 2023 were administered the Mathematical Attitudes and Perceptions Survey (MAPS), except those students under the direct instruction of the author, with 108 students agreeing to participate in the survey. Additionally, students completed several written open-ended questions meant to expand on the constructs identified by the MAPS instrument:

1. How did you choose between Math 0482 and the co-requisite course options?
2. How do you feel about math?
3. Describe a time you felt confident in your ability to do mathematics.
4. Describe a time you did not feel confident in your ability to do mathematics.
5. What makes you feel motivated to learn mathematics?

Using the results from the MAPS survey and supplemental questions, participants were selected and invited to a follow-up interview. Five students were selected, two from each developmental course. These students were identified based on the number of responses made toward the expert consensus established by the MAPS survey. The high scoring students with 80% of responses in agreement with the experts, and students with less than 10% of responses in agreement with the expert consensus were selected to participate in the interview process. This will allow for student interviews with students who have a positive mathematical attitude and compare them with those students with the lowest mathematical attitudes.

The MAPS survey was distributed to all developmental students within the first two weeks of the Fall 2023 semester. Students who elect to be considered for follow-up interviews were contacted in the fourth week of the semester, and interviews were conducted during the fifth and sixth week of the semester. This allowed for the preliminary analysis of the MAPS survey and supplemental questions, and allowed time to contact students to make appointments for follow up interviews. Weeks five and six were selected for the interviews because the students were well into the course work, but did not conflict with the midterm examination schedule, which typically takes place during week eight. Further, having exposure to the course work and instructors allowed students to compare their mathematical attitude from the beginning of the semester and explain their views of course structure.

Table 3.1: MAPS Questionnaire

Number	Question	Expected Response
1.	After I study a topic in math and feel that I understand it, I have difficulty solving problems on the same topic.	Disagree
2.	There is usually only one correct approach to solving, a math problem.	Disagree
3.	I'm satisfied If I can do the exercises for a math topic, even if I don't understand how everything works.	Disagree

Table 3.1: cont.

4.	I do not expect formulas to help my understanding of mathematical ideas, they are just for doing calculations.	Disagree
5.	Math ability is something about a person that cannot be, changed very much.	Disagree
6.	Nearly everyone is capable of understanding math if they work at it.	Agree
7.	Understanding math means being able to recall something you've read or been shown.	Disagree
8.	If I am stuck on a math problem for more than ten minutes, I give up or get help from someone else.	Disagree
9.	I expect the answers to math problems to be numbers.	Disagree
10.	If I don't remember a particular formula needed to solve a problem on a math exam, there's nothing much I can do to come up with it	Disagree
11.	In math, it is important for me to make sense out of formulas and procedures before I use them.	Agree
12.	I enjoy solving math problems.	Agree
13.	Learning math changes my ideas about how the world works.	Agree
14.	I often have difficulty organizing my thoughts during a math test	Disagree
15.	Reasoning skills used to understand math can be helpful to me in my everyday life.	Agree
16.	To learn math, the best approach for me is to memorize solutions to sample problems.	Disagree
17.	No matter how much I prepare, I am still not confident	Disagree

Table 3.1: cont.

	when taking math tests.	
18.	It is a waste of time to understand where math math formulas come from.	Disagree
20.	I can usually figure out a way to solve math problems.	Agree
21.	School mathematics has little to do with what I experience in the real world.	Disagree
22.	Being good at math requires natural (i.e., innate, inborn) intelligence in math.	Disagree
23.	When I am solving a math problem, if I can see a formula that applies then I don't worry about the underlying concepts.	Disagree
24.	If I get stuck on a math problem, there is no chance that I will figure it out on my own.	Disagree
25.	When learning something new in math, I relate it to what I already know rather than just memorizing it the way it is presented.	Agree
26.	I avoid solving math problems when possible	Disagree
28.	All I need to solve a math problem is to have the necessary formulas.	Disagree
30.	Showing intermediate steps for a math problem is not important as long as I can find the correct answer.	Disagree
31.	I only learn math when it is required.	Disagree
32.	I only learn Math when it is required.	Disagree

The MAPS survey allows us to establish the students' attitudes towards mathematics in comparison with an arbitrary expert, which answers the first research question: What are the attitudes that developmental students have for learning mathematics? The survey instrument allows for the study of specific questions and the seven dimensions or within the seven dimensions the questions are categorized under. Additionally, these survey results can be compared against course type to examine the similarities or differences, if any, of the various student populations. The supplemental questions given with the MAPS survey allow for the investigation of all three research questions by having the students expand on their attitudes towards mathematics and identifying relevant and common themes amongst the populations of developmental mathematics students at this institution.

3.3 Survey Data Collection and Analysis

The MAPS survey was distributed to developmental students at the beginning of the Fall 2023 semester as a Qualtrics survey. The investigator visited with classes during the math lab component of all developmental courses to recruit participants. Online students were also contacted by email. Participation was voluntary, and those students who did not wish to participate were free to not scan the distributed QR code to gain access to the survey. If a student did gain access to the survey, they were free to not accept the consent form at the beginning of the survey. Further, any student who opted not to continue the survey at any point after beginning was not considered in the analysis. Additionally, no surveys were distributed to students enrolled in Math 0324 Support for Business Math, nor to Math 0232 Support for Quantitative Reasoning due to the investigator's status as the instructor of these two support courses. This means only students from Math 0482 Math for Business, Science, and Education Majors (Intermediate Algebra), Math 0242 Support for Statistics, and Math 0414 Support for College Algebra were surveyed at this institution. The survey remained available for two weeks in order to allow all students time to decide to participate. Upon closure of new responses, the data was inspected and any student who did not complete all MAPS questions were deleted. Additionally, students who completed the survey more than once had their secondary attempts removed from the data. Finally, the MAPS survey question 19 is a filter statement with the correct selection indicated and those students who did not respond with the given selection were discarded as not reading the questions. Upon completion, there was a total of 108 survey participants.

The remaining participants then had their expertise score calculated from the MAPS survey responses. The MAPS survey utilizes a 5-point Likert scale, but the expertise score is calculated by the response having a score of one assigned if the student answered in the same direction (agree or disagree) as expected from an arbitrary mathematician. If the student did not respond in the expected direction, their response receives a score of zero. Then the average is taken of all 31 question responses. The resulting value is a score between zero and one. The closer the score is to one, the more expertise-like thinking a student has in their attitudes towards mathematics. Conversely, scores closer to zero indicate that the student has not developed an expertise-like way of thinking in their attitudes towards mathematics. After calculating the individual student expertise scores, the overall expertise score was calculated for each of the different courses under study.

Kruskal-Wallis Rank-Sum tests were performed in order to identify differences in specific student populations by course and dimension of attitude. Further, Wilcoxon Rank Sum tests were performed to further identify the courses between which these differences occurred. I elaborate on my methods for using these statistical tests in the results section.

3.4 Interview Data Collection and Analysis

Interviews are necessary to understand students' reasoning about their attitudes towards mathematics and their place in the mathematical community. A total of five students participated in the follow-up interviews: two students from Intermediate Algebra; two students from the College Algebra co-requisite model; one student from the Statistics co-requisite model. The follow-up interviews were conducted using a semi-structured format. Semi-structured interviews are advantageous due to the flexibility the format allows. Using open ended questions allows for a structure for the interview to follow and for follow up questions based on the participant responses (Kallio et al., 2016). Bernard (2013) further explains that this format is particularly useful when there is only one opportunity conduct an interview, as in this study. The interview protocol is in Figure 3.1. The interview protocol was developed to address the categories of mathematical attitude of previously defined by Mazana et al. (2019). These categories are affect, behavior, and cognition. The affect category describes self-confidence, math anxiety, and enjoyment of mathematics. The behavior category describes the student motivation to learn, while the cognition category addresses the students' ideals of the usefulness of mathematics (Mazana et al., 2019). The interview protocol questions are listed below in the figure 3.1 displayed below:

Table 3.2: Interview Protocol

Interview Protocol	
Aspect of Attitude	Questions
Affect	
	1. How would you describe your attitude towards mathematics?
	2. In your opinion, how does your attitude towards mathematics affect your mathematical ability?
	3. How have your instructors influenced your attitude towards mathematics?
	4. What do you do when you feel frustrated with mathematics?
	5. Describe how it feels when you sit down to take an exam
Questions about Behavior	
	6. Do you believe that your ability to understand mathematics is something you were born with?
	7. What could an instructor do to help you develop a positive attitude towards learning mathematics?
	8. How do the attitudes towards mathematics of your family or friends influence your motivation to learn mathematics?
	Can you describe an experience that caused your attitude towards mathematics to change?
Question about Usefulness	
	10. In your opinion, is mathematics important to your degree field?

Interviews were conducted and recorded virtually using Zoom, which provides automated audio transcription, for which the researcher verified and edited for accuracy. Interviews and open-ended survey responses were analyzed using thematic analysis. Thematic analysis is a method of analyzing qualitative data by identifying patterns of meanings called themes. Researchers identify interesting or relevant data in response to the research questions and assign them *codes*. These codes are later organized under shared concepts to build themes which provide a framework for organizing and interpreting the researchers' observations (Clarke & Braun, 2017). Nowell et al. (2017) explain that thematic analysis is a widely used and flexible method for analyzing qualitative data. They continue by explaining that this methodology is particularly useful for the examination of the perspectives of different participants and identifying both similarities and differences. A key advantage is that thematic analysis is capable of identifying unanticipated participant responses (Nowell et al., 2017).

Through the implementation of thematic analysis to the supplemental survey questions and interviews, the coding process and theme development served as the foundation in answering the second and third research questions. Through this method I was able to identify recurring themes, which allowed me to extract insights that answered my research question and provided an understanding of the students' perspectives about their attitudes towards mathematics.

3.5 Validity and Reliability

The validity of the MAPS survey was established by Code et al. (2016) during the development of the survey instrument. This survey has been shown to have reliability by confirming findings of other similar novice-expert measuring tools. For the analysis of the supplemental survey question responses and interview data, the validity was established by a more experienced researcher (Dr. K. Serbin). Additionally, having multiple data sources allows for triangulation increases the validity of the results. Moon (2019) claimed that the use of triangulation "helps increase the validity, reliability, and legitimization" of research conclusions (p. 103). They expand by explaining that *investigator triangulation*, having multiple researchers, helps to control bias in the research process. Also, *data source triangulation*, having multiple data sources, enables researchers to view a “more complete perspective” (p. 103). Finally, using the dimensions of mathematical attitudes established by the MAPS survey as one theory and Mazana et al.’s (2019) theory of affect, behavior, and cognition for the design of the supplemental questions and interview protocol is called *theory triangulation* which uses more than one theory to “guide the research design, research study implementation and interpretation of the data” (p. 103). These multiple sources of validation contribute to the legitimacy of the findings in this study.

