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Predictive Relationship Between Mathematics Pathways and Success Indicators at a Community College

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Walden University
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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

College algebra, a gateway course, has had the lowest passing rate for students of any freshman course. While research exists on the implementation of quantitative reasoning at 4-year institutions, little understanding exists on whether different mathematical pathways predict non-Science, Technology, Engineering, and Mathematics (non-STEM) student mathematics success indicators. This study's purpose was to determine if mathematics pathways (college algebra or quantitative reasoning) predict non-STEM student mathematics success indicators such as course retention, course passage, continuation to one semester after mathematics course passage, graduation within 1 year, and transfer-out within one semester after mathematics course completion while controlling for preexisting knowledge. Holland's personal-environment fit theory was the framework for this study. One research question with 5 hypotheses determined if mathematics pathways predicted the 5 non-STEM success indicators controlling for ACCUPLACER Elementary Algebra test scores. A quantitative predictive design was employed using a census of 138 records on non-STEM students enrolled in one of the pathway courses and who took the ACCUPLACER Elementary Algebra test during the Fall 2018 and Spring 2019 semesters. Binary logistic regression analysis was conducted for each criterion variable. The results indicated that mathematics pathways did not predict the five success indicators. Findings were not consistent with the literature nor with Holland's theory. This study offers implications for positive social change by offering evidence to institutions of higher education that students should be allowed to enroll in the mathematics pathway that best prepares them for their intended programs of study.

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Dedication

First, I would like to give all praises to God, who has led me throughout this entire doctoral journey. This work is dedicated to my loving parents, Charles and Minnie Wilkinson and my sister, Selanda Wilkinson. All have been very supportive of me, especially from the time that I began my undergraduate studies through the time that I was going through an unfortunate situation while pursuing my doctoral coursework. Even now, they have been and always will be my primary support system. For everything that you have done, I am proud to dedicate my dissertation to you.

Acknowledgments

There is an old saying that states “It takes a village to raise a child”. I must say that it took a village to raise a doctoral student and I would like to give thanks to the village that assisted me through this doctoral journey.

I would like to give thanks to my doctoral committee, Dr. Kelly Hall, Dr. Ioan Gelu Ionas, and Dr. Crystal Lupo. Dr Hall, your guidance, expertise, and thoughtful suggestions are the reasons why this dissertation came to fruition and I am deeply indebted to you. I am truly blessed to have you as my dissertation chair. Dr. Ionas, I thank you for providing your insights and suggestions. You and Dr. Hall have conducted a brainstorming session on what direction that I should go with my study and I able to process those recommendations. Dr. Lupo, as my URR, I would like to thank you for your constructive comments as I was trying to get my major documents approved.

I would like to thank the director of institutional planning, planning, and effectiveness and the staff of the cooperating institution for providing me the data set so that I would be able to conduct my study. I would also like to thank Dr. Zin Htway for assisting me in using SPSS to analyze the data set. Your assistance really did clear up any misunderstandings that I had. Thanks to the faculty who were my instructors of my coursework and the advisors from the Quantitative Methodology Office for your support during this doctoral journey. Thanks to my colleagues, past and present, at my educational institution for your encouragement in pursuing a doctoral degree. A special thanks to the members of the Walden University PhD/EdD/DBA group on Facebook. Your postings and comments have encouraged me throughout this journey.

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Chapter 1: Introduction to the Study

Precalculus and college algebra were created as a means of preparing students with algebraic skills necessary for success in calculus (Gordon, 2008). Students enroll in college algebra because the course is usually mandatory to satisfy general education requirements or is mandatory for particular programs of study. Programs preparing students in fields that are mathematically intense and not mathematically intense both require college algebra to progress into a field of study and graduate (Gordon, 2008).

Quantitative reasoning has recently been introduced as a course across the United States (Gaze, 2018). Content in quantitative reasoning includes basic statistical, problem-solving, and mathematical skills; and promotes logical thinking (Asknes, 2017). The goals for offering a quantitative reasoning course are to provide an alternative terminal mathematics course for students who would be better served by a course not heavily focused on algebraic abstraction and manipulation of variables, teach students to solve real application problems with actual numbers and to transfer problem-solving understanding to other real-world situations (Van Peursem, Keller, Pietrzak, Wagner, & Bennett, 2012).

In this study, I determined whether the mathematics pathways (college algebra or quantitative reasoning) at a community college predicted the five success indicators (retention, course passage, continuation, graduation, and transfer). This study was necessary because college algebra has had the lowest passing rate of any freshman course (Wynegar & Fenster, 2009). Determining the predictive relationship between mathematics pathway and course retention, course passage, continuation, graduation, and transfer-out for community college non-Science, Technology, Engineering, and Mathematics (non-STEM) students could have far-reaching implications for future success of college students.

This chapter includes background related to the scope of the study topic, the problem statement, the purpose of the study, and the research questions along with the related null and alternative hypotheses. I provide a discussion of Holland's personal environment-fit theory as the theoretical framework. The nature of the study is explained, followed by definitions of key terms, assumptions, scope and delimitations, limitations, and significance of the study.

Background

For many years, in higher education, the gateway course in mathematics has been college algebra. In 2010, over one-half of 4-year college students and about four out of five 2-year college students were enrolled in college algebra or a pre-college algebraic-intensive course (Blair, Kirkman, & Maxwell, 2013). College algebra was designed to help students at low-performing levels advance to calculus (Gordon, 2008). Emerging data provided a detailed picture of what happens to students because of gateway courses like college algebra. One university examined enrollment patterns for over 14 years. Only one-tenth of the students who successfully complete college algebra would ever begin calculus I and almost none would ever begin calculus III. Additionally, less than one-third of the students who complete college algebra would start business calculus (Gordon, 2008). At several colleges and universities, approximately one-fifth of students repeated college algebra, and another one-tenth of students who complete college algebra enrolled in calculus I (Herriott & Dunbar, 2009).

Five mathematics professional associations recommended multiple pathways that are related to fields of study; some should include an early introduction to computation, statistics, and modeling. While calculus is central to further study in the mathematical sciences, colleges and universities are advised to develop curricula effective for most of the population (Saxe & Braddy, 2015). The creation of effective pathways is a current gap in practice. Most colleges and universities continue to require college algebra to move into all programs of study. The creation of pathways is critical if institutions want to prepare students to advance to higher levels of postsecondary education (Bragg, 2011). According to Bragg (2011), additional research is necessary to support the study of mathematics pathways other than the normative mathematics sequence, like traditional college algebra.

Determining if mathematics pathways for community college non-STEM students can predict the five success indicators is important because having multiple pathways might better serve students. Requiring all students to complete a mathematical sequence leading to calculus is questionable ethically if only about one-tenth of jobs, especially in STEM-related fields, require knowledge in advanced mathematics. Most post-secondary students would be better served by obtaining a solid foundation in statistics, data analysis, and probability. Providing courses like statistics and quantitative reasoning would offer a more relevant, engaging math alternative for those not pursuing majors or careers where knowledge in advanced mathematics is required (Schwartz, 2014).

