Addressing Post-Secondary Mathematics Remediation: How to Encourage Students to Persist Despite Mathematical Deficiencies

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EDUC 499

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February 9, 2022

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Chapter 1

Introduction

In 1988, Bert K. Waits and Franklin Demana from the Ohio State University assessed student success concerning the amount of mathematics understanding before entering a post-secondary institution. The findings from this study established that proper mathematical knowledge is essential for success at the postsecondary level of education (Waits & Demana, 1988). This study occurred almost 35 years ago, yet many students still enter colleges and universities without proper mathematics foundations. Mathematics is the area of study for which students are most likely to need remediation interventions when they reach the post-secondary level (Bahr, 2008). Several reasons could account for this deficiency, but one is that high school counselors do not encourage students to take challenging mathematics courses, especially during their senior year. Counselors do not place appropriate expectations upon students and fail to give them incentives to learn mathematics (McCormick & Lucas, 2011).

Therefore, students are placed in remedial mathematics classes to account for their mathematical deficiencies. Students can be put into College Algebra, Pre-Calculus, or Geometry classes that all target skill sets they should have developed as high school students. While these remediation classes are practical for students in addressing mathematical deficiencies, these classes can be demoralizing. These courses can deter students from future mathematics courses or mathematical-heavy fields (Bahr, 2008). Additionally, these remediation courses do not reflect the nature of mathematics courses students should take throughout college (Couturier & Cullinane, 2015). Mathematics courses should be reflective of the field of study that students are entering and tailored to target the problem-solving skills and mathematical disciplines that students will encounter in their specific field of study (Couturier & Cullinane, 2015; Hodgen &

Marks, 2013; Earnest, Skovsmose, Van Bendegem, Bicudo, Miarka, Kvasz, & Moeller, 2016). With so many students needing mathematics remediation, it is hard for postsecondary educational institutions to create pathways to encourage students to study mathematics concerning their field. Colleges and universities are fighting the crisis that students do not enter school prepared to engage in the level of mathematics expected of them. Colleges are placing students in remedial mathematics to address mathematical deficiencies in this situation. Because of negative experiences and a lack of motivation in remedial courses, students do not want to continue taking mathematics courses in the future.

Statement of the Problem

The participation rate of students in postsecondary mathematics is around 16% in the United States, which is considerably lower than in many other nations across the globe (Hodgen & Marks, 2013). Students should be encouraged towards mathematics and mathematics-heavy fields. Encouraging students is essential because society increasingly depends on technology created from mathematical principles (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). One term often used by policymakers, educators, and people in the technology workforce is STEM, which refers to the emphasized study of Science, Technology, Engineering, and Mathematics (Breiner, Harkness, Johnson, & Koehler, 2012). The study of STEM has become increasingly important in recent years due to the increase in technology. The growth in jobs related to science and mathematics will not magically disappear; it will continue to surge as more technology is created and implemented (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017; Langdon, McKittrick, Beede, Khan, & Doms, 2011). Still, specific demands within the STEM field suggest mathematics and mathematics-heavy degrees are precious in the STEM job market. The fields of academia see shortages in several fields of engineering jobs, and in the workforce, there is a need in the areas of computer development and data analysis (Xue & Larson, 2015). The common factor drawing all of the needs within the STEM field together is mathematics, which is perceived as a hurdle that students have to overcome to pursue their careers in STEM (Couturier & Cullinane, 2015).

Although the influence of STEM is precious in our society today, the importance of mathematics is not bound to careers in the STEM field (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017; Langdon, McKittrick, Beede, Khan, & Doms, 2011). Mathematical principles benefit people in other fields, even if they do not recognize them right away (Hodgen & Marks, 2013; Earnest, Skovsmose, Van Bendegem, Bicudo, Miarka, Kvasz, & Moeller, 2016). The purposes and uses of mathematics lie outside of just solving equations and performing numerical operations; mathematics is used for social purposes, and it is used in everyday calculations such as nurses which drug doses for patients (Earnest, Skoincreasinglyendegem, Bicudo, Miarka, Kvasz, & Moeller, 2016; Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). Simple mathematical principles, such as ratios or proportions, can assist in solving complex real-world problems (Hodgen & Marks, 2013).

Mathematics is essential for all fields within the workforce. The mathematics students come into contact with before they enter their respective fields of study is not preparing them for engaging in complex real-world situations (Hodgen & Marks, 2013). The pathways students are placed in during their college years are not setting them up to understand how mathematics comes into contact with everyday life and society (Couturier & Cullinane, 2015; Hodgen & Marks, 2013). When students do not understand the connection of mathematics to their careers, they are less likely to participate and retain ideas from the class (Layva, Walkington, Perera, & Bernacki, 2022). The need for proper mathematical learning pathways for specific career paths is proving to be a stumbling block for many students regarding mathematics (Couturier & Cullinane, 2015). While colleges and universities across the nation might need help to change the course pathways for mathematics and design new courses to individualize mathematics for students overnight, colleges can focus on how to encourage students to persist through the mathematics they are required to take.

Purpose of Study

In light of the importance of mathematics and students' tendencies to disregard its importance, it is valuable for educators to determine how they can encourage appreciation and spark an interest in mathematics among their students (Hodgen & Marks, 2013; Layva, Walkington, Perera, & Bernacki, 2022). This study aims to identify factors that help influence persistence among students, particularly in mathematics. Factors will be evaluated through interviews with students regarding personal views and experiences toward mathematics. This study aims to help equip educators with tools and strategies they can bring to mathematics classrooms to help encourage persistence and appreciation for mathematics in their students.

Several studies have evaluated persistence generally or in certain groups of people within the field of mathematics based on ethnicity, race, or socioeconomic background. However, there have not been many studies that focus directly on mathematics persistence in the postsecondary setting. This study aims to provide perspectives and information to encourage students to pursue mathematics, regardless of whether they intend to follow careers that are in STEM.

Significance of Study

One of the most significant potential effects of this study is involved with the job market landscape. There is a deep need within various job markets to support the fast-paced development of a complex technological-based world (Gravemeijer, Stephan, Julie, Lin, &

Ohtani, 2017; Langdon, McKittrick, Beede, Khan, & Doms, 2011). Encouraging more students within the fields of mathematics can guide and direct students to more mathematics-involved fields. With more students engaging in the field of mathematics, more people are qualified to fill the gaps within the STEM job market that is experiencing shortages of qualified employees (Xue & Larson, 2015). Suppose the jobs within the STEM job market are no longer battling shortages. In that case, this will continue to establish the U.S. as a technological powerhouse and propel the nation into the next new world of technology.

Another potential effect of this study stems from creating a more appealing and valuable appearance of mathematics within the classes students have to take. Right now, educators are fighting the battle that students do not appreciate the mathematics that they are in, and therefore, they do not engage in the classes (Layva, Walkington, Perera, & Bernacki, 2022). This study has the chance to offer educators tools to undermine these perspectives of students entering mathematics classes. The goal is for students to see mathematics as a valuable asset to their careers and to engage in the mathematics they are placed in (Couturier & Cullinane, 2015). A better understanding and appreciation of mathematics could lead to more accurate and precise interactions and interpretations of mathematics in the real world, and not just within the STEM fields. The data that computers are currently generating for various fields could actually be translated to fit the correct context in the workplace, making the data that the technological world generates more interactive and applicable to the workforce (Hodgen & Marks, 2013). Mathematics has the potential to be accelerated in the workforce of the future with students being raised in environments where they are taught to see the useful principles and qualities of mathematics.

This study is not targeted at analyzing the deficits that students experience and have to battle when they do not receive the standard mathematics education that is required of them before they enter the postsecondary mathematics setting. Although, this study does have the position to highlight the importance of students' appreciation of mathematics. This can be taken into two different contexts, those of elementary and secondary schools and those of colleges and universities. For elementary and secondary schools, this could challenge them to instill mathematics appreciation in students starting from a younger age. Teachers could be attentive to the mathematics anxiety and the disinterest in mathematics represented in students and begin to target these behaviors at an early age to encourage them in this area of study (Waits & Demana, 1988; Jiang, Lui, Star, Zhen, Wang, Hong, & Fu, 2021). For the post-secondary environment, it could inspire colleges to investigate the mathematics pathways they are currently sending students down and change them to reflect better the different nature of mathematics for different career areas (Couturier & Cullinane, 2015).

Definitions

The terms that are listed below are defined to help the reader understand the context in that they will be used in this particular study:

1. Mathematics-Heavy degrees/fields: Degrees that require at least two college-level mathematics courses or courses that are heavily dependent upon the understanding of mathematics principles and processes; these courses do not include any remedial mathematics courses
2. Persistence: the degree to which students are motivated to continue the work set before them in pursuit of a higher goal or achievement (Feather, 1962)
3. Remediation: classes aimed at targeting knowledge deficiencies

4. STEM: students who are involved in one of the fields of Science, Technology, Engineering, and Mathematics (Breiner, Harkness, Johnson, & Koehler, 2012)

Limitations of the Study

At the college where the study was conducted, there was only a cohort size of 33 students that met the qualifications to be interviewed for data collection. For two months, only eight interviewees contacted the researcher back to participate in the study out of 15 students contacted. There was a limitation on time for some of the interviews because of other interviewee obligations.

Organization of the Study

The layout of the research paper is broken down into five different sections. Chapter 1 introduces the study. In this chapter, the researcher records the statement of the problem, the purpose of the study, the significance of the study, definitions essential to the research, limitations to the study, and the organization of the study. Chapter 2 documents the preliminary and supporting research for the study. This chapter addresses the rising need for mathematically qualified individuals in an ever-growing STEM job market. It also covers the lack of mathematically qualified individuals, the nature and purpose of remedial mathematics at the postsecondary level, and the placement process for remedial mathematics post-secondary level. Chapter 3 breaks down the research methodology. This section includes the research questions, research design, qualifications of participants, participant selection process, the role of the researcher, data collection and methods, study implementation, data analysis, the confidentiality of data, and potential research contributions. Chapter 4 reveals the conclusions drawn from the research and the themes that emerged from the data collection process. The themes that emerged from the data are discussed in Chapter 4 and broken down into factors for encouragement and persistence characteristics. The factors for encouragement that are addressed are the disposition of the instructor, willingness to explain content further and to draw specific attention to the application. The characteristics of persistence that are addressed are goal orientation and personal appreciation for problem-solving. Chapter 5 sheds light on applying the conclusions of emerging themes identified in Chapter 4.