CHAPTER IV

RESULTS

The results section will begin with a general overview of the results of the MAPS survey. The overall student expertise score summary will be provided first. The overall student expertise score is the average of the the students' responses to the MAPS survey. The survey uses a 5-point Likert scale: strongly disagree, disagree, neutral, agree, strongly agree. The students' response is awarded one point if they respond in the same direction (agree or disagree) as what is expected by an arbitrary mathematician, but no value is given for the strength of the response. For example, strongly agree and agree would receive the same score of one point if "agree" is the expected response by an arbitrary mathematician. Students who do not respond in the expected mathematical direction received a score of zero. Neutral is always scored as zero. The analysis on these scores provides the support in the examination of these student scores by course. In the subsections that follow, we begin to address the research questions. In the first subsection addresses the first research question: "What are the attitudes that developmental students have for learning mathematics?" The MAPS scores across the seven categories will be discussed to answer the first research question. In the second subsection, the supplementary questions given with the MAPS survey and the student interviews will be used to address the second research question: "Do the attitudes towards mathematics of developmental students differ based on course model and type of course they are enrolled in?" Finally, in the third subsection of this chapter, the supplementary and interviews will be used to answer the final question: "What aspects of the developmental course contribute to students developing a positive attitude toward mathematics?

4.1 MAPS Scores

The instrument of this study was administered to students in three courses: Math 0242 Support for Statistics, Math 0414 Support for College Algebra, and Math 0482 Math for Business, Science, and Education Majors. For Math 0482 both on-campus and online students were surveyed. Students in Math 0324 Support for Business Math, and Math 0232 Support for Quantitative Reasoning, as well as some sections of Math 0482 were not surveyed due to being under the direct instruction of the investigator. For clarity, we will refer to Math 0242 Support for Statistics as simply "Statistics'; Math 0414 Support for College Algebra as "College Algebra"; Math 0482 Math for Business, Science, and Education Majors, the only stand-alone developmental course, as "Intermediate Algebra". Students were contacted via email or by in-class visits and were given the opportunity to complete the survey. After the survey closed, the students' expertise score was calculated.

Students in Statistics had the lowest expertise scores in comparison to the other courses. In this course, the minimum score was 0.0345 and maximum score was 0.6552. Additionally, this course had a mean score of 0.3965 with a median of 0.4138. It is interesting to note that this course had the lowest minimum expertise score out of all three course types. The other co-requisite course in this study, College Algebra, which had the highest minimum score (0.2414) of the three courses. Similarly, the highest expertise score for students in this course was 0.8621, and this course had a mean of 0.4717 and median of 0.4655. Finally, the stand-alone developmental course, Intermediate Algebra, had a minimum score of 0.1034 with the highest maximum score of 0.9310 recorded in this data set. Additionally, Intermediate Algebra had a mean of 0.5057 and median of 0.5172.

Table 4.1: MAPS Student Expertise Scores

Course	Minimum	Median	Mean	Maximum
Statistics	0.0345	0.4138	0.3965	0.6552
College Algebra	0.2414	0.4655	0.4717	0.8621
Intermediate Algebra	0.1034	0.5172	0.5057	0.9310
Overall	0.0345	0.4828	0.4641	0.9310

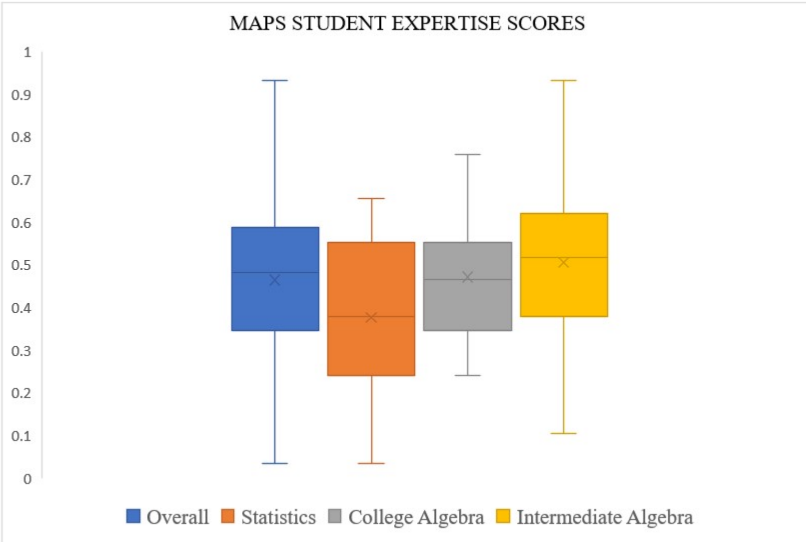

Figure 4.1: MAPS Expertise Scores

After calculating the initial values of the student expertise scores by the three course types, a Kruskal-Wallis Rank-Sum test was performed to determine if there was a significant difference in the populations. The Kruskal-Wallis rank-sum test is used to determine whether the sampled data come from the same distribution (Field et al., 2012). The results indicate that there is a significance difference ($H = 6.5512$, $p = 0.03779$, $df = 2$) at the $p<0.05$ level of significance. Further analysis is necessary to determine where the difference occurs among the populations. Examining two courses at a time, the Wilcoxon rank-sum test was performed to determine where the difference occurs. Similar to the Kruskal-Wallis Rank-Sum test, the Wilcoxon rank-sum test determines if there is a difference in two groups under study (Field et al., 2012). The Kruskal-Wallis Rank Sum test determined that there was a difference in the population, however, it is important to note how these courses are different in terms of their mathematical attitude expertise scores. Through the inspection of the spread of the students' expertise scores, the determination was made to perform left-tailed tests. The means that the null hypothesis is that the two populations are the same (scores are equal to College Algebra or Intermediate Algebra) and the alternative hypothesis is that students in Statistics have a lower attitude towards mathematics (less than College Algebra or Intermediate Algebra). Statistics was compared with both College

Algebra and Intermediate Algebra, and then College Algebra was compared with Intermediate Algebra. The significant result of the Wilcoxon Rank-Sum test occurs between Statistics and College Algebra and between Statistics and Intermediate Algebra. This supports that not only are the students who enroll in Statistics different from their peers in an algebra-based course, but they have a have a lower mathematician-like way of thinking in their attitudes towards mathematics than their peers in an algebra-based course. The results follow in Table 4.2 below.

Table 4.2: MAPS Student Expertise Scores Wilcoxon Rank Sum Test

	Statistics vs College Algebra A=Math 0242, B=Math 0414	Statistics vs Intermediate Algebra A=Math 0242, B=0482
Null Hypothesis	$H_0 : A = B$	$H_0 : A = B$
Alternative Hypothesis	$H_1 : A < B$	$H_1 : A < B$
Test Statistic	R_1=524	R_1=413.5
Sum of Rank A	R_1: N($\mu = 665$, $\sigma = 74.442$)	R_1: N($\mu = 560.5, \sigma = 60.359$)
Standardized test statistic	$z \approx -1.894$	$z \approx -2.435$
p-value	$p \approx 0.02911$	$p \approx 0.00744$

This finding implies that at the $p < 0.05$ level of significance, we reject the null hypothesis, which is that there is no difference between the students in Statistics and College Algebra and the students in Statistics and Intermediate Algebra. This implies that the students who enroll in Math 0242 Support for Statistics are a distinctly different population from the other two courses, with lower attitudes towards mathematics. This means that while all these students are considered “developmental,” the population entering Statistics has less of the mathematical attitude one hopes to cultivate in the field of study of mathematics. This also indicates that students in Statistics will have lower scores across the seven dimensions of attitude that is measured by the MAPS instrument than the scores of students in the other developmental courses.

4.2 Attitudes Towards Mathematics

The first research question is: "What are the attitudes that developmental students have for learning mathematics?" To answer this question, an examination of the student expertise scores across all MAPS dimensions is discussed. Recall that these dimensions of attitude measure: self-confidence, growth mindset, interest, persistence in problem solving, sense making, answers, and real world mathematical relationships. In addition to the student expertise scores, discussed previously, the expertise score from across all dimensions of attitude in the MAPS instrument were calculated. These scores are based on various questions throughout the MAPS survey.

4.2.1 MAPS Dimensions

4.2.1.1 Self-Confidence. The first dimension of the MAPS instrument is that of Self-Confidence. Recall that self-confidence in mathematics is the students' self-identified ability to successfully learn and engage with mathematics (Code et al., 2016). Four questions in the MAPS instrument measure self-confidence. The following Table 4.3 gives the MAPS dimension of Self-Confidence and the associated questions, and Table 4.4 gives the student score for self confidence summary. Then a summarization of these findings, as well as results of hypothesis testing follows.

Table 4.3: MAPS:Self-Confidence

MAPS: Self-Confidence		
Number	Question	Expected Response
1.	After I study a topic in math and feel that I understand it, I have difficulty solving problems on the same topic.	Disagree
14.	I often have difficulty organizing my thoughts during a math test	Disagree
17.	No matter how much I prepare, I am still not confident when taking math tests.	Disagree
20.	I can usually figure out a way to solve math problems.	Agree

Table 4.4: MAPS Student Expertise Scores:Self-Confidence

Course	Minimum	Median	Mean	Maximum
Statistics	0	0.2813	0.3056	1
College Algebra	0	0.5313	0.4082	1
Intermediate Algebra	0	0.5313	0.3980	1
Overall	0	0.6250	0.4801	1

The overall confidence score amongst all students surveyed was 0.3463, on a scale from 0 to 1. An examination of these scores by course type, Statistics had the lowest median score, while the median score for College Algebra and Intermediate Algebra are the same. Table 4.4

shows the comparison of the minimum, median, mean, and maximum scores. These scores indicate that students will have low self-confidence in general, but Statistics will have considerably lower self-confidence than those students in College Algebra or Intermediate Algebra. However, the Kruskal-Wallis Rank-Sum test results indicate that there is not a significance difference ($H = 2.34$, $p = 0.3104$, $df = 2$) at the $p<0.05$ level of significance. The Wilcoxon Rank-Sum Test for Statistics and College Algebra (z=-1.4441, p=0.07435), and for Statistics and Intermediate Algebra (z=-1.4128, p=0.07886) did not indicate a difference in the populations at the $p<0.05$ level of significance. Student self confidence will be further discussed in the following sections.