Problem Statement

College algebra has been a required core course for students at community colleges and universities. College algebra has also been a gateway course in higher education, a gateway course with the lowest pass rate for students of any freshman course (Wynegar & Fenster, 2009). Nationwide, over 45% of students who take college algebra either withdrew or earned grades less than “C” (Ogden, Pyzdrowkski, & Shambaugh, 2014). Each year over 1,000,000 students across the United States enrolled in college algebra. The average success rates ranged between 40% and 60%: on average, roughly half a million students are unsuccessful in advancing in their academic programs because of college algebra (Jaster, 2017). At a local community college in Arkansas, the success rate for college algebra was about 60%. For the fall 2017 semester, the success rate was 59.6% and for the spring 2018 semester, 58.7% of students passed college algebra. Failing college algebra has wider ramifications on student retention, progression, and degree completion across all majors (Okonkwo, Deverapu, Smith, Kunwar, & Paudel, 2018). Quantitative reasoning has been offered as an alternative to college algebra for students pursuing non-STEM programs at some postsecondary institutions (Koch & Pistilli, 2015). While research exists on implementing quantitative reasoning/literacy at 4-year institutions, there is little understanding of whether different mathematical pathways or skills predict non-STEM student mathematics success indicators. O’Connell, Wostl, Crosslin, Berry, and Grover (2018) recommended future studies that would identify students who have taken prior mathematics courses and investigate the specific factors or skills that contribute to current success. To fill this gap in practice, I conducted a study to test whether or not students who are engaged with mathematics appropriate to their major fields of study remain enrolled and succeed in college.

Purpose of the Study

The purpose of this quantitative study was to determine if mathematics pathways (college algebra or quantitative reasoning) predicted non-STEM student mathematics success indicators such as course retention, course passage, continuation to one semester after mathematics course passage, graduation within one year, and transfer-out within one semester after mathematics course completion while controlling for preexisting knowledge. The community college that I focused on implemented quantitative reasoning as an alternative to college algebra since the fall semester of 2018. Determining if the appropriate mathematics pathway predicts the five success indicators would provide an understanding of whether the chosen math pathway can predict student retention, course passage, continuation, graduation, and transfer.

For this study, the criterion variables were course retention, course passage, continuation in college, graduation, and transfer-out. The predictor variable was two categories of mathematics pathways: college algebra and quantitative reasoning. To control for prior knowledge, the ACCUPLACER Elementary Algebra placement scores were the covariate for this study.

Research Question(s) and Hypotheses

To achieve the purpose of this study, I investigated one research question to determine if the two mathematics pathways predicted the five criterion variables.

Research Question (RQ): Controlling for placement scores, does mathematics pathways (college algebra or quantitative reasoning) predict student success?

$H_0 1$*:* Controlling for placement scores, mathematics pathway does not predict retention in course among non-STEM majors.

$H_1 1$*:* Controlling for placement scores, mathematics pathway does predict course retention in course among non-STEM majors.

$H_0 2$*:* Controlling for placement scores, mathematics pathway does not predict course passage among non-STEM students.

$H_1 2$*:* Controlling for placement scores, mathematics pathway does predict course passage among non-STEM students.

$H_0 3$*:* Controlling for placement scores, mathematics pathway does not predict continuation among non-STEM students.

$H_1 3$*:* Controlling for placement scores, mathematics pathway does predict continuation among non-STEM students.

$H_0 4$*:* Controlling for placement scores, mathematics pathway does not predict graduation among non-STEM students.

$H_1 4$*:* Controlling for placement scores, mathematics pathway does predict graduation among non-STEM students.

$H_0 5$*:* Controlling for placement scores, mathematics pathway does not predict transferring out among non-STEM students.

$H_1 5$*:* Controlling for placement scores, mathematics pathway does predict transferring-out among non-STEM students.

Theoretical Framework for the Study

The theoretical framework for this study was Holland's personal-environmental fit theory (Holland, 1997). Holland's theory consisted of some concepts and additional multifaceted elaborations. First, people can be characterized by their similarities to each of the six personality categories: artistic, conventional, enterprising, investigative, realistic, and social. The exhibition of one of the six personality categories is based on how close a person resembles it. Second, the surroundings where people live and work can be categorized by their similarities to the typical environments similar to the six personality types. Finally, the coupling of individuals and environments leads to outcomes that can be predicted and understood from the knowledge of their personality categories and the environmental models. These outcomes include personal competence, social behavior, vocational choice, vocational stability and achievement, and susceptibility to influence (Holland, 1997).

Holland's theory consisted of three premises: environments, individuals, and congruence. The self-selection assumption "assumes that individuals choose occupational and educational environments that are compatible with their personality types" (Smart, Feldman, & Ethington, 2006, p. 12). With the socialization assumption, academic majors require, reinforce, and reward individuals for possessing and displaying vales and competencies consistent with the same traits of those in the same academic majors. The individuals' values, attitudes, competencies, and interests are displayed in a manner that is consistent with the personality types that govern the environments (Smart et al., 2006). As with the congruence assumption, stabilization of vocation and education, satisfaction, and achievement ae related to the congruence between the individuals' environments and the individuals themselves (Smart et al., 2006).

Holland's personal-environmental fit theory was suitable for this study because of the recommendation from the Charles A. Dana Center (2016) that students should enroll in math pathways that fit their intended programs of study. According to Porter and Umbach (2006), congruence between the individual and the surrounding is important to the success of college students, and that congruence of the individual and surrounding is associated with higher levels of educational achievement, satisfaction, and stability. In this study, I investigated congruency between vocational choice and college success indicators.

Nature of the Study

In this study, I employed a quantitative predictive research design using binomial logistic regression analyses of archival data. A predictive research design is useful for identifying variables that will predict a criterion or outcome. The researcher identifies one or more predictor variables and a criterion variable (Creswell, 2015). Data were obtained from a large central Arkansas community college, so that course retention, course passage, continuation, graduation, and transfer-out were analyzed controlling for prior knowledge. The ACCUPLACER Elementary Algebra placement scores were used as a means of controlling prior knowledge.

Definitions

ACCUPLACER mathematics placement scores: ACCUPLACER mathematics placement scores are part of the ACCUPLACER tests that are intended to aid educational institutions with placing students in the most suitable mathematics class during their first year of college (Mometrix Test Preparation, 2019).

Attempted credit: Attempted credit is defined as whether a student was enrolled in the course as of the add/drop deadline (Durham & Cook, 2017).

College algebra: College algebra is defined as a terminal general education course for non-STEM majors and it covers topics including, but not limited to, solving equations; concepts of linear, polynomial, rational, radical, exponential, and logarithmic functions; inverses and compositions of functions; and systems of linear equations (Catalano, 2010).

Continuation: Continuation will be measured as a rate of how many students continued their studies at a higher education institution. Continuation will be based on student activity one year after the start date (Rimington, n.d.).

Course passage: Course passage will be measured as the number of students earning a grade of A, B, C, or D (Childers, Lu, Hairston, & Squires, 2019).

Course retention: Course retention is defined as enrolling in a course after the course census date and successfully completing the course with a passing or failing grade (Liu, Gomez, & Yen, 2009).

Earned credit: Earned credit is defined as whether a student received an A, B, C, D, or Pass (Durham & Cook, 2017).

Graduation: Graduation will be measured as a “rate of students within a cohort graduate from an institution. This is measured in two or three years for associate-level programs” (Voigt & Hundrieser, 2008, p. 4).

Non-STEM students: Non-STEM students are students who have not declared to pursue fields of study identified by the National Science Foundation as representing science, technology, engineering, and mathematics majors. Majors include business technology, digital media, information systems technology, and hospitality management (Gansemer-Topf, Kollasch, & Sun, 2017).