Chapter 2

Review of the Literature

This research aims to identify factors teachers can implement in remedial mathematics to encourage students to interact with the material presented to them and persist to complete degrees in mathematics-heavy fields or in mathematics itself. Thus, this chapter focuses on breaking down research that aligns with the topics of this research study. This chapter breaks down into six different sections that address the following: the increase in the STEM job market, the need for higher mathematics knowledge across all fields, the lack of mathematically qualified individuals linked to mathematics, the current nature of remedial mathematics, and the levels of persistence within the remedial mathematics classroom.

Overall, the job market in the U.S. is rapidly releasing and engaging in new technologies. With the increase of technology in the job market, individuals need to know how to operate and engage with this technology and data. These fields are referred to as STEM fields. The STEM fields of the market that express the most need for employees require a high understanding of mathematical principles and processes. Even across occupations not qualified as STEM fields, there is a need for mathematics because of the high level of technology interaction that everyone is experiencing. Right now, only a few students are engaging in higher-level mathematics, yet many take a remedial level mathematics course during their postsecondary education. This research section dedicates itself to expressing the need for mathematically intelligent individuals and how that can be addressed in the postsecondary remedial mathematics setting.

Increase in STEM Job Market

The U.S. has experienced a technological transformation in its society and workforce over the past few decades. With this transformation of how people work and engage with one another, there is an ever-increasing demand for laborers fit and educated for the heavy-technological fields that define and drive the economy (Langdon, McKittrick, Beede, Khan, & Doms, 2011). These fields are most commonly referred to as STEM fields on the societal level and the educational level (Breiner, Harkness, Johnson, and Koehler, 2012). STEM jobs make up anywhere from 5% to 20% of the U.S. economy, which will continue to grow alongside technology increases (Xue & Larson, 2015). Even concerning other jobs within the job market, the rates of increase of STEM jobs are projected to grow faster because of their growing importance to society (Langdon, McKittrick, Beede, Khan, & Doms, 2011). There is such an increase in the number of STEM jobs being created and becoming available within the job market that the postsecondary education systems within the U.S. need to see an increase of 34% of STEM graduates from their institutions to keep up with the growing demand for STEM working professionals (Xue & Larson, 2015).

There is much appeal for taking a STEM job currently. STEM jobs are ever-increasing in demand, which comes with many benefits. Professionals pursuing a STEM job obtain increased pay and benefits (Langdon, McKittrick, Beede, Khan, & Doms, 2011). These individuals also experienced more job opportunities opened to them, within and outside the STEM field (Langdon, McKittrick, Beede, Khan, & Doms, 2011). Almost two-thirds of individuals holding STEM degrees do not currently have a job in a STEM field (Langdon, McKittrick, Beede, Khan, & Doms, 2011). Other fields are pursuing people with STEM degrees, but those who do not have STEM degrees can only enter the STEM fields with specific qualifications. Overall, STEM jobs come with benefits since many are currently available and are continuing to become available. These fields are the most reliable to go into when choosing a career. STEM is becoming an ever-growing part of society's world (Breiner, Harkness, Johnson, and Koehler, 2012). In order to keep up with the growth of STEM markets and technologies, there is a need for STEM professionals.

The technological surge and STEM that has impacted the nature of the job market in the U.S. The jobs in the highest demand within the STEM job market require a high knowledge of mathematical processes and principles (Langdon, McKittrick, Beede, Khan, & Doms, 2011). Jobs requiring a high understanding of mathematics encompass most jobs within the STEM market. Among the STEM job market, mathematics and computer science jobs make up about 46% of the total STEM jobs, and this percentage is more significant than any other specific STEM job sector (Langdon, McKittrick, Beede, Khan, & Doms, 2011). This percentage does not include the amount of engineering and scientific jobs heavily dependent upon properly implementing mathematical skills and knowledge. Even though most STEM jobs require a more complex understanding of mathematics, there are specific openings within mathematically dependent fields. There is no shortage of professionals in STEM academic employment, the biomedical, or the sciences (Xue & Larson, 2015). The job fields explicitly opening up are those in petroleum engineering, data science, software development, and mobile application development (Xue & Larson, 2015).

Having a solid mathematical background and understanding of entering the workforce is a highly desirable trait (McCormick & Lucas, 2011). This understanding is necessary for STEM fields, where mathematics is directly evident and embedded within the workforce processes and procedures. Although this understanding is not just valued and desired among the STEM fields, mathematical understanding is valuable in all fields (McCormick & Lucas, 2011).

Need for Higher Mathematics Knowledge Across All Fields

The need for mathematically qualified individuals is in high demand within the STEM job fields. However, there is just as much of a need for mathematically qualified individuals outside the STEM job system. Mathematics understanding is not just important within the STEM fields, but mathematics understanding is practical and bridges all different fields in the workplace (McCormick & Lucas, 2011). Mathematics is only directly present in the lives of some people within the workforce. However, it is almost always indirectly responsible for the process, technology, and data collection methods that support careers outside the STEM field (Ernest, Skovsmose, Van Bendegem, Bicudo, Miarka, Kvasz, & Moeller, 2016). The role of mathematics in the workplace and society has been growing alongside technological increases (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). Because of the increase in technology, there has been an increase in workplace mathematics. Most people need to realize the many different modes and principles of mathematics that are evident in our daily tasks. These are production techniques and operations, automatization, decision-making, economic transaction, information processing, communication methods, and security procedures (Ernest, Skovsmose, Van Bendegem, Bicudo, Miarka, Kvasz, & Moeller). Mathematics is all around us and is behind most of the technology (Ernest, Skovsmose, Van Bendegem, Bicudo, Miarka, Kvasz, & Moeller).

Mathematical qualification does not mean everyone should be a computer scientist and understand all the algorithms behind their workplace software. To be considered mathematically qualified individuals, they must understand the concepts that drive the technology (Hodgen & Marks, 2013). Individuals need to know how to use mathematical models, how to interpret data, and how problem-solving models connect with the technological methods they employ (Hodgen & Marks, 2013). All in all, to be a mathematically qualified individual means understanding what mathematics overlaps with the technology employed. It also means that individuals understand what is implemented and how to interpret or interact with the technology. Without this knowledge, workplace issues arise (Hodgen & Marks, 2013).

Most people engage in technology or mathematical transactions in their occupations, yet they need to learn most of the mathematics and methods behind their actions. Some people, if not most, need to learn the algorithms that drive the computer software used. Some, if not most, need to learn the mathematics behind the spreadsheet operations that record and store data for our companies. This lack of mathematical knowledge is evident in the populations' interaction with Information and Communication Technologies (ICT) (Hodgen & Marks, 2013). A term that best refers to people's lack of knowledge about the technology they are engaging with is 'black-boxing' (Hodgen & Marks, 2013). "Black-boxing" means that people do not fully know the mathematics they engage in through their technology and, therefore, do not have complete control over the technology they depend upon for their work (Hodgen & Marks, 2013). Many workplace problems arise from a lack of understanding of the mathematical functions embedded within working life (Hodgen & Marks, 2013). For professionals to function at their total capacity in the workplace, they need to understand the technology they are engaging with, which means they need to understand the mathematical principles at the heart of the technology.

The lack of mathematical knowledge has some roots, mainly attributed to the dependence on computers to do mathematical calculations for people (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). Since there is access to technology that can compute and calculate whenever needed, there is no use for personal calculation methods and mathematical problem-solving skills (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). Although technology has proven useful and continues to push our society into a more profound wealth of knowledge, it has created a dependence upon its functioning skills and operational methods. This dependence drives the lack of mathematical understanding (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017).

Lack of Mathematically Qualified Individuals linked to Remedial Mathematics

There is a sufficient number of jobs in STEM fields, specifically in mathematics (Langdon, McKittrick, Beede, Khan, & Doms, 2011). Higher mathematics knowledge is highly desirable even in fields outside of mathematics (McCormick & Lucas, 2011). Amidst the job opportunities presented with higher mathematics education, only 16% of college students in the United States study mathematics after the age of 16 (Hodgen & Marks, 2013). This statistic is low compared to several industrialized and technologically dependent countries across the globe (Hodgen & Marks, 2013). As a result, many people are in the workforce with low mathematical knowledge and context (Hodgen & Marks, 2013; Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). Mathematical knowledge is becoming increasingly important in today's society, so students must pursue mathematics at higher levels to understand and interact with the different technologies infiltrating the workforce (Hodgen & Marks, 2013). Not enough students engage in high-level mathematics while in a post-secondary institution. Even though multiple reasons determine whether or not students continue to take higher-level mathematics courses, one of the reasons is the nature of remedial mathematics courses that students are required to take.

In the college setting, remedial mathematics courses cover mathematics content that students should have learned in high school (Jimenez, Sargrad, Morales, & Thompson, 2016). More students take remedial mathematics courses than any other subject within the remedial course options at post-secondary institutions (Bahr, 2008). The percentage of students participating in remedial mathematics varies between 30% and 59% (Bailey, Jeong, & Cho, 2010; Roueche & Waiwaiole, 2009; Barber, 2011). With the high level of students taking these courses each year, the cost to taxpayers across the country is billions of dollars yearly (Jimenez, Sargrad, Morales, & Thompson, 2016). These courses can sometimes be a "black hole" for students, meaning that students who enter these courses are less likely to graduate from their institution than students who are not required to take them (Jimenez, Sargrad, Morales, & Thompson, 2016). Mathematics remedial programs specifically address understanding and content knowledge, and these courses are effective in helping students fill gaps in their understanding (Bahr, 2008). Although remedial mathematics courses effectively address deficiencies, most students do not successfully remediate (Bahr, 2008). Successful remediation in mathematics is on as sharp as a decline as sharp as the increase in the need for remedial mathematics courses at the post-secondary level (Bahr, 2008).