4.2.1.2 Growth Mindset. The next dimension is that of Growth Mindset. A student has a growth mindset when they can recognize that mathematical ability is not fixed, but can be acquired and improved through effort. Table 4.5 gives the MAPS dimension of Growth Mindset and the associated survey questions. The overall Growth Mindset score was 0.6560, on a scale from 0 to 1. Upon examination by course type, all courses had the same minimum, median, and maximum scores. Table 4.6 below shows the student growth mindset scores by course type. A statistical difference between populations was not found using the Kruskal -Wallis rank-sum test ($H = 2.2065$, $p = 0.33178$, $df = 2$) at the $p<0.05$ level of significance. The Wilcoxon Rank-Sum Test for Statistics and College Algebra (z=-0.9548, p=0.1698), and for Statistics and Intermediate Algebra (z=-1.4935, p=0.06766) did not indicate a difference in the populations at the $p<0.05$ level of significance. Growth Mindset will continue to be discussed in the next section.

Table 4.5: MAPS:Growth Mindset

MAPS: Growth Mindset		
Number	Question	Expected Response
5.	Math ability is something about a person that cannot be, changed very much.	Disagree
6.	Nearly everyone is capable of understanding math if they work at it.	Agree
22.	Being good at math requires natural (i.e., innate, inborn) intelligence in math.	Disagree
31.	I only learn math when it is required.	Disagree

Table 4.6: MAPS Student Expertise Scores:Growth Mindset

Course	Minimum	Median	Mean	Maximum
Statistics	0	0.7500	0.5789	1
College Algebra	0	0.7500	0.6550	1
Intermediate Algebra	0	0.7500	0.6987	1
Overall	0	0.7500	0.6574	1

4.2.1.3 Interest. The next dimension of the MAPS instrument is that of Interest. This measure quantifies the level of student's interest in learning and engaging with mathematics. Interest is measured by three questions of the MAPS survey, as summarized in Table 4.7 below. The overall Interest score was 0.3512. This indicates that students will have limited interest in learning and engaging with mathematics. The lowest median score amongst course type was in Statistics, with a median of zero. College Algebra and Intermediate Algebra both had a median score of 0.3333. The summary of the student expertise scores can be seen in Table 4.8 below. The Kruskal-Wallis rank-sum test results indicate that there is a significance difference (H = 9.8153, p = 0.0074, df = 2) at the p<0.05 level of significance. A Wilcoxon rank-sum test was performed to determine if there was a difference in the populations. The Wilcoxon Rank-Sum Test for Statistics and College Algebra (z=-0.2.391, p=0.008), and for Statistics and Intermediate Algebra (z=-3.015, p=0.0026) confirmed that there is a statistically significant difference in the populations for Statistics and College Algebra and between Statistics and Intermediate Algebra. This means that the level of interest of a student in Statistics is lower than that of a student in College Algebra or Intermediate Algebra, and they should not be considered as the same population in terms of interest, specifically.

Table 4.7: MAPS:Interest

MAPS: Interest		
Number	Question	Expected Response
12.	I enjoy solving math problems.	Agree
26.	I avoid solving math problems when possible	Disagree
32.	I only learn Math when it is required.	Disagree

Table 4.8: MAPS Student Expertise Scores:Interest

Course	Minimum	Median	Mean	Maximum
Statistics	0	0	0.1930	1
College Algebra	0	0.3333	0.3867	1
Intermediate Algebra	0	0.3333	0.3761	1
Overall	0	0.3333	0.3488	1

4.2.1.4 Persistence in Problem Solving. The next dimension of the MAPS instrument to consider is that of Persistence in Problem Solving. This aspect measures a student's ability to identify and apply an appropriate strategy in order to arrive at a solution of a problem. This behavior is important to understand how students resolve getting 'stuck' on a problem. There are four questions in the MAPS instrument that measure persistence, given in Table 4.9 below. The overall persistence score is 0.3716. This indicates that students will have low levels of persistence when problem solving. Statistics had the lowest median score in comparison with College Algebra and Intermediate Algebra. A summary of the Persistence scores can be seen in Table 4.10 below. While the Kruskal-Wallis test did not indicate that there is a significance difference (H = 5.3027, p = 0.0706, df = 2) at the p<0.05 level of significance. A Wilcoxon rank-sum test was performed to determine if there was a difference in the populations. The Wilcoxon Rank-Sum Test for Statistics and College Algebra (z=-0.2.398, p=0.0083), and for Statistics and Intermediate Algebra (z=-2.129, p=0.01663) confirmed that there is a statistically significant difference. These results mean that the level of persistence in problem solving, as measured by the MAPS instrument, are statistically significant when comparing Statistics to either College Algebra or Intermediate Algebra. In both circumstances, students enrolled in Statistics exhibited a lower ability to appropriately select and apply problem solving strategies to mathematical content. A student with low persistence in problem solving is more likely to stop engaging with mathematics when they are frustrated or the material appears complex.

Table 4.9: MAPS:Persistence

MAPS: Persistence		
Number	Question	Expected Response
8.	If I am stuck on a math problem for ore than ten minutes, I give up or get help from someone else.	Disagree
10.	If I don't remember a particular formula needed to solve a problem on a math exam, there's nothing much I can do to come up with it	Disagree
24.	If I get stuck on a math problem, there is no chance that I will figure it out on my own.	Disagree

Table 4.10: MAPS Student Expertise Scores:Persistence

Course	Minimum	Median	Mean	Maximum
Statistics	0	0.2500	0.2237	0.75
College Algebra	0	0.5000	0.4100	1
Intermediate Algebra	0	0.5000	0.3974	1
Overall	0	0.3750	0.3727	1

4.2.1.5 Sense Making. The next dimension of the MAPS instrument is that of Sense Making. This category is meant to measure the student perspective of their own mathematical knowledge. There are five questions in this survey that contribute to this measurement which are summarized in Table 4.11 below. The overall Sense Making score is 0.6239. This indicates that overall, students in developmental mathematics at this institution may have an understanding of the difference in the superficial approach to mathematics, rote memorization of problem solving steps, to a more deep understanding which is the recognition of mathematical ideas and then relate them to their current mathematical knowledge. These particular scores were very similar amongst all three courses and were not found to have a statistically significant difference amongst the three course types. The scores are summarized in Table 4.12 below.

Table 4.11: MAPS:Sense Making

MAPS: Sense Making		
Number	Question	Expected Response
3.	I'm satisfied If I can do the exercises for a math topic, even if I don't understand how everything works.	Disagree
4.	I do not expect formulas to help my understanding of mathematical ideas, they are just for doing calculations	Disagree
11.	In math, it is important for me to make sense out of formulas and procedures before I use them.	Agree
18.	It is a waste of time to understand where math math formulas come from.	Disagree
23.	When I am solving a math problem, if I can see a formula that applies then I don't worry about the underlying concepts.	Disagree

Table 4.12: MAPS Student Expertise Score: Sense Making

Course	Minimum	Median	Mean	Maximum
Statistics	0.2000	0.6000	0.5895	1
College Algebra	0.2000	0.6000	0.6240	1
Intermediate Algebra	0.2000	0.6000	0.6564	1
Overall	0.2000	0.6000	0.6296	1

4.2.1.6 Answers. The next dimensions of attitude from the MAPS instrument is Answers. This construct measures how the students perceive the structures connecting mathematical ideas. There are six questions that measure Answers in the MAPS instrument, summarized in Table 4.13 below. The overall Answers scores was 0.3547, indicating that students in developmental mathematics will not have a developed ability to understand the underlying structure of the nature of mathematics and mathematical solutions. The scores for Answers are summarized in Table 4.14 below. The Kruskal-Wallis rank-sum test and the Wilcoxon Rank-Sum Test failed to find a statistically significant distinction between the various populations.

Table 4.13: MAPS:Answers

MAPS:Answers		
Number	Question	Expected Response
2.	There is usually only one correct approach to solving, a math problem.	Disagree
7.	Understanding math means being able to recall something you've read or been shown.	Disagree
9.	I expect the answers to math problems to be numbers.	Disagree
16.	To learn math, the best approach for me is to memorize solutions to sample problems.	Disagree
28.	All I need to solve a math problem is to have the necessary formulas.	Disagree
30.	Showing intermediate steps for a math problem is not important as long as I can find the correct answer.	Disagree

Table 4.14: MAPS Student Expertise Scores: Answers

Course	Minimum	Median	Mean	Maximum
Statistics	0	0.3333	0.3509	1
College Algebra	0	0.3333	0.3133	1
Intermediate Algebra	0	0.3333	0.4145	1
Overall	0	0.3333	0.3565	1

4.2.1.7 Real World. Finally, the last dimension of the Mathematical Attitudes and Perceptions Survey is that of Real World. In the creation of this instrument, Code et al. (2016) measure students' ability to transfer their mathematical skill set both inside and outside of field of study of mathematics, and is a goal for all fields in education. Four questions in this instrument account for the Real World score, summarized in Table 4.15 below. The overall Real World score was 0.5767. This indicates that students will have an understanding of the importance of their ability to use mathematics both inside and outside of academia. The summary of Real World scores is shown in Table 4.16 below. A Kruskal-Wallis rank-sum test was performed in order to determine if there was a statistically significant difference between students of the three course types, in terms of Real World scores. The Kruskal-Wallis Rank-Sum test ($H = 9.8153$, $p = 0.0074$, $df = 2$) at the $p<0.05$ level of significance indicated that there is a significant difference between courses. This means that we should consider these students form distinct populations in this aspect of mathematical attitude. Wilcoxon Rank-Sum tests were then performed in an attempt to identify where these differences occur. First, we determine if Statistics is different from College Algebra (z=-0.2.391, p=0.00840) and Statistics and Intermediate Algebra(z=-3.015, p=0.00257) indicate that there is a statistical significant difference between Statistics and College Algebra, as well as between Statistics and Intermediate Algebra. Specifically, students in Statistics exhibited less understanding of the importance of mathematical relationships outside of their academic studies.

Table 4.15: MAPS:Real World

MAPS:Real World		
Number	Question	Expected Response
13.	Learning math changes my ideas about how the world works.	Agree
15.	Reasoning skills used to understand math can be helpful to me in my everyday life.	Agree
21.	School mathematics has little to do with what I experience in the real world.	Disagree
25.	When learning something new in math, I relate it to what I already know rather than just memorizing it the way it is presented.	Agree

Table 4.16: MAPS Student Expertise Scores: Real World

Course	Minimum	Median	Mean	Maximum
Statistics	0	0.2500	0.3553	1
College Algebra	0	0.5000	0.5650	1
Intermediate Algebra	0	0.7500	0.6410	1
Overall	0	0.5000	0.5556	1

4.2.2 Summary of Findings Answering Research Question 1

In conclusion to the first research question, the participating students exhibited low self-confidence in their mathematical abilities but showed robust growth mindsets in their ability to learn mathematics. However, the participating students reported low levels of interest in learning mathematics. The participating students demonstrated little persistence in problem solving, yet they understood that their ability to make sense of mathematics is important. The participating students had an underdeveloped ability to recognize the underlying structures of mathematics.