Quantitative reasoning: Quantitative reasoning is often referred to as quantitative literacy, quantitative fluency, mathematical reasoning, and numeracy. Students apply basic mathematics and algebraic skills so that they can interpret and analyze quantitative data that is relevant to real life (Elrod, 2014).

Success: Success is defined as a measure of how many students have reached a satisfactory or required student outcome. Indicators for desirable outcomes include academic achievement, educational attainment, holistic development, student achievement, and student retention (Cuseo, 2012).

Transfer-out: Transfer-out will be measured as a rate of the number of students who pursue their educational careers in one institution and, then, leave and attend another post-secondary institution before prior to completing a degree or academic goal (Voigt & Hundrieser, 2008).

Assumptions

I made several assumptions in this study. I assumed that all mathematics instructors were covering the required topics that are typically taught in both college algebra and quantitative reasoning, as indicated in their respective course syllabi. I also assumed that all students were properly placed in either college algebra or quantitative reasoning based on whether they were pursuing non-STEM associate degree programs as well as meeting the minimum score in mathematics on the ACCUPLACER Elementary Algebra test. Finally, I assumed that the data from the community college used to measure course retention, course passage, continuation, graduation, and transfer-out are accurate.

Scope and Delimitations

This study was delimited in scope to one community college in the state of Arkansas that has approximately 9,200 students enrolled in classes offered at seven campus locations. Slightly over one-half of the student population was enrolled on a part-time basis. The research question that I have posed for this study determined if course retention, course passage, continuation, graduation, and transfer-out predicted mathematics pathway (college algebra or quantitative reasoning) for non-STEM students at a community college. The community college that I used in this study was unique because of the number of sections that were offered for college algebra and quantitative reasoning compared to other community colleges in the state. For the 2018–2019 academic year, 70 sections of college algebra were offered, and 33 sections of quantitative reasoning were offered.

Limitations

The potential limitations of this study included that it only determined whether the appropriate mathematics pathway for non-STEM students predicted the five criterion variables. I examined a single academic year because the community college in central Arkansas implemented quantitative reasoning for the first time during the 2018–2019 academic year and that data was only collected for the fall 2018 and spring 2019 semesters. I only examined students pursuing non-STEM associate degree or certificate programs that were enrolled in either the traditional college algebra or quantitative reasoning pathway and took the ACCUPLACER Elementary Algebra placement test. Another limitation was that I examined a community college in Arkansas that offered both college algebra and quantitative reasoning. Even though other community colleges offered both courses, they did not offer an adequate number of sections for quantitative reasoning so that an adequate sample could be obtained. Finally, I did not evaluate the qualitative aspects of students matriculating in college algebra and quantitative reasoning.

Significance

Predicting the appropriate mathematics pathway for non-STEM students may help address the issue of the low passing rate of college algebra and the need for an alternative gateway mathematics course. The field of college teaching and learning will also have needed research about offering alternative mathematical pathways and student success. Ellington (2005) cited college algebra as a significant milestone for students, whom the vast majority have no plans to go into a profession requiring a calculus background; therefore, the traditional college algebra course might not be suitable for some students. Approximately 80% of students who are required to take college algebra do not need an algebra-intensive curriculum (Gordon, 2008). The Charles A. Dana Center (2016) recommended that students should pursue math pathways that mirror their planned programs of study and the suitable mathematics pathway for each student should be based on his or her academic goals and interests and not on the student’s preparation level. Determining if mathematics pathways predict the five selected variables at one community college has far-reaching implications for the future success of college students.

Positive social change can occur by providing information on whether the appropriate mathematics pathway for non-STEM students predicts course retention, course passage, continuation, graduation, and transfer-out. With about half a million students failing to advance in their academic programs because of college algebra (Jaster, 2017), offering a different pathway such as the quantitative reasoning pathway might improve the progress of college students through their course sequence and toward graduation. In addition to making an original contribution to the literature by studying the initial implementation of quantitative reasoning, the study contributes to the growing body of research about whether the appropriate mathematics pathway predicts retention, course passage, continuation, graduation, and transfer-out. This study is the first prediction research study that I know of in a community college setting.

Summary

In Chapter 1, I provided an introduction and the background of this study. I explained the problem that students fail college algebra more than any other college course, which has ramifications on student retention, progression, and degree completion as a way of stating the need for this study. I also provided the purpose of this study and the research questions related to the purpose, along with the variables that were measured. I discussed Holland’s personal-environmental fit theory to indicate how this theory is related to this study. I defined the nature of this study and the important definitions. I provided the assumptions, scope and delimitations, and limitations of this study. The significance of this study included the importance of predicting the appropriate mathematics pathway based on non-STEM course retention, course passage, continuation, graduation, and transfer-out. The evidence from this study may suggest that the appropriate mathematics pathway can predict the five selected variables.

Chapter 2 contains the literature review, which will include the literature search strategy used to locate articles that were related to this study, a thorough discussion of the theoretical foundation, and an exhaustive literature review of articles related to the key variables of this study.

Chapter 2: Literature Review

The purpose of this quantitative study was to determine if mathematics pathways (college algebra or quantitative reasoning) predicted non-STEM student mathematics success indicators such as course retention, course passage, continuation to one semester after mathematics course passage, graduation within 1 year, and transfer-out within one semester after mathematics course completion while controlling for preexisting knowledge. In this chapter, I provide a literature review of studies that were associated with the dependent and independent variables in this study. The literature review begins with a presentation of some strategies that have been used to improve success rates in college algebra, like course redesign, flipped classroom, corequisite model, and the emporium model. These strategies are followed by studies that were related to students pursuing STEM or non-STEM related fields. A brief section on quantitative reasoning contains studies that have been published regarding the effectiveness of instruction in quantitative reasoning and the various ways that this course has been implemented. Finally, I discuss studies in the areas of retention rates, transfer rates, completion rates, graduation rates, continuation rates, and success rates as they are related to the field of mathematics. The literature presented in this chapter supports the importance of this topic and that there is little knowledge of research on whether the appropriate mathematics pathway predicts non-STEM course retention, course passage, continuation, graduation, and transfer-out.

Literature Search Strategy

The articles presented below are directly related to the variables identified in this study and the strategies used to improve student success in college algebra. Many of the articles in this background literature were from *Numeracy: Advancing Education in Quantitative Literacy,* a journal published through Scholar Commons from the University of South Florida. In collecting information for the literature review, I used the following portals: ProQuest, Google Scholar, Walden University Library, and Scholar Commons from the University of Florida. The articles were restricted to the ones published since 2015. I used the following keywords: *college algebra*, *corequisite model*, *the emporium model*, *flipped classroom*, *STEM versus non-STEM students*, *quantitative reasoning*, *retention rates in mathematics*, *transfer-out rates in mathematics*, *graduation rates in mathematics, continuation rates in mathematics, completion rates in mathematics, success rates in mathematics*, *ACCUPLACER mathematics placement scores*, and *math pathways*.