Remedial mathematics courses are something that many college students have to go through, and this is a direct result of inadequate education at the high school level in the subject of mathematics (Jimenez, Sargrad, Morales, & Thompson, 2016). Students must enter college with adequate mathematical preparation; if they are not prepared, many doors and opportunities are either closed off or challenging for them to pass through (McCormick & Lucas, 2011; Waits & Demana, 1988). Students who intend to enter the field of STEM and are under-prepared mathematically seldom survive the challenge of catching up and keeping up academically with prepared peers (Couturier & Cullinane, 2015). When students aspire to enter college in a mathematics-heavy field, such as STEM or mathematics itself, they are at serious risk of being unsuccessful if they enter with a deficient mathematics background (Waits & Demana, 1988). As a result, mathematics is seen as the "primary hurdle" for students to jump when entering a STEM field (Couturier & Cullinane, 2015). In these situations where students want to pursue fields that involve high-level mathematics and enter college unprepared, they are less likely to persist through the mathematics content than those who did enter college mathematically prepared (Stewart, Lim, & Kim, 2015).

Mathematics remediation is a difficult hurdle for students to overcome, and many students have to face this hurdle across the nation. What results from unsuccessful remediation is students are disengaging in mathematics at a high level, which is what is needed and desired in the workforce. While it would be desirable to change the processes of mathematics placement or rewrite the mathematics history and preparedness of students, this is a decades-long improvement that would need to happen to eliminate remedial mathematics (Couturier & Cullinane, 2015). One place we can look to understand why students struggle and attempt to address the nature of the remedial mathematics classroom, for this is where many of the reasons students do not successfully remediate reveal themselves.

Current Nature of Postsecondary Remedial Mathematics

One of the most defining natures of remedial mathematics is that it can be demeaning for professors and students (Bahr, 2008). Professors with doctoral degrees in mathematics or mathematics-heavy fields can be discouraged because they teach classes that high school teachers did not effectively teach. Students who enter remedial courses can be discouraged for several reasons. One reason students might be discouraged is that they had already seen the material before and either understood it or did not. Students working through the material more than once might be disheartened that they have to repeat the same course. On the other end of the spectrum, students who need help grasping the material might be easily frustrated since they are engaging in material that was difficult for them the first time. Another reason students might express frustration and disappointment at being in remedial classes is because they are trying to catch up to their classmates who came into college mathematically prepared. There are several reasons why remedial mathematics is demoralizing and demeaning to students and professors (Bahr, 2008). As a result of this specific nature of mathematics, students shy away from engaging with mathematics on a higher level than remedial courses (Bahr, 2008).

Remedial mathematics is standardized for all students, meaning that all students interact with the same material regardless of career path. There is no distinction between mathematical pathways that could be taken after remedial mathematics (Couturier & Cullinane, 2015). Mathematical placement policies do not reflect the career path students choose, regardless of career path (Couturier & Cullinane, 2015). Mathematics courses should reflect the nature of the mathematics that students will be engaging with in their careers when taken at the post-secondary level, but this is not the case with remedial mathematics (Couturier & Cullinane, 2015; Hodgen & Marks, 2013; Earnest, Skovsmose, Van Bendegem, Bicudo, Miarka, Kvasz, & Moeller, 2016). As a result, students need help to see how the remedial classes they are taking connect to what they are pursuing a degree in if algebraic concepts do not directly align with their career endeavors. When students need help understanding how the course they are required to take is helpful for their career or course path, they become disinterested and mentally disengaged with what they are learning (Layva, Walkington, Perera, & Bernacki, 2022). As a result, students are less likely to participate and are less likely to be successful in retaining material from the course (Layva, Walkington, Perera, & Bernacki, 2022).

In addition to being unable to see the use of the courses as a whole, students in remedial mathematics classes need to see real-life applications of the individual mathematics principles studied throughout their remedial courses (Couturier & Cullinane, 2015). When students do not see how mathematical principles translate to their life, they are disillusioned with the course and mathematics and disengage from learning (Layva, Walkington, Perera, & Bernacki, 2022). This disillusion has a much more significant impact on students' views toward mathematics as a whole. Students do not see the applications of mathematics in society and, therefore, do not pursue it in the future.

A final reason remedial mathematics courses are challenging for students is mathematics anxiety. Students who perform at lower levels in mathematics are more likely to experience mathematics anxiety (Hembree, 1990). Particularly in the context of remedial mathematics, there are high levels of mathematics anxiety experienced among students (Hembree, 1990). Mathematics anxiety impairs students' abilities to engage in logical reasoning and problem-solving skills (Jiang, Liu, Star, Zhen, Wang, Hong, & Fu, 2021). Mathematics anxiety also has a positive association with impacting students' perceptions about mathematics in a negative manner (Jiang, Liu, Star, Zhen, Wang, Hong, & Fu, 2021). This negative manner can influence students to avoid mathematics in the future and resist interacting with mathematics altogether if possible (Jiang, Liu, Star, Zhen, Wang, Hong, & Fu, 2021).

Overall, remedial mathematics courses at the post-secondary level steer students away from mathematics courses and mathematics. They demonstrate the material in irrelevant ways to students' careers or educational paths. Therefore, disengagement and discouragement are critical features of the remedial mathematics classroom. There are low levels of persistence within the remedial mathematics setting.

Levels of Persistence within Postsecondary Remedial Mathematics

Persistence is "the behavior of continuing action despite the presence of obstacles" (Holder, 2007). Persistence is demonstrated within a remedial mathematics classroom in several ways. For students who do not have strong mathematical backgrounds, persistence in the remedial mathematics classroom would be working through the content presented, despite any difficulties caused by gaps in understanding. For students who want to continue to STEM fields, persistence in the remedial mathematics classroom would persist through the obstacles of an additional mathematics class to qualify for higher-level mathematics courses required in STEM education tracks. Persistence comes in many different forms in the remedial mathematics classroom. The common underlying factor in all displays of persistence is student engagement.

Some factors of persistence are known within the postsecondary remedial mathematics classroom. One is that students are more likely to persist if they already have a solid mathematical background (Holder, 2007). When students are prepared to encounter content that they are expected to learn, they are more likely to persist through the content amid any difficulties that may arise (Stewart, Lim, & Kim, 2015). A good foundation of mathematical understanding does indicate if students will persist through remedial mathematics, and as persistence looks differently based on context, this factor impacts persistence in different ways and manners based on context. Another known factor that helps motivate students to persist through post-secondary remedial mathematics is academic intervention and assistance from various educators, tutors, classmates, etc. (Stewart, Lim, & Kim, 2015). It is essential for students who do not have strong mathematical backgrounds to have access to this support throughout their course (Stewart, Lim, & Kim, 2015). It is not just the student's responsibility to ensure that support is sought after and available to them. Educators and administrators are responsible for seeking out students who have gaps in mathematical understanding or are struggling in a specific area of the curriculum (Holder, 2007). At-risk students, students who might not persist through the material or earn a passing grade in the class, should be identified and

Persistence is predicted among students in the post-secondary education setting. Persistence is best predicted by the academic achievement history of students in high school (Stewart, Lim, & Kim, 2015). Students who enter post-secondary institutions with solid academic scores will likely persist through their sophomore year of college (Stewart, Lim, & Kim, 2015). In remedial mathematics, this is not typically the case. Students who enter remedial mathematics are underprepared (Jimenez, Sargrad, Morales, & Thompson, 2016). As a result, they are less likely to persist in taking higher-level mathematics courses. For underprepared STEM students, the remedial mathematics setting sets off a chain reaction where students constantly try to catch up with their peers. This chain reaction is something that few people endure and persist through (Couturier & Cullinane, 2015). The high levels of mathematics anxiety experienced within the remedial mathematics setting also steer students away from mathematics courses in the future (Jiang, Liu, Star, Zhen, Wang, Hong, & Fu, 2021). Many students who enter the postsecondary setting with weak mathematical skills have many doors of opportunities closed off to them (Waits & Demana, 1988). There is much research that students do not persist through remedial mathematics courses, which results from experiences in these courses and under-preparedness entering post-secondary settings.

Summary

Mathematics' importance is growing in our society as mathematics fields continue to be expanded, creating ample opportunities for students to fill those positions upon graduation (Langdon, McKittrick, Beede, Khan, & Doms, 2011). Mathematics is becoming a desirable trait among the workforce because of the high levels of technology that all fields engage with (McCormick & Lucas, 2011). Few students pursue these benefits despite the high appeal of advanced mathematical knowledge. Lack of preparedness is attributed to poor mathematics preparedness among high school students and the effects of remedial mathematics on the post-secondary level (Jimenez, Sargrad, Morales, & Thompson, 2016; Bahr, 2008). Remedial mathematics courses are demeaning, showing low participation and successful completion (Bahr, 2008). Student disillusionment relates to students' low-interest levels when further considering the mathematics. (Jiang, Liu, Star, Zhen, Wang, Hong, & Fu, 2021). There are also low levels of persistence among students, regardless of field (Jimenez, Sargrad, Morales, & Thompson, 2016; Couturier & Cullinane, 2015; Jiang, Liu, Star, Zhen, Wang, Hong, & Fu, 2021). If universities seek to keep up with the demand for STEM and mathematics professionals, they need to seek to support and remodel remedial mathematics education. Two factors that can be addressed in this context are how to encourage students and how to motivate students to persist through the process of obtaining higher mathematics education.