Finally, the participating students generally understood the importance of their ability to use mathematics in the real world, outside of academia. These scores from the MAPS instrument provided measures to compare the mathematical attitudes of these students by course type. The next section is an elaboration on the distinctions between course types identified in the survey data and an exploration of these findings through a qualitative analysis of some of the participating students' explanations of their own attitudes towards mathematics.

4.3 Differences in Students' Attitudes Towards Mathematics by Course Type

The second research question is: "Do the attitudes towards mathematics of developmental students differ based on course model and type of course they are enrolled in?" This section will explore the student responses to the supplementary questions given in conjunction with the MAPS instrument. These questions are:

1. How did you choose between Math 0482 and the co-requisite course options?
2. How do you feel about math?
3. Describe a time you felt confident in your ability to do mathematics.
4. Describe a time you did not feel confident in your ability to do mathematics.
5. What makes you feel motivated to learn mathematics?

To answer the second research question, responses from questions two, three, four, and five were examined. First, an examination of the emotional responses that students made in the survey responses in relation to the MAPS instrument categories is provided, followed by a discussion on students' motivations.

4.3.1 Main Claim 1: Students displayed a range of attitudes that varied by course

As part of the supplemental questions all students responded to in the initial survey, one question specifically asked, “How do you feel about math?”. Students expressed a variety of attitudes toward mathematics, which were then classified into the categories of negative, neutral, and positive emotions. The frequencies and percentages of students' responses classified as negative, neutral, or positive emotions by each class are displayed in Table 4.17. An elaboration on students' emotions toward mathematics is given in each of the following subsections.

Table 4.17: Frequencies and Percentages of Students' Negative, Neutral, and Positive Emotions Toward Mathematics by Course

	Negative Emotions	Neutral Emotions	Positive Emotions	No Response
Statistics	12 (63%)	0 (0%)	7 (37%)	0 (0%)
College Algebra	14 (28%)	15 (30%)	17 (34%)	4 (8%)
Intermediate Algebra	13 (33.3%)	11(28.2%)	15 (38%)	0 (0%)
Overall	39 (36%)	26 (28%)	41 (38%)	0 (0%)

4.3.1.1 Sub-Claim 1: Negative Emotions. Students displayed strong negative emotions towards mathematics. In response to the open-ended survey question, "How do you feel about math?", one student in Statistics explained, “Personally, I’m very anxious when it comes to math, it’s always been a struggle for me. I hope to improve, but currently it’s not my favorite.” A student from College Algebra simply said, “scared,” which was echoed by another student from College Algebra who said “worried and stressed.” Students from Intermediate Algebra shared the same sentiments. One student response was, “It gives me anxiety. I will say it’s getting better. I often psych myself out.”

Stress and anxiety were not the only negative responses to the question about how they feel about mathematics. Some students responded with some level of disliking the subject all the way to expressions of hatred. One student from Statistics explained, “Math is my least favorite subject to learn, and I am also very bad at it.” One student from College Algebra responded with “I hate math.” Another student from College Algebra explained, “I don’t like it. I honestly try to understand it and study, but in the end I end up not getting it at all.” Meanwhile, one response from Intermediate Algebra explained, “I don’t like it, and it doesn’t make any sense to me. There’s too many ways to solve a math problem, which makes me so lost.” Many students echoed this response, explaining that their feelings about math were due to their struggle and confusion experienced in doing their coursework. In one follow-up interview, one student from Math 0242 Support for Statistics, who asked to be identified as Jacob, explained:

> It frustrates me because it requires a lot of time and a thinking process to solve certain equations. And it can be very overwhelming because you may have a set of like 35

> questions to answer, and each one is taking almost 15 minutes to solve. You are gonna sit there for a good minute, and you know, pull your hair out a little bit. It frustrates me, and I've always had it, even in high school. Oh my gosh! I hated math. I hated algebra. I hated geometry. I hated calculus. It wasn't fun. It wasn't interesting to me. I wanted to be in the live action, and ever since I was young I was always trying to get in and out of things quickly. The short cut, in other words.

Overall, approximately 36% of survey respondents described their feelings about mathematics as being strongly negative. However, approximately 63% of students in Statistics expressed strong negative feelings about mathematics. In comparison, approximately 33% of students in Intermediate Algebra and 28% of students in College Algebra expressed strong negative feelings about mathematics.

4.3.1.2 Sub-Claim 2: Neutral Emotions. Other students displayed neutral emotions towards mathematics. From the students surveyed in Statistics, no students responded with neutral feelings about mathematics. Their remaining responses will be discussed in more detail in the discussion over positive emotional responses. To continue with neutral responses, students in Intermediate Algebra had approximately 28% neutral responses, while College Algebra had the highest percentage of neutral responses at approximately 30%. One student enrolled in College Algebra explained, "Don't like it, but neither hate it, since it's a required course, I will try my very best to pass it," while another said, "I feel like I can get an A in math, then never have to do a math class again." Another typical type of response from College Algebra was, "It's a harder subject for me," which was a common statement indicating the acceptance of their struggle with mathematics. Another student echoed this statement in the survey responses, saying, "It's hard, but I'm willing to learn." This sentiment of growth mindset was explained in an interview by a student enrolled in Intermediate Algebra, who asked to be identified as Cash:

> In the beginning it was anxiety, frustration. Now, not so much anxiety. I'm not as frustrated. I have a different mindset. I still have no idea what's going on, but I do make an attempt to try. So with conversations with my spouse or anybody that's good at math,

I'm able to make sense between watching lecture videos and these conversations. So, it's getting better and having a more positive attitude I feel like it opens my perspective to understand it, instead of being like, "Oh, I hate this. It's not my favorite." I can't say I hate it anymore. But it's not my favorite.

These responses indicate that these students who have more of a neutral view point of mathematics understand the importance of trying to learn mathematics as a necessary part of their academic journey. The responses also show that students who adopt a growth mindset have the ability to develop a less negative attitude toward the subject.

4.3.1.3Sub-Claim 3: Positive Emotions. Other students displayed positive emotions towards mathematics. Overall, when asked about how they feel about mathematics approximately 40% of respondents claimed that they enjoyed math, expressing a range of "like" to "love". In Statistics, only seven students, meaning 37% of the participants from that course, had a positive response about their feelings, saying, "I love it. Math has always been my strong subject." The sentiment was lower in College Algebra, where approximately 21% of respondents had these positive feelings towards mathematics. One typical response was, "I feel confident," while another expressed, "I like it, but tests are what I struggle on. In Intermediate Algebra, another student gave this type of conditional response by saying, "I really do enjoy math even though it is sometimes confusing." Approximately 15% of students in Intermediate Algebra responded with positive feelings towards mathematics with one respondent explaining, "I honestly like figuring out problems and trying to solve them," with another saying, "I feel positive while doing math, I feel like I understand what I'm doing." These responses indicate that many students feel positively about engaging with mathematics, even when they self-identify particular aspects where they struggle with the content.

4.3.2 Main Claim 2: Students displayed a strong motivation to learn mathematics

Students were asked, "What makes you motivated to learn mathematics?" as part of the supplemental questions given with the MAPS survey. Approximately 29% of all students responded that understanding what their primary motivation to learn mathematics. One student from Statistics explained, “When I actually start to piece the concepts together, it motivates me to keep going,” while another said simply, “Being smart.” Approximately 21% of students in Statistics responded in a similar manner.

In College Algebra, 26% of students responded that understanding was their primary motivation for learning mathematics. One student explained by stating, “Being able to solve the problems, it’s very satisfying.” Another student expressed that their motivation was, “To become great at math.” Intermediate Algebra had the highest growth mindset score of the three class types, and this was reflected in the highest percentage of respondents, 36%, who identified understanding as their primary motivation for learning mathematics. One student explained, “I don’t want to be intimidated by it, it’s also required,” while another student said, “I like learning new things, and I feel satisfied when I learn and get good at a new concept in math.” Another student explained, “Everything. It’s so challenging, if I don’t understand it, it makes me want to keep going.” During their interview, Cash, a student from Intermediate Algebra explained:

> I think it’s important. Yes, because it is a part of critical thinking. It’s not so much as becoming a major in math. So if you can sit down and understand it then, as far as my career path goes; I can sit down and make sense of a lot of things, because math is a foreign language to me. But if I can understand it enough to be able to do it, and without frustration or anxiety, then it’s important to problem solving skills or critical thinking in the future. Do I think that it should be required for psychology? Absolutely not. But I understand why they’re doing it.

Cash’s comment about the requirement of mathematics for psychology is reinforced by many student responses indicating that their primary motivation for learning mathematics is their desire to achieve their academic goals. Overall, 28% of students responded in this manner. Approximately 32% of students in Statistics responded in this manner. From Statistics, one student explained, “My major is in pre-nursing, and I am studying to be a pharmacy technician so I feel motivated to learn more.” Another student responded, “To acquire my degree to do my dream job.” In an interview, a student in Statistics who asked to be identified as Jacob explains:

> Okay, so I'm kind of in this on my own. Now meaning, I have nobody here in this area to like, have my back or to be able to fall back on. So, it's either now or never type of situation. My attitude from this summer, deciding to go to school in the fall has been nonstop persistent of: I need to get this done. I'm going to get this done, and I want to be top of my classes. I want to graduate, you know. I want to graduate top of my class to be able to get into my career flawlessly. I just want everything to be cohesive and transition from one point to the next easily. Being academically confident is gonna help me get there. It does open a lot of doors. In other words, math is a universal language, and we kind of have to learn it, no matter what it is gonna be used for. Every day may not be algebra, but in a way, math is involved. I honestly think math is going to play a huge role in my life. Huge. Moving forward math is gonna be my everyday. Not only do I have to calculate solutions, medications, formulas for you know, infants all the way to geriatric adults. And getting these solutions or formulas incorrect can cost me my job or their life. So there's gonna be a lot of pressure on me moving forward.

From College Algebra, one student explained their motivation as, "Me wanting to become an engineer," while another said, "My major in STEM." Approximately 18% of students in College Algebra had this type of survey response. In their interview, a student from College Algebra who asked to be identified as Clark K. explained:

> Honestly, just passing the test because I've never been good at math. So math is just been a big challenge for me. I don't want to barely pass, like I want to pass good. So that's really my motivation for like the whole math course. I feel like most kids that go to college, they don't really think like, "Oh I don't wanna take any extra classes." I wanna do my classes and get it done as fast as possible, and then graduate and get on with my life.

Intermediate Algebra had approximately 38% of survey responses indicating that achieving their academic goals was their primary motivation for learning mathematics. On student responded, “I want to be a geologist and mathematics is a step towards that goal. Also, I like to do my own check-booking.” Another student responded with, “What makes me motivated is by knowing I need to learn it in order to pass the class,” with another echoing, “If I need to learn it to pass, I will do my best to try to learn.” Approximately 20% of overall students indicated that their learning of mathematics was motivated by their career goals (not necessarily academic) and by math’s real world applications.