Theoretical Foundation

The theoretical framework for this study was Holland's (1997) personal-environment fit theory. Holland's theory grew from his experience as a vocational counselor in educational, military, and clinical settings. This led to the notion that it may be helpful to categorize people in terms of interest or personality sorts (Holland, 1997). The basic premise of the personal-environment fit theory is that human behavior comes from the interaction between individuals and their surroundings. Through the application of this theory, students select academic environments well-suited to their personality sorts, and in turn, academic surroundings reward different forms of student abilities and interests (Porter & Umbach, 2006). Holland developed this theory to help students choose careers or majors in which they would have the highest probability of future success (Smart et al., 2006). Based on prior evidence, Holland's theory can potentially offer a theoretical approach for investigating student success at the postsecondary level (Smart et al., 2006). Three premises comprise Holland's theory: individual self-selection, environmental socialization, and congruence. Congruence was the focus of this study. For the congruence premise, stabilization of vocation and education, achievement, and satisfaction are related to the congruence between the individuals' environments and the individuals themselves (Smart et al., 2006). Holland (1997) mentioned that investigators examined the effect of congruence upon the stability of vocational choice, satisfaction with college, achievement, personal adjustment, and other outcomes. Recent research suggests that congruence between the individual and the environment is important to each college student's success (Porter & Umbach, 2006). Chen and Simpson (2015) stated that students "prefer academic environments that parallel their own personality types, choose academic environments that match their interests and values, and choose academic environments that match their strongest academic competencies" (p. 728). Congruence of the individual and the environment is associated with advanced levels of educational stability, satisfaction, and achievement (Porter & Umbach, 2006). Applied to the present study, congruency between vocational choice and achievement in a mathematical pathway (college algebra or quantitative reasoning) was investigated.

Literature Review Related to Key Concepts and Variable

In this literature review, I focused on articles that are related to the study, including strategies that were used to improve success rates in college algebra, students who were pursuing STEM or non-STEM related fields, and the implementation and effectiveness of a course in quantitative reasoning. I also focused on articles that are related to the following key variables: retention rates in mathematics, transfer rates, graduation rates, continuation rates, completion rates, and student success. I included a few studies related to the ACCUPLACER test scores.

Strategies to Improve Success Rates in College Algebra

Course redesign, the flipped classroom, the corequisite model, and the emporium model are four strategies that have been implemented widely to improve success rates in college algebra.

Course design. Research indicated that there are several approaches used to redesign college algebra to improve success rates in college algebra (Chiorescu, 2017; De Markus, 2018; Pinzon, Pinzon & Stackpole, 2016; Porter, Ofodile, & Carthon, 2015; Tunstall, 2018). One study of redesigning college algebra involved the use of cooperative learning, student presentations, writing assignments, bonuses, and quizzes (Porter et al., 2015). Active learning was the approach taken in an article by Pinzon et al. (2016), where students worked in small, structured groups on guided inquiry activities after watching short videos before class. A discussion of a portion of an in-class activity and the use of a writing project was incorporated in the redesigned course. De Markus (2018) examined the use of animations related to various concepts of algebra to determine if there was an impact on students' ability to learn college algebra. Chiorescu (2017) reported the adoption of open educational resources (OER) for college algebra, offered as a hybrid learning model used by one college instructor. Tunstall (2018) reported the use of a modified college algebra course that focused on modeling and problem-based learning. Although most of these studies indicated positive results using these redesigned methods as opposed to the traditional methods, one study indicated that the use of a reformed college algebra course was insufficient in developing students' quantitative literacy and for students who only plan to pursue a final mathematics course, the majority of the material is not relevant to their everyday lives (Tunstall, 2018). I attempted to conduct a study to support the recommendation by Tunstall (2018) regarding considering the place for college algebra at any institution.

Flipped classroom in mathematics. The flipped classroom is one in which homework is completed at school, and the classwork is completed at home. The flipped classroom approach provides learners the chance to obtain firsthand experience and exposure to materials outside of the classroom using technologies such as hardcopies, softcopies, videotapes or web-based lectures, and PowerPoint presentations with voice-over (Charles-Ogan & Williams, 2015). All the studies about using a flipped-classroom approach had positive results (Charles-Ogan & Williams, 2015; Jaster, 2017; McCallum, Schultz, Sellke, & Spartz, 2015; Schmidt & Ralph, 2016; Zengin, 2017).

Two studies regarding the use of the flipped classroom focused on increased in academic achievement (Charles-Ogan & Williams, 2015; Zengin, 2017), one study focused on perceptions of the flipped classroom (Jaster, 2017), and two studies focused on student engagement (McCallum et al., 2015; Schmidt & Ralph, 2016). Charles-Ogan and Williams (2015) reported that the students in the flipped classroom had a higher mean achievement gain in pretest-posttest scores than those in a conventional class. Although no significant difference was evident in the average achievement gain based on gender, both male and female students agreed that the flipped classroom provided them a chance to acquire firsthand experience. Jaster (2017) mentioned that students had mixed perceptions of a flipped classroom; however, their overall perceptions were generally positive. Zengin (2017) stated that the flipped classroom approach helped increase student achievement, and it heightened students' understanding and provided visualization in mathematics teaching. The flipped classroom promoted retention and made comprehension much easier. McCallum et al. (2015) indicated that student academic engagement was present by taking notes, viewing lecture videos, actively learning in class, and teamwork and from the students' perspective, peer-to-peer and student-faculty engagement was vital to rapport building, peer learning, and worthwhile connection with faculty. Schmidt and Ralph (2016) stated that the use of the flipped classroom does raise student engagement, increase team-based skills, offer individualized student guidance, focus on classroom discussion, and provide faculty choice.

However, using this approach should be done with caution. Some disadvantages are that many students lack the required technology at home, the flipped classroom was created from the traditional method of teaching and learning, and flipped homework is still homework, which interferes with a student's out-of-school time (Schmidt & Ralph, 2016). When implemented appropriately, the flipped classroom is an effective instructional strategy because it provides an assortment of content, activities, and videos that will have the students actively engaged in the learning.

Corequisite model for mathematics. The corequisite model involves concurrently enrolling students who place into remedial courses into both a developmental class and a college-level course, thus allowing students to learn from peers in the college-level course while receiving fundamental skills and support in their developmental courses (Hartman, 2018). Articles have mentioned how the use of a corequisite model can have an impact on student achievement (Belfield, Jenkins, & Lahr, 2016; Kashyap & Mathew, 2017). For example, Kashyap and Mathew (2017) concluded that student performance and perceptions were significantly higher when they completed the quantitative reasoning course under the corequisite model compared to the prerequisite and the stand-alone models. Belfield et al. (2016) revealed that the pass rates were higher in the fall 2014 and spring 2015 pilot implementation of corequisite math and writing remediation, at 63% and 67%, respectively. Both studies indicated that the use of the corequisite model could produce significant increases in student achievement and pass rates; however, implementing this model can pose challenges. For example, the inadequate buy-in among advisors, students, and faculty; issues with scheduling and advising logistics; limited preparations and support for model design and instruction; and, rapid speed of an uncertainty around state policymaking can hinder the implementation and success of the corequisite model (Daugherty, Gomez, Carew, Mendoza-Graf, & Miller, 2018). Adequate buy-in from all stakeholders, preparations, and support are necessary to make the corequisite model effective for improving student achievement.

Emporium model in mathematics. The emporium model is widely used on campuses across the United States for students who place into remedial mathematics courses. With the use of the emporium model, students do as many problems as necessary to become proficient in each concept under the supervision of an instructor or mentor, move at their own pace rather than that of a regular class, get one-on-one help with an instructor or mentor when they need it, and move rapidly through the material they already understand and concentrate on new material or concepts they have failed to master (Pierce, 2015).