Chapter 3

Research Methodology

The United States job market is experiencing a shortage of mathematically qualified individuals to fill the gaps within the STEM job market (Xue & Larson, 2015). Without these individuals, the U.S. will be unable to support and keep up with the fast-paced technological advancements displayed during the 21st century (Langdon, McKittrick, Beedee, Khan, and Doms, 2011). The problem with the lack of mathematically inclined individuals displays some of its root issues at the college level. More college students need to take mathematics courses at the postsecondary level. Therefore, more college students need to earn mathematics degrees and train in mathematics skills (Hodgen & Marks, 2013). There can be many reasons for students not engaging in higher-level mathematics, ranging from mathematics anxiety to negative mathematics experiences. One reason that affects students at the collegiate level is the nature of the remedial mathematics courses they are required to take. These courses can be demoralizing for students, and students have difficulty connecting the mathematics they will interact with in their potential careers (McCormick & Lucas, 2011). Students exit these courses discouraged and disinterested in mathematics. It is difficult to rewrite the mathematics history of students before they choose their major, and it is impossible to change the content that students engage with in remedial mathematics classes. Educators can determine how to motivate and encourage persistence among students in remedial mathematics courses and instill an appreciation for the mathematics on display. Educators can also guide students to directly connect the mathematics they are learning and the mathematics they will engage in within their careers. This research aims to identify factors inside the remedial classroom that affect the persistence and engagement of students in remedial mathematics classes.

Research Questions

What factors inside the remedial mathematics classroom influence students' engagement in the mathematics content in the remedial mathematics classroom?

What factors inside the remedial mathematics classroom influence students' persistence through remedial classes and onto more challenging courses?

Research Design

This research was conducted by gathering qualitative data. A qualitative data study is best for this research study because it allows for flexibility in responses since the researcher will gather personal opinions and unique mathematical backgrounds from each participant. To analyze the qualitative data that is gathered, the researcher will follow Creswell's six-step approach for analyzing and interpreting qualitative data (Creswell, 2013). The six steps are:

1. Organize and Prepare the Data for Analysis
2. Reviewing all of the Data
3. Coding the Data
4. Setting up Themes for Analysis
5. Themes are represented in a Qualitative Manner
6. Interpreting the Data and Results

Participants in the Study

Potential participants were identified through approved data collection. Milligan's Institutional Research Board (IRB) has approved the collection of the names and majors of students from the academic years of 2019-2020, 2020-2021, and 2021-2022 who were enrolled in any of the following mathematics courses: MATH 090, MATH 107, MATH 111, MATH 171. Along with this data, the researcher gathered the mathematical course load for each student enrolled in the above mathematics courses. From this list of students, eight participants were identified and selected for data collection. Participation in the study consisted of one interview and one follow-up email with the researcher regarding the information collected in the interview. The participants in the study are not a part of a unique population, and the participants were not compensated for participating.

Selection of Participants

Participants was selected by gathering a stratified sample. From the list of students that did enroll in any of the listed mathematics courses, three categories are drawn from the data:

1. Students who did not take any more mathematics courses
2. Students who did continue to take two or more mathematics courses and did not major in mathematics
3. Students who did continue to take two or more mathematics courses and did not major in mathematics

Initially, three students were to be chosen randomly from each of the three groups, totaling nine participants in the study. The first nine students were to be contacted via email by the researcher gauging interest in participating in the study and gathering consent to participate. If the students were uninterested or uncomfortable in participating, the researcher would continue randomly selecting students from the three groups until each group had three participants. If no students were in one group, the researcher would redesign the groups to have nine participants.

The researcher did have to redesign the groups in the study because at the college where the research was conducted, there were no students who took remedial mathematics and continued to major in mathematics. The researcher aimed to get nine students to participate in the study, but only eight students were willing to participate in the research study. There were still students representing the remaining two groups in the stratified sample.

Role of the Researcher

The researcher conducted all the interviews and data collection/analysis. The researcher was a teacher's assistant in several of the remedial mathematics courses at the university of study. This factor could have created bias among the responses of participants.

Data Collection Methods and Procedures

The qualitative data was collected through interviews with each participant. The interviews were conducted in person or via Zoom, based on the interviewee's preference. The interviews were electronically recorded, and the researcher took notes during the interview process. The responses were transcribed after each interview and used later in the research findings and conclusions.

All transcripts of the data were gathered and assessed after the interview process. The data was used and distributed in the research, but the interviewee remained anonymous throughout the research writing. The researcher and researcher's mentor were the only ones with access to student data to analyze and synthesize.

Before the Study

Before the initiation of the study, the research proposal was evaluated and approved by Milligan University's Institutional Research Board (IRB). In addition, participants gave consent to participate in the study.

Potential participants' personal information (PII) was collected. The information collected was the name, student contact information, previous MATH course enrolled in, future

MATH course selection, and major of each student. The information will be used to separate the groups of students into different strata for the stratified sample and to identify the participants.

Implementation of the Study

After contacting the registrar's office where the study occurred, the researcher obtained a copy of the list of students who had taken any qualifying MATH courses. In addition to the students' names, the data from the registrar's office included the majors and a list of the other MATH classes each student had taken. The researcher divided the list of students up based on the three groups in the stratified sample. Since there were no students in one of the stratified sample categories, the researcher aimed to get a total of nine participants divided among the two groups who did have students qualified to represent them. Eight participants were able to be gathered for data collection. The researcher then randomly selected participants from each group and contacted them via email to inform them about the study and inquire about their willingness to participate in the study. Once students identified their interest in participating, the researcher collected participant consent forms from each interviewee. The researcher then met with each interviewee individually to collect data through an interview. These interviews were recorded using "Voice Memos" and Otter.ai. Each recording was transcribed by Otter.ai and the transcripts were saved in the researcher's password-protected Google Drive. Once the interviews were transcribed, the researcher emailed the transcript to each interviewee to gain their final approval to ensure accuracy. From this point, the researcher analyzed each transcript and collected emerging themes from the data.

Throughout the interviews, the researcher asked the questions from the interview guide, and each of these questions was open-ended. Open-ended questions were used to capture the unique perspectives, opinions, and experiences of each of the interviewees. Some questions were asked that were unique to the interviewee's experience and asked for further input on certain responses.

Data Management

Research data was collected and kept secure by the researcher, and it was located in a password-protected Milligan account throughout the research process. The research data will be kept confidential for three years, and after this time period has passed, the researcher will securely destroy all physical and digital files. The culminating research report will be archived in the office of Institutional Research and Effectiveness and maintained by the IRB. The researcher will also keep a copy of the culminating research report.

Research data was collected using "Voice Memos" and Otter.ai recording software. After each of the interviews had been recorded, the researcher used Otter.ai software to transcribe each of the interviews.

Data Analysis

The data analysis process followed Creswell's 6 steps of qualitative data organization and analysis (Creswell, 2013):

7. Organize and Prepare the Data for Analysis
8. Reviewing all of the Data
9. Coding the Data
10. Setting up Themes for Analysis
11. Themes are represented in a Qualitative Manner
12. Interpreting the Data and Results

The decoded and organized data allowed the researcher to pull several themes from the data regarding why students are not persisting in mathematics careers and are not encouraged in mathematics. The themes will be separated into the two categories of affecting persistence and affecting encouragement, and the themes will be addressed and analyzed as such. The aim of gathering these themes through qualitative data interviews is to address them in the research for educators to identify how they can increase persistence and encouragement within the remedial mathematics classroom.

Privacy and Confidentiality of Data

Participants identifying information (PII) were collected and connected to the research process, but the researcher was the only person with access to this information. The data distributed and written about in research conclusions keeps private participant information anonymous.

Potential Contributions of the Research

There will not be any benefits to the group of participants. However, this research will benefit the general population of students preparing to take remedial mathematics courses. One of the main goals of this research project is to get more students to enjoy the mathematics that they are placed in and help students develop an appreciation for mathematics regardless of the career path that they choose. This research will help identify what factors discourage students from engaging in remedial mathematics content. This research will also identify why students do not pursue higher mathematics education. With the knowledge of why students do not engage and persist, educators in remedial mathematics settings can target specific attitudes of students to improve their attitudes towards mathematics and encourage them to continue their learning in mathematics. The benefits of this research are not guaranteed. If there are no factors that positively/negatively influence encouragement and persistence among students in mathematics courses, then there will be no benefits from this research project.

Chapter 4

Data Analysis and Findings

This qualitative research study aimed to identify factors of encouragement and persistence among students taking remedial mathematics at the post-secondary level. The researcher sought to collect data through interviews with students who had already completed one of the remedial courses. The groups of students were selected by which category their major fell into: mathematics major, STEM major, or non-STEM major. The details of the research process are recorded in Chapter 3. Qualitative data was from each interview as they shared their personal experiences with mathematics classes before reaching the post-secondary level, personal experiences with remedial mathematics courses at the post-secondary level, and their general observations in mathematics class settings.

The qualitative data collection occurred through one-on-one interviews with the researcher, ranging from 20 to 45 minutes. Using the one-on-one interview experience, the interviewees were given space to share their thoughts with the researcher. The researcher protected their identification from other participants and those reading the research. The one-on-one interviews allowed for extra questioning into specific topics of conversation during the interview.

A total of eight students participated in the research interviews. For two months, the researcher contacted a total of fifteen potential candidates for the study, with eight willing to participate. The candidates were randomly selected and given one to two weeks to respond and express interest in participating. The data set included five non-STEM majors and three STEM majors. The non-STEM majors included four females and one male, and the STEM majors were all males.

Analysis of Data

The data gathered from the research interviews were analyzed using Creswell's six-step approach for analyzing and interpreting qualitative data (Cresswell, 2013). The data analysis process included organizing and preparing the data for analysis, reviewing all the data, collecting the data, setting up themes for analysis, qualitatively representing themes, and interpreting the data and results. Data was collected and transcribed throughout the interview process, and the researcher organized the data into emerging themes once all interviews were completed.