Only two students from statistics (11%) responded to the survey question in this manner. One Statistics student explained in the survey, “The fact that everything in this world has math involved in it. How things and places are created, how they work… math plays a huge part.” Another explained that their motivation to learn mathematics was “The basic general understanding of math so I can use it in the real world.” In his interview Jacob, a Statistics student, explained:

> I work in retail, and every day I work with money. I have to pull out money from a safe. I have to put back money into a safe, and I have to make sure it’s balanced. All the paperwork needs to be completed, and a lot of math is involved to do this. Everything has to balance out at the end of the day. If not, we’re short and we have discrepancies and paperwork.

This was higher in College Algebra with 22% saying that career and real world math applications was the source of their motivation. One student said “Whenever it’s something I can use on a day-to-day basis.” Another said, “Taking little bits and pieces into the real world.” In Intermediate Algebra, nine students (23%) had similar responses. One survey response said “I’m in the car business,” while another said, “The fact that it’s apart of my every day job and I want to be best at it.” In an interview, one nursing student in Intermediate Algebra, who requested to be called Angel said:

> I don’t know that I will really use what I learned in class, but with my daughter just the other day, I was explaining division to her. I was able to because we went over division in class. I was able to explain it to her. And I want to say that with the way my instructor showed us, she was able to understand it.

Only two students (4%), in College Algebra, indicated that their primary motivation was due to enjoyment, and two (4%) did not answer the question. The remaining responses to this supplementary survey question will be considered in the next section, in response to the third research question. In conclusion to the second research question: students display a range of emotions in identifying their attitude towards mathematics. From the confidence results scores and the overall MAPS expertise scores discussed in the previous section, students in Statistics had a higher negative response rate when compared with the other two courses. Their understanding, mirroring the dimensions of sense making and answers, was more similar to their peers in College Algebra and Intermediate Algebra. Similar to the results of the Real World score discussed in the previous section, the relationships with mathematics and the real world as a source of student motivation for learning mathematics was less identified in Statistics than in College Algebra and Intermediate Algebra.

Table 4.18: Frequencies and Percentages of Students' Motivation

Student Motivation				
Motivation	Statistics	College Algebra	Intermediate Algebra	Overall
Understanding	4 (21%)	13 (26%)	14 (36%)	31 (29%)
Academic	6 (32%)	9 (18%)	15 (38%)	30 (28%)
Real World	2 (11%)	11 (22%)	9 (23%)	22 (20%)
Nothing	3 (16%)	2 (4%)	0 (0%)	5 (5%)
Enjoyment	0 (0%)	2 (4%)	0 (0%)	2 (2%)
Instructor	4 (21%)	11 (22%)	1 (3%)	16 (15%)
No Response	0 (0%)	2 (4%)	0(0%)	2 (2%)

4.3.3 Main Claim 3: Students can identify the source of their lack of confidence

One of the supplemental questions asked students to describe a time when they did not feel confident in mathematics. The most typical response was students felt the least confident during examinations. Overall, approximately 21% of students responded that examinations were when they felt the least confident. This feeling was higher amongst students taking Statistics where approximately 32% of these students identifying examinations as the time when they were the least confident in their mathematical ability, with one student explaining, "When I am taking a test it feels like it is a foreign language and I don't know what to do." In comparison, 22%

of students in College Algebra identified examinations. This was much lower in Intermediate Algebra, where approximately 18% of students identified examinations. One student explains by stating: "Every math class since junior high, I would think I'm confident but then the test would start and I wouldn't remember anything. I over-stressed myself studying and it didn't work out for me in the end."

Approximately 21% of all respondents stated that their lack of confidence started in high school. With an additional 6% stating it developed in an earlier grade. One student enrolled in Statistics stated, "I probably lack confidence in my ability to do mathematics most of the time. But I struggled with algebra all throughout the teaching of it." Another Statistics student had a survey response that said, "Seventh grade year, I had a teacher who didn't think I was smart enough to be in the Pre-AP classes and told me, so I dropped out of them." One student in College Algebra stated that they lost confidence in their ability to learn mathematics in the second grade, while another identified the fourth grade. Yet another student responded, "I didn't feel confident all through high school since COVID hit, and online learning didn't sit well for me." Interesting side note: Approximately 76% of all respondents were in high school during the COVID-19 quarantines in the United States. These sentiments were echoed in Intermediate Algebra where one student stated, "In 5th grade, when multiplication and division was introduced it took me a little longer to figure it out," and another said simply, "My entire high school years." In their interview, Angel from Intermediate Algebra said:

> Because when I was in high school, I would ask the teachers for help. Saying, "I don't understand this every day." Okay, no big deal. And if they actually took the time to explain it, I still wouldn't understand it. They'd be like, "Okay, move on."

In Statistics, this was echoed in Jacob's interview, who said:

> Honestly? These teachers have a lot of students, and can not focus on one student so much. But, you know, I performed pretty average in high school. Most of my grades were either B's or C's, so honestly, my efforts were really just so that I can continue to compete in athletics. That's the reason why I took all these classes and maintained

> my average. Just so I can be able to compete. But I was never really interested in math and appreciate it like I do now.

Further, 15% of overall students said that they have always felt that they did not have any confidence in their ability to learn mathematics. In Statistics, four students (19%) said that they always experience a lack of confidence in their mathematical ability. One student wrote in their survey that they felt this lack, “Pretty much in all day to day life. I’m great at every other subject but math,” while another said, “every time I do math.” This response rate was much lower in College Algebra, at approximately 8%. One student’s survey response was, “Any time I’m doing anything math related,” while another explained by saying, “Most of the time.” In Intermediate Algebra, this type of response was approximately 21% of responses. One survey response states, “Almost most of my education. Most of my teachers just expected me to understand and when I didn’t and asked for help they wouldn’t break the information down for it to be easier for my understanding so I started to give up.”

Approximately 19% of overall students explained that their lack of confidence was due to a lack of understanding. From Statistics, approximately 16% of students responded in this manner. One student’s survey response explained, “When I don’t fully understand the assignment,” while another said, “When I didn’t learn about what it is asking.” This percentage was higher in College Algebra, where approximately 22% of students that they experienced a lack of confidence when they struggled with understanding the material. One survey response from this group said, “When there was no explanation or steps to a problem,” and another explained, “When I couldn’t solve the problem.” In Intermediate Algebra, the rate of this response was approximately 18%. One student’s survey response stated “When I failed to recognize and solve math problems,” and another stated, “When the questions get difficult and I’m not sure what to do. In their interview, Cash from Intermediate Algebra echoed this experience saying:

> It’s like, this wasn’t in the book. These weren’t part of the examples. So, I go back and look at a part of the chapter. Then I just feel lost. But, overall, I would have a better attitude if I could sit down and understand it. When I get frustrated I just leave it alone.

> I'll just walk away for a little bit. It might be hours, it might be a day, but at that point I'm not learning anything. My brain is just like, get it done.

The remaining responses to this question fall into two types of responses. Approximately 12% of students overall responded in the survey that their lack of confidence in their mathematical ability began after completing high school or during college. No students in Statistics responded in this manner. From College Algebra, six of the fifty students surveyed (12%) responded in this manner. One survey response from College Algebra explained, "pretty much right now, when my memory at it is messy," and another stated, "Now that I've been out of school for years." This rate was higher in Intermediate Algebra with approximately 21% of respondents explaining that their lack of confidence began after high school or during college. One stated, "Every day in this class. I get overwhelmed and frustrated." Another student's survey response was, "Right now I don't feel confident in my mathematical abilities. I feel since I don't use it as much in my daily routine, I don't practice as much as I want to." The remaining 4% stated that they always felt confident in mathematics. While no one from Statistics had this response, three from College Algebra (6%) and one from Intermediate Algebra (3%) had this sentiment. One from Intermediate Algebra stated, "I always feel confident," which was echoed in the responses from College Algebra. Finally, one student in College Algebra did not answer this question, constituting the remaining overall 1%.

To summarize, students in Statistics are more likely to have a lack of confidence during examinations than their peers in College Algebra or Intermediate Algebra; however, both Statistics and Intermediate Algebra had a response rate of 21% that claimed they never felt confident in mathematics. Furthermore, for students that responded that their lack of confidence was due to not understanding the material this response rate was lowest in Statistics. Students that claimed their lack of understanding occurred post-high school were either enrolled in College Algebra or Intermediate Algebra. Additionally, no student from Statistics said that they always felt confident in mathematics, while 6% from College Algebra and 3% from Intermediate Algebra responded in this manner.

4.4 Course Placement and Co-requisite Structures

The third and final research question is: "What aspects of the developmental course contribute to students developing a positive attitude toward mathematics?" To begin, consider the responses to the first of the supplemental questions given with the MAPS instrument to all students. This question asks: "How did you choose between Math 0482 and the co-requisite course options? Please explain." It is important to recall that students are placed into developmental mathematics based on TSI scores prior to enrollment. Math 0482, Intermediate Algebra, is the only stand-alone developmental mathematics course at this institution. This means that in this four-hour course, students are intended to satisfy Texas Success Initiative (TSI) expectations only. This course does not contribute to a certification or degree plan. Any student placed into developmental mathematics is free to choose this option in preparation for a transfer-level math course such as College Algebra, Business Math, Quantitative Reasoning, or Statistics. The other two courses that are apart of this study are co-requisite courses. These courses allow a student to enroll in a transfer-level course, such as Statistics, without satisfying TSI standards as long as they enroll in an additional support course. In particular, Statistics consists of the three credit-hour transfer-level course of Statistics, as well as Support for Statistics, a two non-credit hour course. For College Algebra, the transfer portion of the course is also three credit hours, however, Support for College Algebra is an additional four non-credit hour course. All developmental mathematics courses also include one additional hour of a mathematics lab course. These courses allow a student to fulfill both their TSI obligation as well as receive those math credits that contribute to a certification or degree plan.

4.4.1 Factors Informing Students’ Selection of Course Type

In Statistics, there were six general responses to how students selected their particular course type, either Intermediate Algebra or a co-requisite course. The highest response rate was that enrollment was due to advising. with 8 students (42%) One student explained, “I chose my class as it was already laid out by my advisor. In terms of math I didn’t do much research into which class to choose, as it tends to be a course I struggle with.” Another student explained, “My college advisor suggested I should do the co-requisite since I did not pass my TSI." Two students (11%) responded that the reason for their particular course enrollment was due to low performance on the TSI placement exam. One student simply said, "I failed my math TSI," while the other responded with, "I was placed into the class after not meeting my TSI test score requirement."