Studies have indicated that the use of the emporium model can be an effective instructional method for students (Cousins-Cooper, Staley, Kim, & Luke, 2017; Hopf, Sears, Torres-Ayala, & Maher, 2015; Krupa, Webel, & McManus, 2015; Webel, Krupa, & McManus, 2015). Cousins-Cooper et al. (2017) mentioned that students who matriculated in the emporium classes performed better than students who matriculated in the traditional lecture classes on the posttest. Krupa et al. (2015) mentioned in a study that students in the emporium style group achieved better final exam scores and were more likely to satisfactorily complete the open-response tasks than students in the traditional group; however, students in the emporium group showed limited capabilities to interpret an equation and make connections to the contextual conditions as compared with the traditional lecture group. For both groups, students showed limited capabilities to write algebraic equations to represent contextual conditions. Webel et al. (2015) found students who successfully navigate an individualized program of instruction but also exhibit critical misconceptions about the structure and nature of the content they supposedly had learned. Hopf et al. (2015) mentioned that students enrolled in the redesigned course outperformed their traditional counterparts on the departmental final examination, and the failure rate was lower than students enrolled in the traditional classes. The use of the emporium model helped increase opportunities for students to take more ownership of their learning and regulate their time more efficiently.

Based on these studies mentioned, the emporium course can be a vehicle to improve students' performance in college algebra. These studies all compared the outcomes of students using an emporium model to the outcomes of students using the traditional face-to-face model. I presented course redesign in this literature review because various approaches of redesigning mathematics courses, both developmental and college-level, have been successful in improving success rates. Quantitative reasoning is another approach because it is a part of the Guided Pathways initiative, which has promise in boosting graduation rates and addressing the achievement gap for first-generation, low-income students (Gaze, 2018).

Students in STEM or non-STEM Related Fields

Researchers have published various studies regarding students who are pursuing STEM-related fields or non-STEM related fields (Gil-Doménech & Berbegal-Mirabent, 2017; Li & Payne, 2016; Mau, 2016; Salomone & Kling, 2017; Shin, Levy, & London, 2016; Su & Rounds, 2015; Wei et al., 2014). Students in STEM-related programs of study were twice as likely to transfer to a 4-year college from a 2-year college than their peers in non-STEM programs of study (Wei et al., 2014). Shin et al. (2016) stated that role model experience had positive outcomes on both STEM and non-STEM students' interests in STEM and it also had a beneficial impact on academic sense of belonging among STEM and non-STEM students as well as a beneficial impact on academic self-efficacy among STEM students, but not non-STEM students. Li and Payne (2016) indicated that STEM majors outperformed non-STEM majors on both pretests and posttests. There was only a slight difference between pretest averages and posttest averages for both STEM and non-STEM majors (Li & Payne, 2016). Students from non-STEM majors benefitted more from teaching with technology than those in STEM majors. Salomone and Kling (2017) mentioned that the group in which a mandatory comprehensive peer-cooperative learning system was implemented earned significantly higher grades in their initial courses in each major. The increase was related to an increase in the 2-year student retention rate among STEM majors (Salomone & Kling, 2017). The findings suggested that implementing a mandated peer-led cooperative learning system may have an impact on academic preparation in introductory STEM courses as well as leading to retention rates in STEM.

Implementing alternative activities can change student attitudes toward mathematics. Gil-Doménech and Berbegal-Mirabent (2017) mentioned that students in non-STEM programs tend to demonstrate negative thoughts towards mathematics-related courses, which typically leads to low student engagement if only using traditional lecture styles. The use of the game-based learning (GBL) activities helped students cooperate in teams, challenge ideas, and acquire a deep comprehension of the concepts; challenged the teams to obtain the correct answer as soon as possible, and become used to games making it simple for them to comprehend the fundamentals that characterize it.

Gender differences can have an impact on whether students pursue STEM-related or non-STEM related fields. Su and Rounds (2015) reported that the greatest difference by gender was among men who pursue engineering disciplines, whereas the greatest difference by gender was among women who pursue social sciences and medical fields. Mau (2016) indicated that there was a significant difference by gender and race when students enter, complete, and persist through the STEM channel. White students and male students are more likely to declare a STEM-related major than female students and minority students. Only a small number of female students and minorities would finish a STEM degree in 5 years. When completing a STEM-related major, the best predictors for persistence were high school grade point average, college grade point average, being a White male student, and the number of earned college credit hours within the first year. On the other hand, the predictors for students who are unlikely to persist are students who enter college for the first time, students who transfer from other institutions, and students who register for remediation courses. Students enrolled in STEM and non-STEM related fields can be impacted in various ways from success and attitudes towards mathematics-related courses, gender and racial differences, and a sense of belonging. This proposed study will only focus on students pursuing non-STEM related fields who are either enrolled in college algebra or quantitative reasoning.

Quantitative Reasoning

Researchers have published studies regarding the effectiveness of quantitative reasoning and the various ways that a course has been implemented and compared. The various methods are the flipped classroom approach (Todd & Wagaman, 2015), the hybrid approach (Piercey, 2017), and the project-based learning model (Tunstall & Bossé, 2016). Todd and Wagaman (2015) reported that students registered in a redesigned quantitative literacy course in which a flipped classroom was incorporated outperformed their peers who registered in the traditional course on a quantitative reasoning assessment. Piercey (2017) presented a hybrid quantitative reasoning/algebra two-course sequence that challenges the claim that QL and QR are less rigorous alternatives to algebra. The findings indicated that through using inquiry-based materials, students construct an understanding of algebra and develop the skills within the framework. The students' performance suggests that quantitative reasoning is a powerful framework for learning algebraic manipulations.

Tunstall and Bossé (2016) reported in their study that project-based learning in an online environment is a promising approach for strengthening the affective element of quantitative literacy in college algebra. Stump (2017) discussed a course called Quantitative Reasoning for Teachers, which was intended to assist graduate teacher education majors to expand their comprehension of quantitative reasoning, advance their skills in quantitative reasoning, and advance mastery and skills for teaching quantitative reasoning. The course materials and assignments were carefully selected so that the participants are introduced to the important ideas and new experiences. Both studies were qualitative in nature. Contrarily, this proposed study is quantitative.

Shaw (2015) presented a selection of problem types that have been used with some success to motivate the topics in a quantitative literacy class so that learners may begin doing mathematics with a period of discussion beforehand. The type of problems that the author mentioned is expected value, systems of linear equations, subsets, and operational efficiency. These types of problems are like the ones that could be applicable to this proposed study because these carefully selected complex problems would help students realize the relevance of the material taught in a quantitative reasoning class.

Retention Rates in Mathematics

Researchers have provided a few student-centered programs that have been implemented to determine if they have had an impact on student retention. Three studies reported no significant differences in retention (Cancado, Reisel, & Walker, 2018; Dula, Lampley, & Lampley, 2018; Graham & Lazari, 2018). Four studies reported significant differences in retention (Carver et al., 2017; Dagley, Georgiopoulos, Reece, & Young, 2016; Kimbark, Peters, & Richardson, 2016; Van Dyken, Benson, & Gerard, 2015). Cancado et al. (2018) reported no significant improvement in the odds of students being retained in engineering or graduating from engineering in comparison to students of similar abilities who did not participate in a summer bridge program. Dagley et al. (2016) reported that the EXCEL program in Florida had been successful at increasing the retention rates of its students in STEM. Carver et al. (2017) reported preliminary data that revealed at one university in Ohio, the retention of OpSTEM scholars was higher than the retention of other students and among STEM students. While the various programs yielded valid results, the effectiveness of them was mixed.