Research Questions

What factors inside the remedial mathematics classroom influence students' engagement in the mathematics content?

What factors inside the remedial mathematics classroom influence students' persistence through remedial classes and onto more challenging courses?

Interview Questions

The following questions serve as the main outline of interviewees' questions during their research interview. The researcher asked additional questions to have interviewees explain their answers or discuss a particular topic of interest to the study and research conclusions. The supplemental questions the researcher asked were unique to each interview; therefore, they are not recorded in the research.

1. What is your major? How did you choose the major that you are involved in right now?
2. Would you say that you like mathematics? Explain your answer.
3. Do you see mathematics fitting into your future career, if at all? Does this elicit any sort of emotions or reaction from you? Do you feel adequately prepared to interact with real-world mathematics?

4. Describe your experiences in mathematics during middle school or high school.
    a. Was it a time when you enjoyed or disliked mathematics?
    b. Did you experience any turning points to liking mathematics or not or vice versa during this time?
    c. Did you have any teachers that influenced your mathematics journey? It could be positive or negative. Describe to me the teaching style of this teacher. Did they make active efforts to motivate you?
5. Describe your experience with the mathematics class you took during your post-secondary education career.
    a. Describe the general nature of the class.
    b. What did you draw from the class?
    c. Were you motivated in this class to do your best?
    d. Did your teacher make active efforts to motivate you?
6. How do teachers help encourage you in mathematics to engage with the material?
7. How can teachers make mathematics courses more interesting?
8. How can teachers motivate you more in the mathematics classroom?

The researcher collected emerging themes from the data through an inductive approach. First, data was collected via 'Voice Memos' or directly on Otter.ai. The interviews were transcribed via Otter.ai and reviewed by the researcher. The researcher sent each transcribed interview to the interviewees for final approval and editing if they desired. After having each transcript approved by the interviewee, the researcher began to analyze the transcripts individually and collectively for emerging themes and commonalities. For factors of encouragement among the mathematics classrooms, the following themes emerged: disposition and attitude of the instructor, willingness to participate in one-on-one instruction or to further explain content, and drawing specific attention to practical application. For persistence characteristics, the following themes emerged: goal orientation and personal appreciation for problem-solving. The study included a total of eight participants. A pseudonym identified each participant in the study. The pseudonym consisted of "Interviewee" followed by the number indicating the order in which the interviews were conducted. Data individually captured each interviewee's reflections via 'Voice Memos' or Otter.ai.

Factors for Encouragement

Factors that focused on encouragement were identified throughout the research process as factors that would help students engage with the content with a higher level of interest. These factors would boost students' esteem in interacting with the material and promote high levels of engagement for students in the learning environment. Encouragement would address the problem of students positively interacting with the mathematics they are presented with and developing an appreciation for mathematics in the real world and education settings. The following were identified as factors of encouragement: disposition and attitude of the instructor, willingness to explain content further and to draw specific attention to the practical application of the content being learned. The instructor's cheerful disposition and attitude toward learning and content help boost students' perceptions about the material they are being taught and the problem-solving process. A willingness to explain the problem-solving process more in-depth to students helps them navigate periods of frustration and understand the methods of mathematical solving and analysis they are engaging in. When specific attention is dedicated to ensuring that students see the practical application of what they are learning, students see the material as valuable and, therefore, have a higher interest in what they are learning. Each of these factors helps encourage students' engagement with the material being presented, regardless of major.

Disposition and Attitude of the Instructor

Six out of the eight participants directly liked their personal enjoyment of learning mathematics with a positive attitude toward the instructor teaching them. Both STEM and non-STEM majors identified that the attitude and general disposition of the teacher determined how they were encouraged to learn and interact in the classroom.

Among STEM majors, they noticed their instructors' positive attitude and passion toward mathematics. When asked about his experiences with professors at the post-secondary level, Interviewee 1 noted that his instructor "had such a passion for math, and he loves to teach it." The result of the professor's personal appreciation and enjoyment of mathematics affected the student above. His following comment was, "and that made me, like, kind of want to learn it because he was so ready to teach us." For this particular student, the passion that the teacher had encouraged him to learn and engage with the mathematics presented in class. Another STEM major noted similar positive interactions with his teachers leading up to his post-secondary education experience. Interviewee 6 noticed that his secondary school teachers "had really positive attitudes towards math," and he attributed this to "because they dedicated their whole life to math in general." This same participant stated that "you have to have a positive mindset towards what you want to be teaching people. Because if you are not positive to it, then even the people learning it will not be positive," noting the cheerful impact disposition carries in the classroom. Interviewee 6 further communicated that his attitude towards math was positive, indicating that the positivity of his teachers helped develop his appreciation and positivity towards mathematics. Overall, the STEM interviewees communicated that the attitude impacted their enjoyment and mood toward mathematics that the instructor carried. These students' instructors' positivity and passion helped create positivity within their minds. Their good experience and outlook on mathematics helped contribute to their career selection, which was evident in their interviews.

Among students who did not choose a STEM field for their major, they discussed factors about the instructor's disposition that encouraged or spurred them on in their learning. Interviewee 2, who did not have very positive associations with mathematics in years before post-secondary education, noted that his professor at the post-secondary level "was very, very encouraging and energetic." The energy the teacher carried went hand in hand with the act of encouragement in the student's mind. Interviewee 3 discussed this aspect of her instructors before post-secondary education. She stated:

> "Honestly, when the teacher is excited, it makes me excited. So having like my high school teacher, who was always happy to be there, and one of those to have fun with, … Yeah, having a professor who's excited about their subject makes it a whole lot easier to be excited as a student."

The attitude and disposition of the teacher are contagious for the students, and Interviewee 3 communicated that this made a significant difference in her feelings and energy towards the mathematics content she was learning. Interviewee 8 brought this up in the context of a poor mathematics learning experience that she went through before her time in post-secondary education. She mentioned that she had a first-year mathematics teacher growing up, and the teacher gave little support from the teacher throughout the class, and this was when she struggled with mathematics. When asked about some of the teacher's learning styles, she mentioned that "he did have a love for math, which I think would have been encouraging." Amid different circumstances, Interviewee 8 felt this teacher's affection for mathematics would have been helpful in her learning experience. These sentiments reveal that love of mathematics cannot be the only factor that makes a good mathematics teacher. In addition to a good disposition and love of the subject, teachers must be willing to step into the students' shoes and help them through moments of frustration.

Willingness to Further Explain Content

In addition to the disposition and attitude of the teacher, seven out of the eight participants mentioned their appreciation for teachers being willing to sit down and further explain the content to them. Every STEM major noted this sentiment, and four non-STEM majors also said this.

Among the STEM majors, two directly mentioned the professor's willingness was essential to their encouragement in mathematics classes. For Interviewee 1, this was something that he highly valued among his professors and had experienced in his post-secondary mathematics classes taken after remedial mathematics. When talking about his transition from homeschooling to post-secondary education, Interviewee 1 stated,

> "But when I got to college, and I saw that my professors were willing to sit down with me for hours and, if need be and study a subject, it made it really, really easy to want to learn that subject."

About this same professor, Interviewee 1 mentioned, "His patience and resilience and willingness to teach was a huge driving factor in my love of math." Interviewee 6, when asked about what teachers can do to encourage students in mathematics classes specifically, answered, "Attitude and willingness to help. Those are the two main ones." Interviewee 5 indirectly addressed this, mentioning his own experiences with struggling amid corporate learning settings. Interviewee 5 stated,

> "So I've always found the difficulty of keeping up corporately when I've never been good at it, you know, so there's always, it always seems like the classes have been kind of running at the speed of the kids at the higher end of the spectrum. Whereas [for me] that doesn't make any sense."

In this scenario, this would be a time where a teacher would need to introduce one-on-one instruction to further explain the content to specific students who are becoming frustrated with the problem-solving process or are not grasping the content. Interviewee 5 also mentioned that,

> "You know, nobody wants to be the one guy [out of] twenty people that have to run through that ten times and waste everyone's time."

To prevent student frustration, teachers must be willing to break down concepts further for some students to grasp the material. This act prevents students from giving up in response to frustration. The willingness of teachers to help students through problem-solving and mathematics processes prevents students from becoming detrimentally frustrated, and it encourages students to continue interacting with the material.

Non-STEM majors also mentioned that an instructor's willingness to help them with their work encourages them in mathematics classes. The four students directly addressed willingness as a factor that helped inspire them in the learning process. Interviewee 2 previously did not have positive mathematics experiences, and he mentioned that coming into college he

> "I was afraid that you know, the math teacher that I was going to get was, you know, going to be one of those who do everything on their own. And he was the exact opposite

> of that. And he was always willing to jump in and help me figure something out if you didn't quite understand."

His post-secondary remedial mathematics professor made a direct effort to pursue the students and make sure that they knew he was available to help. Interviewee 2 mentioned that "He was very patient with me. He always had a smile on his face when he was helping me." Interviewee 2 was significantly impacted by the professor, and even though he had a negative experience with mathematics learning in the past, he mentioned that " it was kind of enjoyable, being there learning under him and just kind of like going through the math courses." Interviewee 3, who had a personal appreciation and love for mathematics, noted about her post-secondary remedial mathematics professor that he "was very intentional about letting us know that he wanted to help us; he wanted to make sure we understood." Interviewee 4 noted that her post-secondary remedial mathematics professor said, "when he sees that we were doing like a good job or like if we were struggling, he would come help and not always depended on us to go to the teacher." For each of these students, the professor's actions to pursue students to ensure that they were doing well and answering any problems were greatly valued and noted throughout their class experiences. When asked about what teachers could do to encourage students, Interviewee 8 responded,

> "I think just letting us know that like they're there if we need help, or like have questions or anything and like be fully willing to help us like work through the problems and sit there with us. And help explain it to us as many times as we need."