An additional three students (16%) stated that they chose or were placed into the Statistics co-requisite model because it was a requirement for their particular major. One response for Statistics was, "I was put into co-requisite because I am majoring in pre-nursing." Also, three (16%) of students in statistics explained that they did not choose their particular course, but did not give a further explanation. One student (5%) explained their decision to enroll in the support class as, "I chose the support group because I'd rather fully understand a concept than struggle in the future." Finally, two (11%) students chose not to answer the question.

From College Algebra, approximately 10% of students indicated that they were in their course due to TSI scores. One such student explained, "I didn't choose, it was required after getting my results from the TSI test." Another student response was, "Did not pass my TSI math and knew I was gonna need help understanding math a bit more." Seven students (14%) indicated that they did not have a choice. One student stated, "I didn't choose, it was given to me. I enjoy having two math classes, it is really going to strengthen my mind towards math." Another student said, "I was put into whatever class that was best for me." Further, nine students (18%) indicated that they were in College Algebra plus Support because it was a requirement of their major. One student explained, "I chose this one because it best fit my needs and I need to take this class for College Algebra." another student said, "It was a requirement for me to take this class for the major I chose. I am terrible at math, so I'm happy to take it to help me understand math since I have always struggled with it." An additional 18% stated that they trusted their advisor to make the correct placement decision for them. One stated, "My advisor signed me up for the class after taking my TSI test." Another student said, "My advisor thought about me and gave me a class where I can understand thoroughly and without complications! That's why I am here."

Another 18% of College Algebra students indicated that they chose the co-requisite model for the type of help it offers. One student responded that "Co-requisite is more of a help," while another echoed, "I needed extra help and someone who has time to answer my questions." The final 11 students, or approximately 22% gave either no response or indicated they did not understand the question.

Finally, Intermediate Algebra had the highest response rate of placement due to TSI score. Ten of 39 students (26%) indicated in this manner. One student said, "This seemed like the best fit for me and I needed a help math because I failed my TSI." Another student echoed this response and said, "I had to take this math class because I failed my TSI and it was one of the last ones available and it seemed like a good fit for me." Two students (5%) had similar responses about it being the most appropriate fit because of the course type. One student explained, "I just got back into the school scene and I did not want to overwhelm myself." Another student concurred and said, "I thought it would be best to choose Math 0482 (Intermediate Algebra) so I can get a little bit of practice before taking my pre-requisite classes." These responses may imply that the number of course hours dedicated to math in the co-requisite model could intimidate some students.

Overall, students tend to understand their placement in developmental mathematics due to low placement scores or their understanding of the level of math skill that they have when enrolling in college. They also appear to trust that their advisors place them in the most appropriate math course for their needs and degree plan. Recall that this is the intention of mathematical pathways advising. College Algebra tended to be the default math course for a variety of degree plans. Similarly, Intermediate Algebra is a default developmental math course meant to fulfill TSI requirements, but not grant credit towards a degree. For co-requisite courses such as Quantitative Reasoning and Statistics, students bypass Intermediate Algebra and take a support course to more quickly fulfill the math requirements for their degree or certification.

4.4.2 Students' Perceptions of Advantages and Disadvantages of Each Course Type

During the interview portion of this study, students also discussed their thoughts about their course placement. Cash, from Intermediate Algebra, is an online student. The online Intermediate Algebra is also a four non-credit hour course plus an additional one hour of a math lab. Online students are not obligated to attend the math lab that non-online students use. This portion of their course is handled by the instructor using study skill assignments and options to meet with the instructor virtually on a regular basis. Additionally, all students have the option to visit with a virtual tutor who is employed by the college. Cash explained:

> Online is difficult. The absolute value was something that happened in the lecture yesterday. And it was like the absolute value turned it into an opposite. So when I'm going through the lecture, I didn't understand it. But it makes sense, so negative five becomes positive, so that much I can grasp. But if you give me a problem right now, could I do it? Probably not. I could probably get to a certain point. And it's like, okay, what do I do? That's what gets confusing, and it always has been. Cause there's so many different rules that go with it that just goes back to: I think if I were in a classroom, I would have a better understanding in person. And another thing for me is online again. The online homework is very picky. And even in their examples, like when you're doing the homework and you click on an example, it doesn't break it down. Why do these negative stays or why it disappears. So then you get three attempts. And if you get lucky you get it right, but if not, you have to start all over again, and that's frustrating.

When the co-requisite option was explained to Cash, they were asked if they would have considered this model they stated:

> Yes. There's more one-on-one. And then, of course you have your math lab. So would it have been difficult. Yes, but I don't think it would have been as difficult as it is to me now because I would have had the interaction. I would have that lecture time and that support for understanding. The tutors have been helpful, and don't get me wrong, but they know it. So they're trying to help you, but not break it down to you. So I think

> it would have been very beneficial. I would have definitely gone that route, given the option. Would it have been stressful? Probably, but it wouldn't have been as stressful. It would have made more sense along the way.

Also from Intermediate Algebra, in her interview Angel also explained their placement and said, "I never wanted to take this class online. They told me I had to take this class because of the TSI. And the ladies at the testing center recommended I take it with a specific instructor." After the co-requisite model was explained, they commented, "No. I was only asked, 'Do you want to take it online?' I have doubt about myself. I was like: 'Hey, no I need to be in person, cause I'm not gonna learn online.'"

From Statistics, Jacob also discussed the advantages and disadvantages of the the co-requisite model and explained the support course:

> No lie. I can say that it's a lot of homework. Having to do Statistics homework, which is basically your main class. And then you have another set of homework due either before your Statistics homework or right after that. And you have, you know, a different lecture towards statistics. And you have video assignments due. I do feel a little tension there, because I do work full time. I am a full-time manager, and I'm salaried, so it requires all of my attention as well. I don't really have that much time to do my homework, but I do feel it is beneficial in some ways, because there is open time in class for me to do my homework if I have to, which is math lab. You can sit there and complete your assignments that need to be finished. The only thing is, as soon as I'm done with class I literally have 30 minutes to get to work. So I'm in a hurry to put up my stuff so I can get to work. It's stressful.

It is important to note that Jacob's support course instructor is not the same instructor as the instructor for Statistics. All Statistics courses cover the same material. Some courses are part of the co-requisite model, while students who are TSI ready, only take the Statistics portion. These classes are not co-mingled, meaning TSI ready students are not in the same class meetings as developmental students who are also taking a support course. Some instructors elect to teach both portions of the co-requisite model, while others decide to team with another instructor who will teach the support course. Jacob continued by explaining his enrollment in the course as, "I was really close to being at the exceptional level, so I can just take a math course, but I missed it by a few points," in reference to his TSI placement score, and then said, "I was kind of only given the option to take Statistics with the math supplemental course. That was the only thing that was offered to me."

Clark, from College Algebra also discussed the co-requisite model during their interview. Again, note that the instructor for College Algebra is not the same instructor that teaches the support portion of the model. Clark stated:

> In the college-level course, that instructor does a good job of making sure the class is engaged, and she does take a break in the middle of the lesson. Like she doesn't just like go on a ramble. She makes sure to dive in and explain everything. So, she's very aware of how the class is going and if everyone's all confused, she's not gonna continue that way. The two instructors complement each other. Because I learned certain things a different way and I learned from certain teachers. I learn certain tools from the college-level course. And I learned certain tools from the support instructor. It gets a little frustrating, because like sometimes I learn the easier way from the support instructor, and sometimes I learn the easier way from having their different perspectives, but otherwise I feel like it's a good experience. In the math lab, I feel like it would be better if we had more instructors. I feel like it's a good time for me to just like sit down and actually pick other peoples' minds. Like we hope that we all help each other. But I mostly just go to tutoring outside of lab during my support instructor's office hours. It's not as a loud environment and very calm. It's just a better choice, it is not that they're not helping in math lab.

Another student was interviewed in the College Algebra co-requisite model. This student is also in a co-requisite section where the support instructor is not the same as the transfer-level instructor. This student, who asked to be identified as "Optimus" explained their placement as:

> The TSI that's mandated by Texas. I didn't pass, right, so I talked to my advisor and she recommended that I take this remedial course. But I'm learning. I'm keeping it retained in my mind. I have different points of views and different outlets for me to go about solving the same problem. When I'm alone I always try to pull up a website or online video discussing the concepts. I feel like the math lab is there for credit. When we're there with our math class, it's not actually helpful. I try to regularly attend office hours with my support instructor when I need extra help.

These interviews support the claim that co-requisite students tend to trust that the course in which they were enrolled is the correct placement for their needs. Cash, commented on the difficulty of Intermediate Algebra online, also expressed that they would have taken Intermediate Algebra as a face-to-face course, but these sections were full at the time of their registration. It may be that they would have taken the College Algebra plus Support option solely based on the availability of have mathematics in face-to-face course and not because of the type of help it offers. They expressed the need to have someone that they could sit down with and discuss mathematics. Overall, the three students in co-requisite models spoke favorably of the support course and the help they receive from the support instructor in particular. This sentiment was also expressed in the supplemental survey questions.

4.4.2.1 Course Structures. Students identified aspects of the developmental course types that seemed to foster students' positive feelings towards mathematics. Some students expressed positive feelings about mathematics in answering the question: "How do you feel about math?" While we have already answered this question with positive, neutral, and negative feelings, it is important to note that approximately 18% of all students responded that they either liked or enjoyed mathematics when they felt as if they understood the material. One student in Statistics explained, "I have mixed feelings about it. If I don't fully understand how to solve a problem or use a formula, I feel discouraged, but if I do understand the concept I actually enjoy math." Other students in Statistics echoed this statement, explaining that they often struggled with mathematics, but found enjoyment in understanding. Approximately 32% of students taking Statistics responded in this manner.

In College Algebra, approximately 16% responded in this manner with one student saying, "I feel like I can be good at math if I understand what I'm working with," and another said, "It's okay as long as the problems are explained to me right until I understand." This sentiment was echoed by 13% of students in Intermediate Algebra, "I try very hard to understand it, but I always fall short. Math is a very difficult subject but it helps when someone is willing to try and explain it in broken down parts." In their interview, Cash from Intermediate Algebra explained:

> I'll use this analogy. If you can't stand your job, then you're gonna be miserable.You're gonna have a bad day. It's not gonna be anything that you want. Time's gonna go by slow. But if you can make sense of it, you can understand it, then you can get through it even if you don't like it. If you have a more positive attitude and understand the "why" it makes it a little bit easier, in my opinion. The teacher, the professor, makes a huge difference, I've seen. I was one of them. I couldn't understand algebra, and I switched schools and got different teachers, and I went from a very low C to an A plus. It was a husband and wife, but they had many different ways to teach it. They were very patient, they were understanding. They weren't condescending. I'm the type of person that the way you show me may not work for me. You give a second or third option, for whatever reason, that clicks. So in giving more than one example to come to a solution is helpful, and it depends on the person teaching. If you have a passion for it, you're gonna want your students to understand. You're gonna want to make sure that they're not confused or left out.