Researchers has indicated that course enrollment might have an impact on student retention. Kimbark et al. (2016) reported a statistically significant relationship between whether a student had taken a student success course and continued enrollment to the following semester. Sixty-eight percent of students who participated in the student success course was retained to the following fall term. Graham and Lazari (2018) reported no significant difference in retention when comparing students registering in an online section of college algebra to students registering in a traditional section of the same course. Both studies provided mixed results regarding retention based on course enrollment.

Researchers have evaluated retention among students enrolled in mathematics. Dula et al. (2018) revealed that when students were clustered by similar ACT mathematics sub-scores, no significant differences were found in 1-term and 2-term retention rates between students who enrolled in a learning support unit of probability and statistics and students who chose to take the traditional course. Van Dyken et al. (2015) wanted to determine what percentage of students were retained one year based on their first mathematics course. Both grade and course significantly predicted retention after one year; however, students earning lower grades in their initial mathematics course were less likely to stay in engineering majors, and women were less likely to be retained in engineering than men. Although these studies (Dula et al., 2018; Van Dyken et al., 2015) provided mixed results based on the evaluation of retention, students who earn passing grades were more likely to be retained.

Transfer Rates

Researchers have indicated the use of a logistic regression to identify factors that predict certain outcomes (Cohen & Kelly, 2019; Sheldon, 2009). Cohen and Kelly (2019) used binary logistic regression to determine significant independent variables contributing to successful outcomes (graduation or transfer) versus non-completion. Sheldon (2009) used a logistic regression to determine if student transfer to for-profit, 4-year colleges is a function of students' social background features, the students' academic experiences at the community college, and the transfer background of the community college attended. Both studies provided significant predictors for transfer. While one study cited course completion, course enrollment, and remediation as significant predictors (Cohen & Kelly, 2019), the other cited age, part-time enrollment, and grade point average as strong predictors for transfer (Sheldon, 2009).

Studies regarding transfer to 4-year institutions had mixed results. Wang, Chuang, and McCready (2017) stated that transfer students with an associate degree displayed no significant difference in bachelor's degree achievement, retention, or grade point average. On the other hand, Umbach, Tuchmayer, Clayton, and Smith (2019) revealed captivating insights in the relationship between the community college they attended, transfer students, the 4-year transfer college, and educational outcomes. Furthermore, transferring to a historically black college or university was positively related to grade point average, degree completion, and college persistence. Both studies used grade point average as a variable to determine the relationship with transferring, but the results were different.

Graduation

Various regression models have been used to predict graduation. Only one study reported no significant increase in graduation (Cancado et al., 2018) and three studies reported significant increases in graduation (Larson, Pesch, Surapaneni, Bonitz, & Wu, 2015; Laugerman, Rover, Shelley, & Mickelson, 2015; Millea, Wills, Elder, & Molina, 2018). Cancado et al. (2018) used logistic regression models to determine whether a summer bridge program had an impact on retention and graduation rates and found no significant improved odds of participants in a summer bridge program graduating from engineering compared to non-participants. Laugerman et al. (2015) used a boosted logistic regression to determine variables that had significant correlations with graduating in engineering and reported that overall grade point average and the amount of community college credits had significant effects on increasing the graduation rates in engineering. Millea et al. (2018) used probit regression models to identify contributors to success and reported that retention and graduation rates were higher for students who were academically prepared, acquired scholarships and grants, and were registered in small classes. Larson et al. (2015) used the binary logistic regression to investigate if self-efficacy in mathematics and science would predict graduation rates after finishing high school 4 to 8 years later and reported that self-efficacy in mathematics and science from the first semester at a university contributed to graduation status 4 to 8 years after finishing high school. Based on most of the research studies, high graduation rates and graduation can be considered a good predictor.

Continuation

Research on continuation has provided mixed results. Brinkerhoff and Sorensen (2015) reported that students who had taken Math Pass, a technology-enhanced acceleration remediation tool, made up a small but statistically significant percentage of overall students. Over 70% of the Math Pass students continued to take another mathematics course. On the other hand, Babes-Vroman, Tjang, and Nguyen (2018) reported that with students receiving at least a B, no significant difference was evident between ethnic groups in relations to continuation rates, but for students receiving a C or C+, African-American students had a more likelihood of continuing to enroll in the next computer science course at a 4-year program than White students. Daun-Barnett and St. John (2012) reported that policy changes in the secondary curriculum through stricter course requirements and compulsory exit examinations seem to increase the percentage of students who continue on to college if they do finish high school, even though the policies might hinder some students from finishing high school. The use of remediation tools, attaining a minimum passing grade, and implementing strict policies may have an impact on continuing to the next course or on to college.

Completion

Researchers have focused on completion rates through the evaluation of intervention programs and instructional methods (Childers et.al, 2019; Loes, An, & Pascarella, 2019; Prystowsky, Koch, & Baldwin, 2015). Childers et al. (2019) evaluated remediation efforts at a 4-year institution by describing redesign efforts that led to the implementation of co-requisite mathematics remediation. Prystowsky et al. (2015) reported the use of the Gateway to Completion (G2C) program as a means of helping institutions enhance student learning and success in difficult gateway courses. Loes et al. (2019) evaluated the exposure to clear and organized teaching to determine if it would lead to an increased level of satisfaction with college experience and better grades, thus leading to a greater likelihood of graduating from college. All studies about completion reported positive results from enrolling in the next gateway courses to better achievement in the subsequent course in a sequence.

Student Success

Researchers (Childers & Lu, 2017; Chiorescu, 2017; Lunsford, Poplin, & Pederson, 2018; Salomone & Kling, 2017) have reported on the use of various supplemental resources to help improve student success. Two studies (Childers & Lu, 2017; Chiorescu, 2017) reported no significant differences in student success. Two studies (Lunsford et al., 2018; Salomone & Kling, 2017) reported significant differences in student success. Chiorescu (2017) mentioned the replacement of traditional expensive learning resources with open educational resources as a means of determining if this change would have an impact on student success. Childers and Lu (2017) wanted to determine if students attained success in their college-level mathematics course after completing the Pre-Core program, a mastery-based computer learning environment used in developmental mathematics classrooms. Lunsford et al. (2018) mentioned the use of mandatory peer tutoring for students who were at risk of being unsuccessful in an introductory statistics course. Salomone and Kling (2017) examined student success through the implementation of a required, comprehensive peer-cooperative learning system in supported classes. The implementation of various supplemental resources to improve student success has produced mixed results, especially the use of the computer-based emporium model, which failed to produce successful results.

ACCUPLACER Test Scores

Researchers have recently published peer-reviewed articles (Copus & McKinney, 2016; James, 2006) dealt with ACCUPLACER placement test scores. Both studies focused on success in developmental mathematics courses. James (2006) reported a significant relationship between scores on the ACCUPLACER OnLine mathematics tests and students' grade point averages in developmental mathematics courses. Copus and McKinney (2016) reported that after completing an early intervention program, the pass rate of participants who scored in the bottom third on the ACCUPLACER exam was 65.6%. Based on these studies, the ACCUPLACER test scores seem to be valid predictors of student success in remedial mathematics courses.

Summary and Conclusions

In this literature review, I provided various strategies that have been effective in improving success rates in college algebra were presented. The researchers' results of studies about redesigned courses revealed that, when implemented effectively, positive results could be achieved compared to using a traditional lecture approach in teaching mathematics. Additionally, I have provided various studies regarding the key variables of this study. Less studied is whether the appropriate mathematics pathway for non-STEM students can be predicted based on retention, continuation, graduation, transfer-out, and course passage. Such is the topic of the present study.