This response was tied to her experiences in mathematics, especially her positive experience in the post-secondary remedial mathematics experience. She mentioned to her professor and TA,

> "If we needed help, we were encouraged to ask for help, and like the professor and the TA were, fully willing to come over and help us with our problems. If we didn't fully understand it."

Similarly to the students who were pursuing STEM degrees, the students who were not seeking a STEM degree found that the willingness of the professor to pursue students and walk through questions or processes was something that encouraged them to learn and interact with the material in mathematics settings.

Drawing Specific Attention to Practical Application

The last factor common among the interviews was teachers' need to ensure students recognize the personal and real-life applications of what they were learning in their mathematics classes. All of the STEM majors mentioned that this was important in their mathematics settings, and four out of the five students were pursuing majors outside of STEM degrees.

Among the students involved in STEM majors, two mentioned that they did not seem interested in a material where they did not see the real-life applications of it. The other student said that drawing real-life connections is something teachers can do to encourage students to engage in the material. Interviewee 1, when talking about mathematics experiences leading up to post-secondary school, stated about the material, "It wasn't anything super intriguing because there was no real-world example." His interest was affected by the value he saw in the mathematics he was learning. At the time, this student did not see any use for the mathematical material he encountered. Similarly, Interviewee 5 expressed that he struggled to engage with the material when he did not see the real-life connection and meaning behind what he was learning. Interviewee 6 mentioned that "Little written things that are in textbooks that seem kind of fruitless and pointless, but it's definitely just trying to maintain the motivation of this does actually apply." When elements of the material being learned did not seem like they applied, it was hard to maintain the motivation to continue learning and stay engaged in the material. The last STEM major interviewee directly addressed real-life application as something that would help students interact with mathematics material at a higher level and get students to appreciate mathematics content more. Interviewee 6 stated,

> "I think to show them that math exists. Yeah, that's because that's one of the first things my professor did in high school. They like, came up with one of the longest examples that explained how math exists everywhere. [They showed] Even when you don't do the math, you do."

All in all, students need help to be interested in material that they do not see as intrinsically valuable to what they want to pursue with their life and career. Therefore, to encourage the participation and engagement of students, teachers need to draw real-life connections between what is being taught and how students can apply this knowledge later in their life or how it is helpful in the world around them.

Students who were not pursuing degrees in STEM majors also identified that they either needed to see the real-life applications of mathematics or recognized that making students aware of the real-life applications of mathematics was important. Most of the students expressed that they did not see the applications of mathematics in their personal lives. Therefore they either needed to be more engaged with the material or did not continue studying mathematics. Interviewee 2 addressed that he had difficulty seeing how mathematics applied to his life. He expressed that he "did not see any form or fashion or function and how it would incorporate into my future," and therefore, "And so that's kind of when I got frustrated because I didn't understand why I needed to learn it." Interviewee 4 expressed similar yet different sentiments.

When she was presented with the opportunity to continue her mathematics learning in a higher-level class in high school, she turned it down because she did not see how it applied to her life and career. She said, “They encouraged me to do AP calc through Indiana University…Not really going to use that. I’m not going to take it and that sort of thing.” Interviewee 7 also mentioned that she struggled to stay engaged in a material where she could not see its real-life application of it. She expressed in her interview that mathematics “was a lot like, hypotheticals … I found that a little bit frustrating to initially wrap my mind around.” These three interviewees did not see the applications of mathematics in their careers or lives. Thus, they either did not continue to take mathematics classes or became disengaged with the mathematics they were learning. Interviewee 8 directly mentioned that real-life connections being drawn in a mathematics class is something teachers can do to encourage students to continue learning in mathematics classes. She stated, "relating it to real-life experiences that we are currently experiencing and stuff.” In conclusion, when teachers do not actively highlight the real-life application of the material that students are learning in mathematics classes, they become frustrated that they are not learning valuable concepts and discontinue their pursuit of mathematics. For teachers to encourage students to continue to encourage students to interact with the material that they are presented with, instructors need to make active efforts to show students that the material that they are learning is valuable and applicable in real life.

Characteristics of Persistence

Factors that focused on persistence were identified as processes that would drive students to continue to pursue mathematics in their education at the post-secondary level, whether directly in the field of mathematics or in an area heavily dependent upon the principles of mathematics. These factors encourage students to pursue mathematics or mathematics-heavy careers to help address the lack of mathematically qualified individuals in the job market discussed in Chapter 1. Instead of finding characteristics and methods teachers could employ in the classroom to get students to continue to take mathematics classes, the interviews found traits that students who continued to learn mathematics displayed. The following are persistence characteristics: goal orientation and personal appreciation for the problem-solving process. When students are goal-oriented, they are encouraged to see the evident results and knowledge of their struggles in learning. They continue to pursue mathematics because they see its importance in the job market and the particular career they want to pursue. Additionally, when students enjoy problem-solving, they can connect and identify with how the same problem-solving principles apply in the mathematics setting. Problem-solving is central to the study of mathematics, and when students begin to enjoy this process, they are more likely to continue their journey in mathematics.

Goal Orientation

A critical characteristic of students who continued to pursue learning mathematics is that they were goal-oriented and driven by these goals. Among the STEM students, there were two who demonstrated this characteristic. Interviewee 1 went into the engineering field, knowing how much mathematics would be required of him. He had done preliminary research before entering this field. Thus, he knew that he would have to take several mathematics classes and have a deep understanding of mathematical concepts to be proficient and thrive in engineering. In the process of discussing this, we discussed the importance of remedial mathematics as a stage in his mathematics education, and he mentioned that,

> "I knew how important mathematics was. And I knew that if I did not keep up in this early level of math, so if I did not get the concepts immediately, then I would have so much more trouble later down the road."

Interviewee 1 recognized that mathematics played a vital role in the career that he wanted to pursue and the degree that he wanted to pursue and earn. He continued to persist in mathematics classes because he had a goal in mind, with mathematics being a part of that goal. Interviewee 6 also could see into the future and see how mathematics played a role in his future career goals as well. Interviewee 6 is also an engineering major, and he was discussing his previous teachers' positive attitudes toward mathematics. During this discussion, he stated, "So obviously, them having this positive attitude gave me a positive attitude on how to look into the future." His teachers' attitudes towards mathematics helped him have a positive attitude to seek a career in mathematics. He also recognized that mathematics is based on previous mathematics classes' foundations. He described this further in his interview based on his own experiences:

> "Most of what we were doing in precal[culus] is a base of what we are doing right now… but as long as you understood that and it's your base of cal[culus], then that's what led me to understand the thing I understand right now."

Both experiences led the students to understand that mathematics is something that you need to diligently work to know and understand to pursue the goal of a career in engineering. Educators can apply this to other majors that are heavily dependent upon the study of mathematics. Both students also came to recognize the importance of setting solid foundations in mathematics early to pursue mathematics at a higher level. Mathematics was recognized as a part of the goal they worked to achieve within their personal career goals. They had to be diligent in understanding the mathematics presented. Teachers must help students cast a vision of what they want to pursue and highlight mathematics's role. Students need to know the levels of mathematical understanding that will be required of them to pursue specific careers. This knowledge can motivate students to work intensely to understand the mathematics they are presented with.

Personal Appreciation for Problem Solving

Another common characteristic among students pursuing STEM careers was that they had a personal appreciation and love for mathematics. Two of the three STEM students expressed and demonstrated this quality during their interviews. Interviewee 1 discussed some elements of mathematics that he began to appreciate and enjoy throughout his mathematics classes. He started seeing mathematics as a puzzle and responded, " It kept me going. Because that's what I enjoyed about it was finding the answer part." This student came to love problem-solving and the process of finding answers. In his interview, Interviewee 1 stated, "It was just a personal love for math that got me through those classes." Through developing a personal appreciation, Interviewee 1 was able to persist through difficult mathematics moments to pursue higher-level mathematics courses and content. Interviewee 6 also expressed similar sentiments. When discussing his appreciation for mathematics, he stated, "And I like challenges. And math has always been that thing for me." Interviewee 6, like Interviewee 1, found an element of mathematics that he enjoyed and has kept him pursuing challenges in mathematics and engineering.

Teachers in remedial mathematics courses can encourage persistence among students who desire to complete STEM degrees by helping students identify the pieces of mathematics that they enjoy and love. When students discover the elements and principles of mathematics that they want, it propels them to continue to pursue mathematics and the things that they love within the study of mathematics.

Summary of the Research Themes and Findings

Chapter 4 identified and assessed the emerging themes from the multiple interviews. The following themes emerged for encouragement: disposition and attitude of the instructor, willingness to explain content further and to draw specific attention to practical application. The following themes emerged for persistence: goal orientation and personal appreciation for problem-solving. The quotations and excerpts from the interviews provide an accurate representation of the perspectives and opinions of the interviewees.

The following chapter, Chapter 5, will address the implications of this study and how educators in secondary and post-secondary settings can encourage students to interact with high-level mathematics and come to appreciate the mathematics they are taking.

Chapter 5

Summary of Findings, Discussions, Recommendations, and Conclusions

With the rapid increase in the use of technology in the workforce, more jobs are opening up within the STEM field (Langdon, McKittrick, Beede, Khan, & Doms, 2011). These jobs are mainly opening up within the field of mathematics since mathematics is at the heart of the technology used daily (Xue & Larson, 2015; Langdon, McKittrick, Beede, Khan, & Doms, 2011). On the other hand, with the increase of mathematics being used across all areas of the workforce, mathematics knowledge has become a highly desirable trait among professionals entering the workforce (McCormick & Lucas, 2011). Mathematical knowledge equips professionals to interact and interpret the data and technology that they come into contact with in their respective fields (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017; Ernest, Skovsmose, Van Bendegem, Bicudo, Miarka, Kvasz, & Moeller, 2016; McCormick & Lucas, 2011). Despite this, few students engage with mathematics at a high level in post-secondary education settings. One of the reasons explaining this is the demeaning and discouraging environment of remedial mathematics, which most students have to engage in during their time spent in post-secondary education settings. This study aimed to uncover students' experiences within remedial mathematics settings and identify factors of encouragement and persistence that educators could begin to employ in remedial mathematics settings.