Further, in response the survey question: "What makes you feel motivated to learn mathematics?", approximately 21% of students indicated that they were motivated by an instructor. One student from statistics explained, " When there are teachers that know how to explain things to my understanding and show examples and sample questions." Another student from College Algebra expressed, "A good teacher that explains and is patient with the learning process." Only one student from Intermediate Algebra had this response type saying, "When the teacher does it in front of me and I take notes on the formulas and subject."

These responses indicate that a student may have a more positive attitude when they feel as though they understand the material. Cash, in particular, indicated that it was by adopting a growth mindset attitude and the support of the instructor that increased their understanding, which allowed them to have a more positive attitude. These sentiments were also expressed in the supplemental survey questions. A supplemental question asked as part of the survey portion of this study asked students to describe a time that they felt confident in their ability with mathematics. Similar to the question discussed earlier that asked students to describe a time they did not feel confident, approximately 16% of overall respondents answered that they never or rarely felt any confidence in their mathematical ability. In this survey question, one student from College Algebra explained, "I don't even remember when I ever felt like I knew what I was doing."

However, approximately 10% of responses explained that the support of a particular instructor was the source of their mathematical confidence. One student from Support for Statistics explains, "I had a very good statistics teacher in high school and that's when I felt most comfortable with my math abilities." Another student said, "Algebra 2, my junior year, the teacher would go over the assignments and homework for as many times as I needed to understand." This sentiment was also expressed in College Algebra, with one student explaining, "My senior year, I just loved how my math teacher explained it to me." Another student from Intermediate Algebra said, "Around 10th grade, my educator at the time would use the math equations to real-life relatable situations, which made it easier for me to understand."

Similar to the responses about students' feelings about mathematics, when asked to describe a time that they felt confident in their ability to do math, approximately 16% of overall students explained that they were confident with mathematics when they understood the material in response to this supplemental survey question. One student from Statistics responded, "When I take a test over a chapter that I feel confident in and pass the test," while another said, "When I knew how to solve the problem or equation." From College Algebra, one student explained, "When I fully grasp the concept and understand why I'm doing what I'm doing." Another response from College Algebra was, “When I was able to understand and keep doing problems over and over until I got the hang of it.” From Intermediate Algebra, one student responded, “I feel confident when I know what I’m doing and understanding the work,” while another said, “When I understood the material.”

Approximately 5% of students indicated that they were confident in their mathematical abilities when they were working with “real world” mathematics. Two students (11%) from Statistics had this response, one explained, “Simple or basic math to solve calculations for intravenous medications.” From College Algebra, only two students had this response and they stated, “When building things I feel confident in my math when everything works.” and the other said, “Filing and paying my taxes.” One student from Intermediate Algebra also indicated that they were confident with their real world mathematics applications and said, “I felt confident in mathematics when I was working as a bookkeeper. I felt so comfortable counting and calculating the money.”

Overall, approximately 8% of students indicated that they felt confident due to study skills. One student (5%) from Statistics indicated that study skills was the source of their confidence, and stated, “studying before a test.” One student from College Algebra said they felt confident “studying before a test,” while another stated, “taking notes and giving all my attention to the teacher.” This response rate was approximately 6% in College Algebra. However, in Intermediate Algebra, approximately 13% of students indicated that their confidence level was based on their study habits. One student explained, “When I usually have time to study and go through a problem, I can catch on quick and I feel confident in repeating the problem without help.” Another response from Intermediate Algebra was, “When I take notes and do a worksheet and take a test, I’m pretty confident.”

In his interview, Jacob, from Statistics, explained how he found this type of support in the co-requisite model:

> Honestly, the involvement the teacher gets with the class, like she’s going to be breaking down and doing the homework herself. And you know, she’s actually working through

> each of these problems, just like you are. I feel like we have a better understanding of what's going on in the class because everybody's doing it together. We're not just, "This is the instructions, and go ahead and do your homework" Which was high school. I really do like the way that this course is set up currently because it does help me stay organized in Statistics. I think this is the most organized I've ever been attending college right now. Attending this college has opened my eyes a little bit more about the lifestyle of college. Not only is tutoring available for us college students, it's free. There's no reason for me not to pass another course in college because of the help that is available. I feel like not a lot of people do take advantage of the help and they either fail their course or barely pass.

This quote gives evidence to the claim that having a supportive instructor contributes to the development of a more positive attitude in learning and interacting with mathematics. Additionally, Jacob also indicates that it is the course structure of his co-requisite model has contributed to his overall understanding and organizational skills. The comments about tutoring are in reference to the Math Lab portion of the course. The co-requisite model for Statistics at this institution consists of a three-credit hour transfer-level course of Statistics and a two non-credit hour course called Support for Statistics and also one additional hour as a lab. In this instance, the instructor for Statistics is not the same as the instructor for Support for Statistics.

These findings answer the third research question: "What aspects of the developmental course contribute to students developing a positive attitude toward mathematics?" Pathways advising places students in the course that the student feels is most beneficial to them. Increased exposure to a supportive instructor along with the adoption of a growth mindset and seeing real-world applications, helped increase students' understanding of course material. Increased understanding contributes to students developing a positive attitude towards learning mathematics. Additional research would be necessary to comment about the times students were confident while in high school. Other factors may be contributing to this time period, be it instruction or level on material, or something not yet identified.

The codes from Thematic Analysis can be seen in Table 4.19 below.

Table 4.19: Thematic Analysis Codes

Thematic Analysis Codes	
Theme	Codes
Students' Emotional Responses	
	Positive
	Negative
	Neutral
Student's Motivation	
	Understanding
	Academic
	Real World
	No motivation
	Enjoyment
	Instructor
Lack of Confidence Development	
	Never Confident
	Always Confident
	Exams
	Before High School
	During High School
	After High School
Course Selection	
	Advising
	TSI Score
	Type of Support

Table 4.19: cont.

Themes	Codes
Course Selection Continued	
	No Choice
	Requirement of Major
	Course Requirements

CHAPTER V

DISCUSSION

Recent changes to developmental mathematics are meant to alleviate barriers to college-level coursework for students entering higher education. Multi-course sequences, which increase student cost, and high rates of failure prevent students from gaining access to mathematics courses that contribute to the completion of a degree or certification. While longitudinal studies of these changes, such as the implementation of co-requisite models, is limited, identifying factors that promote student success is necessary to allow institutions and instructors to develop effective and efficient models to increase student success. One such factor related to student success is students' attitudes towards mathematics, which was the focus of this study. This study uses the novice-expert continuum to measure dimensions of students' mathematical attitudes through the use of the MAPS instrument (Code, et al., 2016). Students were assigned student expertise scores that include all dimensions of the MAPS instrument, as well as scores for the specific dimensions that the instrument contains. Kruskal-Wallis Rank-Sum tests were performed in order to identify differences in specific student populations by course and dimension of attitude. Further, Wilcoxon Rank-Sum tests were performed to further identify the courses between which these differences occurred. Responses to supplemental survey questions and student interviews were also collected to gain a better understanding of students' mathematical attitudes. The qualitative method of thematic analysis (Clark & Braun, 2017) was utilized in studying these responses, many of which linked back to previously established concepts such as positive attitude, self-confidence, and motivation. Thematic analysis also identified aspects of the courses that, in their opinion, contributed to various dimensions of mathematical attitude, such as real-world applications and understanding.

5.1 Discussion of the Study's Main Claims

This study is an attempt to identify the mathematical attitudes of community college students placed into developmental mathematics. One main factor of placement in developmental mathematics is the requirements established by the Texas Success Initiative, or TSI. Current literature indicates that changes in developmental mathematics are necessary. Two such modifications are the use of mathematical pathways and accelerated course models (Ryu et al., 2022). This institution at which this study was conducted uses mathematical pathways for placement into specific co-requisite courses. Enrolling students are aware of their TSI obligations and generally feel that they have been placed in the required course or co-requisite model for their degree or certification.

Mathematical attitudes have been shown to be an important factor of student performance (Mazana et al., 2019). The combination of a positive attitude and confidence contributes to student success (Farooq & Shah, 2008). Thus, having negative attitudes toward mathematics and a lack of confidence in mathematics can be detrimental to students' success. Many students in this study reported that they had developed a negative attitude towards mathematics before enrollment in community college. Approximately 36% of the overall population surveyed indicated they had a negative attitude toward mathematics and approximately 27% stated that their lack of confidence in mathematics began in high school or before. However, this percentage was higher for students enrolled in the Statistics co-requisite model course, as approximately 63% of those students had negative attitudes towards mathematics. The finding regarding students' formation of negative attitudes towards mathematics before their enrollment at higher institutions has been documented in other studies, as well (e.g., Dogbey, 2010). However, the finding that a much higher percentage of Statistics students had negative attitudes toward mathematics than College Algebra and Intermediate Algebra students presents a contribution to the literature on students' mathematical attitudes.

Students also identified their primary source of motivation to learn mathematics that linked back to the dimensions of the MAPS instruments and the literature in general. High levels of motivation increases have been found to increase a students' desire and interest in learning mathematics, and such increases in motivation can affect students' degree of engagement with the material, career, and academic performance (Mazana et al., 2019). Through the supplemental survey questions, many students indicated that their academic and career goals were their primary motivation to learn mathematics. Others indicated that the usefulness of mathematics in the real world was their motivation for learning. Another factor that was identified by students was their desire to increase their understanding of mathematics, which relates back to the dimension of Sense Making in the MAPS survey.

Also, previous research indicated that students with different attitudes towards mathematics need different types of support in the development of a more positive attitude about mathematics (Hwang & Son, 2021). The students' responses to supplemental questions and interviews gave perspective on students' attitudes, sources of their motivation, and self-confidence (or lack thereof) between the types of developmental mathematics courses offered at this particular institution. Additionally, students were able to explain advantages and disadvantages of the particular developmental model in which they were enrolled. For instance, in his interview, Jacob explained how he found the Statistics co-requisite model helped him develop a better attitude towards learning mathematics due to a supportive instructor and the structure of the co-requisite course. He identified that the manner in which the support course was conducted, specifically instructor-guided problem-solving activities, directly increased his understanding of the material. Also, the structure of the paired courses, while at times overwhelming, increased his organizational skills and increased his willingness to utilize the additional support this institution offers. Thus, these aspects of the co-requisite course contributed to his formation of a more positive attitude toward mathematics.