What is also known in the literature is that unless alternative activities are implemented, students in non-STEM related fields will have negative attitudes towards mathematics-related courses and will less likely to participate. The quantitative reasoning course is a new pathway contains activities that are meaningful and will get students to be actively engaged in the learning. Many of the articles in this review of the literature indicate that quantitative reasoning or quantitative literacy is a course that does make mathematics relevant to real life. What I have investigated is whether the appropriate mathematics pathway for non-STEM students can predict the five selected criterion variables (retention, passage, continuation, graduation, and transfer).

Researchers has indicated the various ways that quantitative reasoning has been taught as well as the importance of the careful selection of topics that will help students view the relevancy of the material being taught. There is no research on whether the two mathematics pathways can quantitatively predict five success indicators regarding students in non-STEM related fields.

In Chapter 3, I provide the proposed setting, the details of the research design, and methodology of this study. I include the target population, the archival data collection, the operationalization of the variables, and the data analysis plan in the methodology section. I also provide the threats to validity and reliability and ethical procedures.

Chapter 3: Research Method

The purpose of this quantitative study was to determine if mathematics pathways (college algebra or quantitative reasoning) predicted non-STEM student mathematics success indicators such as course retention, course passage, continuation to one semester after mathematics course passage, graduation within 1 year, and transfer-out within one semester after mathematics course completion while controlling for preexisting knowledge. In this chapter, I provide the setting for this study, the research design, and rationale, the methodology which includes the target population and approximate size, the type of sampling and sampling procedures, archival data and how it is accessed, operationalization of constructs, the data analysis plan, threats to validity and reliability, and ethical procedures.

Setting

The setting for this study was an urban community college located in central Arkansas (CATC, a pseudonym). As of the Spring 2018 semester, this community college served about 5187 students at seven campus locations in central Arkansas, with 35.9% of the student population being male and 64.1% being female. The average age of students at this community college was 27 years old. About 40% of the college's student enrollment was full-time. The racial composition at CATC was 43.8% Caucasian, 50.1% African American, 0.2% Hispanic or Latino, and 15.9% other. While the student population has declined by 22% over the past 5 years, the student-teacher ratio of 33:1 has remained the same over the same time period. As of the Spring 2018 semester, 58% of students at CATC required at least one developmental course.

Research Design and Rationale

In this study, I used a quantitative predictive design as the methodological approach to predict mathematical pathways (college algebra or quantitative reasoning) based on retention, course passage, continuation, graduation, and transfer. The predictive research design is used "to identify variables that will predict an outcome or criterion" (Creswell, 2015, p. 342). The researcher identifies at least one predictor variable and a criterion variable (Creswell, 2015). A predictor variable is used to predict something occurring later and the criterion variable is the variable that is being predicted. A predictive study is similar to a correlational study, but the difference is that "the behavior or experience measured by the predictor variables occurs before the behaviors or experiences represented by the criterion variables" (Lodico, Spaulding, & Voegtle, 2010, p. 289).

For this study, the predictor variable was a dichotomous grouping variable indicating the mathematics pathway in two categories, college algebra or quantitative reasoning. The criterion variables for this study were also dichotomous and measured course retention, course passage, continuation, graduation, and transfer-out. The covariate for this study was the ACCUPLACER Elementary Algebra placement test scores.

Methodology

In the methodology section, I provide the target population for this study, the sampling procedures, the archival data and how they were accessed, instrumentation and operationalization of constructs, the data analysis plan, threats to validity, and ethical procedures.

Population

For this study, the target population was CATC community college students majoring in non-STEM programs who were enrolled in either college algebra or quantitative literacy at CATC during the 2018–2019 academic school year. For the academic year, the number in the population for students registered for college algebra was 1,050, and the population of students registered for quantitative reasoning was 450. These enrollments are based on students pursuing STEM-related programs and non-STEM related programs. The number of students enrolled in non-STEM related programs during the 2018–2019 academic year who were enrolled in a mathematics course was 1321 (810 students for the Fall 2018 semester and 511 students for the Spring 2018 semester).

Sample

For this study, I used a census as a sample. According to Lodico et al. (2010), census sampling is a “nonrandom sampling technique used in quantitative research” (p. 226). The researcher uses the entire realistic population in the study. A census may be used when either there are unlimited resources for the study, or the true population is not excessively large. Non-STEM majors will include business technology, digital media, information systems technology, and hospitality management (Gansemer-Topf et al., 2017). Non-STEM majors who were enrolled in either college algebra or quantitative reasoning and who took the ACCUPLACER Elementary Algebra placement test were included in this study. Students who pursued STEM-related fields of study and non-STEM students who took a math placement test other than the ACCUPLACER Elementary Algebra placement test were excluded. Because a non-random census of the population is being studied, power analysis to calculated sample size is irrelevant (Nayak, 2010).

Archival Data

I collected archival data from the institutional data archives located at CATC. ACCUPLACER Elementary Algebra placement test scores, retention in the course, completion of course, transfer, graduation, continuation, and success from both college algebra and quantitative reasoning were attributes of students obtained for this study.

To ensure access to the data set prior to proposing the study, I completed and submitted a research application to the director of institutional research, planning, and effectiveness at CATC for review. A letter of cooperation was returned by email allowing access to data for conducting this study at CATC. Conducting this study about CATC was contingent on providing evidence of approval from the Institutional Review Board at Walden University.

Instrumentation

In this section, I provide a description of instrumentation used to measure the covariate, ACCUPLACER mathematics test scores, along with the validity and reliability of the instrument.

ACCUPLACER Mathematics Test Scores. For this study, I used the Elementary Algebra placement test scores from the ACCUPLACER tests. Developed by

The College Board (2019a), ACCUPLACER is a series of computer-based assessments designed to provide information on students' reading, writing, and mathematical skills. For decades, ACCUPLACER has been used to determine if students have achieved the necessary preparation to enroll in college-level courses. Educators, counselors, and testing managers depend on the validity and quality of ACCUPLACER as they counsel and support students in their academic and career endeavors (The College Board, 2019b). Three mathematics tests are used to assign students in their appropriate mathematics classes properly. The Arithmetic test measures the student's capability to do simple mathematics and problem solving of basic math concepts. The student's ability to complete basic algebra and problem solving of algebraic concepts is measured by the ACCUPLACER Elementary Algebra test. The College-Level Math test measures the student's problem-solving skills that contain concepts found in college-level mathematics courses (The College Board, 2019a). Because ACCUPLACER tests was not be administered as a part of this study, the student scores on the Elemenatary Algebra section was used as a covariate and permission to use the instrument was not required.

Reliability of ACCUPLACER. Reliability refers to "the consistency of scores, that is, an instrument's ability to produce about the same score for an individual over repeated testing or across different raters" (Lodico et al., 2010, p. 95). The ACCUPLACER Online Technical Manual supplied estimates of the internal consistency of the ACCUPLACER test studied. The Arithmetic test and the Elementary Algebra test each had a reliability estimate of 0.92 and the College-Level Math test had a reliability estimate of 0.86 (Mattern & Packman, 2009).

Validity. Validity focuses on "ensuring that what the instrument claims to measure is truly what it is measuring" (Lodico et al., 2010, p. 96). Test validity and predictor validity are used when administering the ACCUPLACER tests. Test validity is defined as validating the use of a test in a specific context, like placement in a course (The College Board, 2015). A study by Mattern and Packman (2009) defended the placement validity of ACCUPLACER scores as a means for deciding the proper assignment of college courses for students. Their study supported a moderate-to-strong association between test scores and successive course performance. The percentage of students appropriately placed was high, thus supporting for the validity of ACCUPLACER test scores for placement purposes.