The study addressed two questions:

1. What factors inside the remedial mathematics classroom influence students' engagement in the mathematics content?
2. What factors inside the remedial mathematics classroom influence students' persistence through remedial classes and onto more challenging courses?

The qualitative data for this study was collected through interviews with current students who completed remedial mathematics during their time in post-secondary education. Interviews allowed students to have the opportunity to share their experiences and opinions freely, with a similar interview guide that was used for all interviews to ensure consistency throughout the interviews while keeping findings unique and experiential. The interviewees were selected based on major to gather findings from several students with differing opinions and experiences with mathematics, all meeting the requirement of taking one remedial mathematics course at the university where the research was conducted. After the data collection, the researcher transcribed the interviews, coded the data, and discovered emerging themes and similarities across the interviews.

Summary of Findings

In this section, the research findings are addressed, and the emerging themes are identified. The presentation and analysis of these themes are detailed in Chapter 4 of the research paper. Findings were generated from the participants' transcripts generated from the interview process. Findings are discussed concerning related literature, discussed in the Literature review in Chapter 2. This section will address themes and make recommendations based on the themes.

Themes Regarding Encouragement

There were three themes identified in the data that targeted how to encourage students to interact with the material they are presented with in remedial mathematics. These three themes were the disposition and attitude of the instructor, willingness to explain content further and to draw specific applications to practical application.

The first theme evident in the data was the disposition and attitude of the instructor. People within remedial mathematics classes experience high levels of mathematics anxiety

(Hembree, 1990). High levels of mathematics anxiety indicate that students do not have positive views of mathematics (Hembree, 1990). Negative attitudes towards mathematics are hard to overcome, influencing students' course selection over the remaining years at a post-secondary institution. Students with high levels of mathematics anxiety were more likely to dislike mathematics and were less likely to engage in mathematics further in their post-secondary education careers (Jiang, Lui, Star, Zhen, Wang, Hong, & Fu, 2021). There needs to be a way to target the negative association and experiences that students have faced with mathematics. One method to do so emerges throughout the data collection. Six out of the eight participants in the research mentioned that the instructor's disposition helped encourage the student to engage with mathematics. One interviewee stated, "And he had such a passion for math, and he loves it, to teach it. And that made me kind of want to learn it because he was so ready to teach us math." Another participant said, "Having a professor who is excited about their subject makes it a whole lot easier to be excited as a student." One particular student had negative experiences with mathematics in the past and demonstrated some of the sentiments that are markers of mathematics anxiety. In light of this, this interviewee stated that his professor "was very, very energetic and encouraging," and this made his remedial mathematics experience "kind of enjoyable, being there learning under him and just kind of like going through the math courses. For all the students, it made a difference in their engagement and enjoyment level when the teacher displayed positive emotions and energy towards the content they were teaching. These efforts helped boost positive attitudes and engagement in the remedial mathematics classroom, combating the high levels of mathematics anxiety that typically mark remedial mathematics classes (Hembree, 1990). To conclude, students are encouraged by their instructor's energetic disposition and positive attitude, which is an element that teachers should strive to include in the remedial mathematics classroom.

The second theme of encouragement that was evident was the willingness of the instructor to explain further the content presented during class time. Rates of successful remediation within mathematics are low (Bahr, 2008). One way that students can be supported amid difficulties successfully remediating is through a series of academic and counseling interventions (Stewart, Lim, & Kim, 2015). Studies show that services such as tutoring, academic advising, and counseling have helped aid students who enter the post-secondary setting with academic deficiencies (Stewart, Lim, & Kim, 2015). Statements from the interviewees echoed these research findings. The interviewees frequently mentioned that the teachers in their remedial mathematics experience were willing to provide tutoring or academic mentoring assistance with content in the classroom. One interviewee stated, “I was afraid that you know, the math teacher that I was going to get was, you know, going to be one of those do everything on your own teachers. And he was the exact opposite of that. And he was always willing to jump in and help me figure something out if you didn’t quite understand.” This interviewee benefitted from academic support within the classroom. He stated later in his interview how he valued this support and began to enjoy mathematics when support systems were available. Another interviewee similarly mentioned, “But when I got to college, and I saw that my professors were willing to sit down with me for hours and if need be and study a subject, it made it really, really easy to want to learn that subject.” This interviewee had similar support experiences outside of the classroom. Tutoring services and office hours were available to students to receive one-on-one guidance from the professor. A third interviewee went so far as to state, “The absolute best way to learn would be, you know, somebody teaching you one-on-one.” Within the remedial mathematics setting at the college studied, several academic supports were available to students within the remedial mathematics setting. Tutoring, in-class mentoring, and office hours outside of class are all methods that teachers could use to help support students throughout their academic journey. In tandem with the various support systems, interviewees felt encouraged by the instructor's attitude when aiding students. An interviewee stated, “He was very intentional about letting us know that he wanted to help us; he would make sure we understood.” When professors demonstrate a willingness to help, students are more likely to use the supports that are made available to them. This sentiment was captured by one interviewee’s experiences with a teacher. She stated, “So he was very intentional about letting us know that he wanted to help us; he wanted to make sure we understood.” Overall, academic mentoring and counseling services are important aids in the context of the remedial mathematics classroom. To best promote students utilizing these services, teachers can work to demonstrate a willingness to help students. Teacher openness to helping students with the material was one encouragement factor that all but one interviewee mentioned. It plays a vital role in students taking advantage of the services offered to ensure successful remediation.

The final theme of encouragement that emerged from the data was the importance of the instructor, explicitly highlighting the real-life application of the content. Currently, many schools present mathematics abstractly (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). Mathematics problems are contextualized and presented in a way that students will never encounter in the real world (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). Mathematics teaching and content need to reflect how mathematics appears in the real world, including real-life applications, examples, and problems for students to encounter within the classroom (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). Consistent with this research's findings, students feel encouraged when they can see how the mathematical principle they are learning applies to the real world. Many students expressed within the study that the practical application was essential to them and stimulated their engagement with the material. Some interviewees addressed this topic positively; they addressed how knowing the importance and application of the material helped them interact with it. One interviewee mentioned, “And then he would pull up a graph or a chart, and he’s like, this is what we use it for. And that is what made it a lot easier to focus in because we had an image to put it with.” In addition to positive discussions about practical application, several students addressed how they had teachers who neglected to show practical application in the past. These students further explained how this generated negative perceptions about mathematics. One interviewee stated, “I did not see any form or fashion or function and how it would incorporate into my future,” and later, “And that is kind of when I got frustrated because I did not understand why I needed to learn it.” Overall, teachers need to make explicit references to how the concepts students are currently learning will be helpful to them in the future. Students do not always have this vision and perspective, so educators need to make this knowledge accessible to students. Instructors can do this through various graphics and illustrations, real-world examples, and real-world problems, to name a few ways. This research reveals that students are encouraged when a real-world application is modeled and explained. This finding is consistent with research that calls for mathematics education to reflect how students will interact with mathematical problems and problem-solving methods in the future.

Themes Regarding Persistence

There were two themes identified in the data that were characteristics of students who persisted in mathematics-heavy careers. These two characteristics of persistence were goal orientation and personal appreciation for problem-solving.

The characteristics of goal orientation were displayed in two of the three STEM students who participated in the research. Many students need to be aware of mathematics's usefulness in their careers since their educational upbringing has not reflected the real-life application of mathematics (Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). Students need to see the result of studying mathematics because they do not see how it fits into their career and, therefore, have no desire to study it during their time spent in post-secondary educational settings. When they do not see the result of studying mathematics long-term, they believe there is no use in pursuing it. There are some of the interviewees demonstrated these sentiments. One interviewee stated about her opportunity to take calculus in high school: "They encouraged me to do AP calc through Indiana University…Not really going to use that. I'm not going to take it." On the other hand, two students saw the usefulness of mathematics, and as a result, they cast a vision for how mathematics might benefit them in their future careers. It is important to note that these students are STEM students. One of the STEM students described his goal of becoming an engineer, and as he was researching his career path, he discovered the amount of mathematics he had to take. The interviewee then described how he kept pushing through mathematics classes, even when they were difficult, because he had an end goal driving him to continue to study mathematics. When students have an idea of how mathematics applies to their life and how important it is to study it, they are more inclined to continue to study it past the remedial level in a post-secondary setting. The other STEM student addressed how his teachers created a "positive attitude to look into the future." This attitude helped this interviewee understand the challenge of studying mathematics while seeing it from a different perspective. Rather than seeing all the negatives, this individual could see the upcoming challenge with hope and appreciate it because of the positive goal orientation that he had gained from his previous experiences and the guidance of his instructors. Many students do not understand how mathematics can play a role in their careers, but mathematics is in almost every field with the increase of technology in the workforce (McCormick & Lucas, 2011). To see more persistence among students within the remedial mathematics classroom, students need to be goal-oriented and understand the benefits of learning mathematics. Without seeing the fruit of understanding mathematics, there is nothing for students to work towards in studying mathematics. Students need to see the usefulness of mathematics, identify a goal that involves how mathematics is helpful for their career, and work towards that goal by pursuing higher mathematical knowledge through post-secondary education.