5.2 Limitations

It is important to note the limitations of this study. The first limitation of this research is that not all developmental courses at this institution were surveyed. Math 1324 Business Math and Math 0324 Support for Business Math were not surveyed due to being under the direct instruction of the primary researcher for this study. This co-requisite model is only taught one semester per academic year and offers the same opportunity for students to complete a transfer level math course with three hours of additional support. This researcher both developed the course and is currently the only support instructor for this co-requisite model for the last three academic years. When this course is not offered, students enroll in Math 0482, Intermediate Algebra and then are free to take Business Math without support. A survey and interview with these students may contribute greatly to the overall findings of this research. Business Math is unique in that it is an applied algebra course that connects algebra to business and financial mathematics topics. Additionally, it contains components of Statistics and Probability Theory.

A second limitation of this study is that Math 1332 Quantitative Reasoning with Math 0232 Support for Quantitative Reasoning were also not included in this study. This researcher developed the course and is the only support instructor for this co-requisite model. This course is offered every semester. The main focuses of this course are critical thinking skills, communication skills, and empirical and quantitative skills. This course covers numeracy, probability and statistics, financial mathematics, and mathematical models. All aspects of this course are taught in the context of real-world applications. Since this course is offered every semester, students who enroll in Quantitative Reasoning without support rarely take Math 0482, Intermediate Algebra in a previous semester. A survey and interview with these students may contribute greatly to the overall findings of this research.

A third limitation to this study is the small sample size of the interviews. All students who took part in the initial survey were asked if they wanted to participate in the interview process. Only five students replied to the interview invitation. The limited response may be due to a variety of factors, such as genuine lack of interest or lack of available time due to academic and non-academic factors. Further student interviews would also contribute to the results presented previously.

Another limitation to this research is that, due to the timing, students were surveyed at the beginning of the semester, leaving no opportunity to make comparisons of mathematical attitudes and pass rates of students amongst these courses. Also, it would have been interesting to have resurveyed the students at the end of the semester and compare students' expertise scores to compare any changes in mathematical attitude that may have occurred over the course of the semester.

These limitations indicate that further study is needed in order to have a more accurate understanding of mathematical attitudes of developmental mathematics students at the institution where the study was conducted. The inclusion of all co-requisite models, as well as further survey administration and follow-up interviews, will give future researchers the ability to continue to make comparisons between these populations.

5.3 Implications for Future Research

The study adds to the existing body of literature the mathematical attitudes of developmental students as they enroll in their first college mathematics course, whether it be an accelerated model or a traditional stand-alone developmental course in community college. Besides mathematical content, research is necessary to identify factors that inhibit student success in these courses. This research contributes a measurement of mathematical attitude of incoming students. Due to the large proportion of developmental students in community college, the pre-existing mathematical attitudes of these students is an important measure to have in order to allow educators and institutions to continue to modify and create courses to help students develop a more expertise-like way of thinking about mathematics. Also, this study is an examination of several types of co-requisite models and developmental courses, which allowed us to establish that the population of students requiring Statistics is not the same as students in algebra-based courses. The students in these courses have a lower expertise score in general, as well as in several of the dimensions measured by the MAPS instrument. These students have lower self-confidence, interest, persistence, and understanding of the relationships between mathematics in the real world. Also, these students had a dramatically higher level of negative emotional responses about mathematics. Moreover, this research allows students to explain in their own words their feelings towards learning mathematics. Additionally, students were able to provide insights into the portions of their courses that they identified as being helpful.

Future researchers can extend these findings by including the courses that were not surveyed for this study. This will increase the understanding of the mathematical attitudes of all developmental students at this institution. Further, this study can also be conducted at another Texas community college with similarly defined courses. This will allow an increase in the understanding of mathematical attitudes of incoming developmental students across Texas as a whole. This may indicate that mathematical attitudes, or aspects thereof, vary by location or region. Similarly, with the increased application of the co-requisite model across various states, we may begin to compare similarities and differences by state. Typically, the majority of community college students tend to be local or close in proximity to their institution. Identifying various similarities and differences in the populations will allow educators to better tailor their courses to fit students' needs.

Future researchers may consider this as a model for longitudinal studies. Subsequent applications of the MAPS instrument, as well as rates of successful completion, will allow for the study of changes in mathematical attitudes over a course. This information would be helpful to educators to determine if their treatments to increase the mathematical attitude or any of the dimensions measured are effective. Continued interviews could help identify areas of the co-requisite structure that are effective from the students' perspective. Mathematical attitude has been shown to be a key component of student success, not only in these courses, but in college in general. The co-requisite model has been shown to produce a higher graduation rate for students, but differences between the structure of these courses is an important consideration when comparing institutional success rates.

5.4 Implications for Instruction and Course Design

5.4.1 Institutional Context

The overall goal of this institution's mathematics department is to minimize barriers to students' successful completion of their mathematics courses in order to achieve their academic goals. The developmental courses at this institution are under constant examination by the faculty in order to determine how to best serve this particular population. While implementation of the co-requisite model was mandated at the state level, a majority of the course design and delivery was left for the institution and mathematics department to develop. As such, it is important that this institution designs a co-requisite model for these courses that is mindful of the students' experience in order to foster a more positive attitude towards mathematics and, therefore, increase student success.

An important consideration by any study of the co-requisite model is the wide variability within the design of these courses. At this particular institution co-requisite courses vary by factors such as number of hours for support courses, instructional approaches, course content, and number of instructors. Students in different sections of the same course could have very different experiences. As an example, consider three students in different sections of a random co-requisite model. Student A is taught by a single instructor, who uses the hours of in-class time to slow down the lectures and incorporate active-learning strategies. Student B has two instructors, one for each portion of the course. The instructor for the credit-granting portion of the course lectures for three hours a week. The instructor for Support uses this time for students to work on homework and ask questions but offers few additional assignments. However, Student C also has two instructors, but their support instructor lectures during their course time in order to skill build for the upcoming sections in the transfer level course and has separate homework assignments. This lack of required structure and variation of course content makes an analysis of the effectiveness of these courses complex. Examining the overall pass/fail rates for these courses is insufficient in determining whether the co-requisite model is more effective than the traditional model of developmental courses. All three students may be successful, or conversely they may not be successful; therefore, it is important to know what factors contribute to, or inhibit, their success. Using students' attitudes towards mathematics as a base for instructors to develop their courses and interventions allows for individual instructors to be successful with a variety of methods that they can adopt quickly in order to cater to the needs of their particular students.

Another important consideration of this study is that students were surveyed at the beginning of the semester and had little time to interact with the course content. These measures are based on their general attitude towards mathematics, not specific content. It is typical to assume that most students have the foundations of algebra prior to enrollment, Statistics students may be approaching mathematics with attitudes developed from their algebraic struggles, and these results cannot determine their attitude towards Statistics. This is important because the skill set necessary to be successful in elementary statistics is not considered algebraically rigorous. Students mainly deal with formula work, charts, and calculators. However, one of the challenges of this course is interpretation of their particular solutions, and why it is important in the context of the question. These students, having a more negative attitude towards mathematics, need different interventions to foster a more positive attitude than their peers in an algebra-based course. Specifically, these students will have a lower interest in learning mathematics, will have lower persistence while problem solving, and will have less of an understanding of the real-world importance of mathematics. The implication here is that instructors will have a harder time engaging students with the content of the course, and that students will give up more quickly on concepts they feel they cannot master. One consideration for this institution is whether or not students would benefit from a stand-alone developmental course, similar to Intermediate Algebra, in that it is meant to satisfy TSI liability while preparing student directly for the course content of Statistics.

A final consideration for this institution is whether or not the courses themselves are creating academic barriers not previously identified. For instance, does the number of hours required by the College Algebra co-requisite model inhibit successful student completion? Conversely, does the low number of support hours for Statistics limit student success, and would these students benefit from more contact hours within the support course?

5.4.2 Recommendations for Instruction

Understanding the factors that contribute to student success is essential for educators to create and administer effective treatments for developmental mathematics students. Through the use of the MAPS instrument, and student feedback, educators can identify the needs of their students in terms of mathematical attitudes, which are key areas for which to implement effective treatments to assist students' development to an expert-like way of thinking about mathematics.

One suggestion for educators is to incorporate treatments specifically designed to foster student understanding of the real-world usefulness of mathematics, especially for Statistics (and possibly other non-STEM pathway courses). Recall that Statistics students' scores for this particular dimension were significantly lower than the other two courses studied. While some might argue that Statistics (and Quantitative Reasoning) are more "real-world" based courses, it is important to reinforce this dimension for the developmental population who have a difficult time making these connections. This may be done by incorporating more project content, where students identify and solve a real-world mathematical problem utilizing their various skill sets. Also essential is the inclusion of treatments that specifically address students' persistence in problem solving. This area was also found to be significantly lower amongst students in Statistics than in their peers, but it was low in general. One way to do this was identified by the student interview with Jacob, who felt that problem solving as a group activity under the guidance of an instructor contributed greatly to his learning.

At the institutional level, developmental mathematics courses need to be successful because they cater to a majority of the student population in community college. The goal of these institutions is successful course completion and program certification or degree completion. As mathematical attitude is shown to be a factor in student success, it should also be taken into consideration in course development. There is no set number of hours a co-requisite course needs to be and it can be structured in a variety of ways, which allows for the inclusion of mathematical attitude treatments. Since some students identified the time they felt the most confident was with a particular instructor, professional development within the dimensions of mathematical attitude and co-requisite structure needs to be offered to instructors. At this particular institution, many courses are co-taught with another instructor, so both instructors should be involved in the development and implementation of course materials. Professional development in team teaching would be beneficial to institutions who have developmental models with more than one instructor.

For this particular institution, it is the recommendation of this researcher to examine the pass/fail rates for Statistics co-requisite support in order to determine whether or not this co-requisite model is efficient and effective in producing successful students. It may be that this model will require a restructuring to provide additional support to these students to allow for the development of a more positive attitude towards mathematics and, therefore, increase student success for this population. Additionally, comparison of pass/fail rates for College Algebra between the students in the co-requisite model and students who completed Intermediate Algebra previously will help determine if either course structure is more effective or efficient.

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BIOGRAPHICAL SKETCH

Benjamin Ortiz was born in Long Beach, California. He is the middle child of three sons. Growing up between California and Texas, he attended Santa Ana High School and Pecos High School, graduating in 1997. He became a non-traditional college student at 32 years of age at Midland College. He graduated with his Bachelor of Science in Mathematics from Sul Ross State University in 2016 in the Sul Ross at Midland College program (SR@MC).

He began community college as a developmental mathematics student and spent two semesters in developmental math before taking College Algebra. He then became a tutor in the Math Lab. From the tremendous amount of encouragement and support from the Mathematics Department at Midland College, he finally decided to major in Mathematics, with a minor in Biology, upon his transfer to Sul Ross State University.

Upon completion of his bachelor's degree, he became an adjunct instructor for Midland College, and he later became a full-time instructor while completing his Master's of Science in Mathematics with a concentration in Mathematics Teaching in December 2023 from the University of Texas Rio Grande Valley.

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