Students who persisted to higher levels of mathematics achievement and understanding developed a personal appreciation for problem-solving somewhere in their learning journey. Many students do not appreciate the operations and the processes of mathematics, and one way this is demonstrated is in STEM majors' attitudes toward mathematics. Mathematics is seen as the primary hurdle for STEM majors to overcome instead of being seen as an integral component of their field (Couturier & Cullinane, 2015). This hurdle is hard to overcome for those who do not have a strong mathematics background (Couturier & Cullinane, 2015). Two of the STEM students who participated in the study described their love for mathematics and how that encouraged them to continue studying it amid difficulties. These interviewees opposed the perspective that STEM majors see mathematics as a hurdle they must overcome (Couturier & Cullinane, 2015). One interviewee stated, "It was just a personal love for math that got me through those classes" and that he "enjoyed the finding the answer part" of a mathematical problem. Another interviewee stated that he saw mathematics as a "puzzle," which presented a challenge he enjoyed tackling. Each of these interviewees displayed a personal appreciation for mathematics. They each found an element within mathematics that they enjoyed, and their enjoyment of mathematics drove them to continue engaging in mathematical learning. Thus, teachers need to help students identify elements of mathematics and the problem-solving process they enjoy. Each of these interviewees mentioned how teachers could foster this in the classroom. One of the interviewees said his teacher's love for mathematics encouraged him to find an element of mathematics that he enjoyed. Teacher disposition, a factor of encouragement that teachers can control, is one way to foster a personal appreciation for mathematics. In this study, personal appreciation demonstrated itself to be a characteristic of students who persist through mathematics classes despite entering a post-secondary institution with low levels of preparation. Based on this study, instructors should consider making specific efforts to encourage students to find elements of mathematics that they enjoy. One way this encouragement can be accomplished is through the instructor's positive attitude toward mathematics.

Additional Discussion of Findings

This section will provide additional insights for those involved in the remedial mathematics setting in various capacities. These insights will be related to the emerging themes and essential literature discussed in Chapter 2. This discussion will further explore the research findings and how they can integrate into remedial mathematics settings.

No Mathematics Majors in Remedial Mathematics

A finding not directly related to the research questions was that no mathematics majors began remedial mathematics at the university where the research occurred. This finding resulted in the groups of the study being rearranged to represent students from non-STEM majors and STEM majors. This finding of sorts is interesting in light of particular research. Academically prepared students are more likely to persist through higher levels of various subjects than their peers who begin college or university in remedial mathematics (Stewart, Lim, & Kim, 2015). The combination of the research and the occurrence within the research process can infer that individuals who enter post-secondary institutions and pursue a mathematics degree enter with the mathematical preparation needed. At the university where the research was conducted, there were no mathematics majors that emerged from remedial mathematics, also indicating that remedial mathematics is not the appropriate place for teachers to try and convince students to major in mathematics. The focus should gear toward showing students the value of mathematics within their careers and creating an environment for them to enjoy and interact with the mathematics they are encountering.

What Instructors Can Control within the Classroom

It is essential to note that each of the three factors for encouragement goes hand-in-hand with teacher behavior and actions within the classroom setting. Teachers have control over their disposition toward the material and towards students. Teachers need to interact with and teach mathematics to students in a positive manner. Additionally, teachers have control over their willingness and availability efforts toward students. One way that teachers can communicate openness to students is by being patient when solving problems with them. One participant mentioned, “And he was very patient with me. He always had a smile on his face when he was helping me.” It is vital to communicate to students that you are willing to help them throughout the problem-solving process to address any gaps in understanding. This willingness can be communicated through patience, willingness to address issues, and welcoming nonverbal cues. Lastly, teachers can control how often they draw connections between what is being learned and how it appears in a real-world situation. It is advised for educators to switch instruction from being mostly abstract to reflecting how mathematics appears outside of the classroom

(Gravemeijer, Stephan, Julie, Lin, & Ohtani, 2017). All in all, each encouragement factor is a skill or method that the teacher is advised to employ within his or her classroom. Teachers' actions and teaching methods significantly impact the encouragement of students within the remedial mathematics classroom, and three areas identified were their disposition, openness to aid, and real-world connections to learning.

How Instructors Can Use Encouragement Factors to Boost Persistence

As discussed within the themes for persistence, the factors of encouragement help generate and lead to the characteristics of persistence within students in the remedial mathematics setting. The characteristic of goal orientation is supported by drawing real-life connections. The practical application piece of mathematics is one that many students do not see, and the first step is to apply this practice within the context of what is currently being learned. After revealing to students how the material they are engaging with applies to the real world, the teacher can guide students into exploring how mathematics, on a grander scale, intertwines with their future careers. This path of inquiry can further encourage students to persist within mathematics to reach knowledge that they know is relevant to their careers. The characteristic of personal appreciation within mathematics can be facilitated by the encouragement factors of the instructor's disposition and willingness to help. These two factors of encouragement combine to make the learning experience and process more enjoyable for students. When teachers have created the space for students to enjoy what they are learning through environmental controls, they can begin to explore why they are enjoying what they are learning. This action can lead to the discovery of elements of mathematics that they enjoy. Creating a positive learning environment promotes inquiry and allows students to discover a love for mathematical learning.

This appreciation for mathematics is a characteristic of persistence that serves as a catalyst for students through post-secondary mathematics education.

Limitations of the Study

This study only captured students' perceptions about what would help encourage them within a mathematics classroom. None of the above themes were evaluated explicitly within the study. Additionally, there were a limited number of students available to select from with the size of the university where the research was conducted. Few students were willing to participate in the study out of the total number of students who qualified to participate. If more students were available to participate, there might be additional findings, or the current findings might not have been as firm. In addition to a few students being willing to participate, most participants had a personal connection with the researcher. The last limitation would be that students willing to participate might have a better understanding of and viewpoint toward mathematics. If students were willing to talk about their mathematical experience, they might have experienced a more positive mathematics upbringing.

Conclusions

The study's conclusion identifies the various factors of encouragement that teachers can apply within the remedial mathematics classroom and the classification of various characteristics of persistence among students who continued to take mathematics courses at the post-secondary level after being initially placed in a remedial mathematics program. This conclusion can help equip teachers to encourage students to interact with the mathematics material placed before them in the remedial setting. It can also help teachers identify the characteristics of persistence within students. Moving forward, students need to remediate successfully with positive attitudes toward mathematics and knowledge of how it can appear in their field of study.

Students highly value the disposition of the teacher, and this helps students have positive perceptions towards mathematics and engage with the material. Students also greatly benefit from the teacher ensuring that they understand all mathematical processes covered within the concepts. For teachers to accomplish this, they need to be willing to explain content to students further. Additionally, students are more engaged with material when they see the practical application of it, and this is one effort made by teachers that students greatly benefit from in the remedial mathematics setting. This study successfully identified several factors teachers can control within their classrooms to promote a warm learning environment marked by inquiry and participation.

Students who demonstrated persistence through remedial mathematics displayed goal orientation and personal appreciation for problem-solving. Teachers can aim to cast a vision for students on how mathematics applies to the field of study they are engaged in and encourage them to pursue more excellent mathematical knowledge in this area. Additionally, students who persisted in higher mathematics classes demonstrated a personal appreciation and enjoyment found within mathematics. Teachers can help students explore the different aspects of mathematical problem-solving and encourage students to discover the elements of mathematics they enjoy the most.

Recommendations

In the data collection process, students had several insights to offer, and all of the students had a positive experience with the instructors at the university where the research took place. Although they all had positive experiences with remedial mathematics at this specific post-secondary institution, some students, STEM and non-STEM, still held very negative perceptions of mathematics. The following suggestions for students are to aid in developing the two characteristics of persistence that emerged from the data. The following recommendations for remedial mathematics instructors aim to target and promote the factors of encouragement that emerged from the research. Lastly, the suggestions for further research address how research on this topic can continue.

For Students

- Being open to mathematical learning experiences, even if they are directly outside of their field of study in the post-secondary setting
- Researching ways that mathematics influences the career path they are choosing
- Researching what mathematics courses their college offer and which courses best fit his or her chosen career path
- Focus on maximizing their time spent in remedial mathematics courses by accessing different avenues for student success (tutoring opportunities, one-on-one instruction, counseling, knowledgeable peers, etc.)

For Instructors

- Display a positive attitude toward the mathematics that they are teaching
- Model appreciation and enjoyment while interacting with the content
- Seek out individuals in the classroom to provide help if students need
- Be diligent in showing each step in the mathematical processes on display, in ensuring that students are not left behind
- Devote class time to further explaining content to some students
- Highlight the application of the content that students are learning
- Include real-life examples in problem-solving
- Ensure that content is not entirely comprised of abstract principles

- Help students identify aspects of problem-solving and mathematical processes that they enjoy
- Provide support for students outside of the classroom, such as tutoring opportunities for students or one-on-one instruction opportunities

Recommendations for Further Study

- Students enter remedial mathematics with different perceptions of mathematics. Further research could explore how many students enter remedial mathematics courses with positive and negative views of mathematics. This research might also determine how likely students are to remediate successfully based on personal perceptions of mathematics.
- Further research might examine students' perceptions of mathematics at the beginning of remedial mathematics courses and after remediation is completed. This could identify the effects of encouraging efforts in a post-secondary remedial mathematics setting.
- Potential research could discover how many students continue to take mathematics courses in the post-secondary setting after taking a remedial mathematics course(s) who are not in a mathematically-heavy field of study. This research will shed light on if encouragement efforts correlate with more students engaging in mathematics, even if it is outside of their field.
- One might conduct the research at a more prominent university to see if findings remain the same across more significant participant numbers and different environments.
- Further research could implement and compare the effect of each of the three factors for encouragement inside a remedial mathematics program.

- Potential research could examine the strength of the two factors of persistence among all STEM and mathematics majors to see if this is a common trait among this group of students.

Summary

This study aimed to identify elements of encouragement and persistence within the remedial mathematics setting. This research was conducted at Milligan University, and the students who participated in the study were from mathematically heavy fields and some that were not. The study participants included five non-STEM majors and three STEM majors. Three themes of encouragement emerged from the research. Two persistence characteristics were identified among students who had continued to take more mathematics courses at the post-secondary level. These themes emerged from a qualitative data collection process through interviews with each participant. Results reflected students' perceptions and insights as to what encourages them within the mathematics classroom, and persistence factors were also evident in the students' statements.

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