Predictor validity is the effectiveness of an instrument to predict the outcome of future behavior (Rovai, Baker, & Ponton, 2014). A study by James (2006) mentioned that the Arithmetic and Elementary Algebra test scores of the ACCUPLACER assessments seem to be valid predictors of student success in remedial mathematics courses. Mattern and Packman (2009) supported that the results indicated a considerable correlation between scores on placement tests and success in a course after correlations for statistical artifacts of range restriction, unreliability, and measurement error were conducted.

Operationalization of Constructs

In this section, I explain how the covariate, the ACCUPLACER Elementary Algebra placement test scores, the criterion variables (course retention, course passage, continuation, graduation, and transfer-out), and the predictor variable (mathematics pathway) were measured or manipulated. Additionally, I explain how each variable was calculated and what each variable represented.

Predictor variable. For this study, the predictor variable, mathematics pathway, was dichotomous, indicating the two levels, either the college algebra or quantitative reasoning pathway. A dichotomous level of measurement was employed as a means of classifying who was enrolled in one of the two gateway math courses (Lund Research, 2018b). For this study, a 0 was assigned to the student enrolled in college algebra and a 1 was assigned to the student enrolled in quantitative reasoning.

Criterion variables. The five criterion variables for this study were also dichotomous. In this section, I explain how each of the five criterion variables were operationalized in this study.

***Course retention*.** Course retention was operationalized as either the student was retained or not retained to the end of the course of the mathematical pathway. For this study, a 0 was assigned to the student who did not retain in the course and a 1 was assigned to the student who did retain in the course. Course retention was operationalized as having not withdrawn (W) and received any grade (A through F) in the class.

***Course passage*.** Course passage was operationalized as either the student had completed and passed the course (grades A through D) or completed and failed the course (grade of F). A dichotomous level of measurement was employed as a means of identifying each student's course completion status. For this study, a 0 was assigned to the student who completed but failed or withdrew from the course and a 1 was assigned to the student who completed and passed the course.

Transfer-out. Transfer-out was defined as a student having transferred from CATC to another post-secondary institution. This variable was operationalized as either the student did transfer from CATC to another institution or the student did not transfer within the subsequent term after having taken the mathematics pathway class. A dichotomous level of measurement was employed as a means of identifying each student's transfer status. For this study, a 0 was assigned to students who did not transfer and a 1 was assigned to students who did transfer from CATC to another post-secondary institution.

Graduation. Graduation was operationalized as either the student graduated from CATC or the student did not graduate from CATC within one year after the mathematics class was taken. A dichotomous level of measurement was employed to identify each student's graduation status. For this study, a 0 was assigned to students who did not graduate from CATC the term following enrollment in a mathematics pathway course, and a 1 was assigned to students who did graduate from CATC.

Continuation. Continuation was operationalized as either the student did continue his or her studies at CATC, or the student did not continue. A dichotomous level of measurement was employed to identify each student's continuation status. For this study, a 0 was assigned to the student who did not continue his or her studies at CATC, and a 1 was assigned to the student who continued at CATC.

Covariate. For this study, the covariate was the ACCUPLACER Elementary Algebra placement test scores. The ACCUPLACER Elementary Algebra placement tests are scored in a range between 20 to 120. These scores may determine if the student is prepared for a college-level course or would benefit from a developmental course (The College Board, 2016). ACCUPLACER scores represent a continuous and interval level of measurement because the reference point on test scores is not an absolute zero (Bhat, 2019).

Data Analysis Plan

I assumed that data acquired from CATC were accurate. Individual cases that contain missing data values for all criterion variables were excluded. Any data values that were outside the range of usual values for the covariate and for the criterion variables were excluded. After screening and cleaning data, I recoded the data. IBM SPSS (version 25) was used as the statistical software to test hypotheses and inform research questions.

I investigated one research question with five hypotheses to achieve the purpose of determining if the two mathematics pathways predicted the five criterion student outcomes variables.

RQ: Controlling for placement scores, does mathematics pathways (college algebra or quantitative reasoning) predict student success?

$H_0$1*:* Controlling for placement scores, mathematics pathway does not predict retention in course among non-STEM majors.

$H_1$1*:* Controlling for placement scores, mathematics pathway does predict retention in course among non-STEM majors.

$H_0$2*:* Controlling for placement scores, mathematics pathway does not predict course passage among non-STEM students.

$H_1$2*:* Controlling for placement scores, mathematics pathway does predict course passage among non-STEM students.

$H_0$3*:* Controlling for placement scores, mathematics pathway does not predict continuation among non-STEM students.

$H_1$3*:* Controlling for placement scores, mathematics pathway does predict continuation among non-STEM students.

$H_0$4*:* Controlling for placement scores, mathematics pathway does not predict graduation among non-STEM students.

$H_1$4*:* Controlling for placement scores, mathematics pathway does predict graduation among non-STEM students.

$H_0$5*:* Controlling for placement scores, mathematics pathway does not predict transferring-out among non-STEM students.

$H_1$5*:* Controlling for placement scores, mathematics pathway does predict transferring-out among non-STEM students.

Data analysis. To address the research question and the 5 hypotheses, I conducted binomial logistic regression analyses for this study. The binomial logistic regression is "a nonparametric procedure that describes or predicts membership in two mutually exclusive groups from a set of predictors" (Rovai et al., 2014, p. 389). In a binomial logistic regression, the dependent variable is categorical, and the independent variables may be continuous, categorical, or both. For this study, the predictor variable (mathematics pathways with two levels) was the categorical variable and the criterion variables (course retention, course passage, continuation, graduation, and transfer-out) were classified as categorical variables as they are dichotomous. I chose the binomial procedure because the procedure permits analyses of bivariate models with covariates.

In this study, I used a covariate to account for prior knowledge (Penn State Eberly College of Science, 2018). According to Creswell (2015), by introducing a covariate, the explained variance increases, and the total amount of unexplained variability decreases because the researcher explains more variance. For this study, I introduced the ACCUPLACER Elementary Algebra placement test scores as the covariate. By doing this, I can increase the amount of explained variance from the placement test scores and decrease the unexplained variance.

The results from this study is reported in Chapter 4, which contains the null hypotheses being evaluated, descriptive statistics, and regression models for the research question. Four assumptions related to the option of study design and measurements that were chosen were considered when using a binomial logistic regression. The first assumption is that there is one variable that is dependent and dichotomous. The second assumption is that there is at least one independent variable that is measured on either a continuous or nominal scale. The third assumption is that the study should contain observations that are independent, and the categories of the dichotomous dependent variable and all nominal independent variables should be exhaustive and mutually exclusive. The fourth assumption is that there should be at least 15 cases for each independent variable (Lund Research, 2018a).

Model fit is assessed using the Hosmer and Lemeshow goodness of fit test**.** The Nagelkerke R Square values are interpreted to understand how much variability in the criterion variable can be explained by the model, the effect size. The level of significance for model fit and variable odds ratios are set at .05, *a priori*. Odds ratios are presented for each criterion variable (Lund Research, 2018a).

Threats to Validity

Construct validity. Construct validity is referred to as "the degree to which inferences can be made from the operationalizations in a study to the theoretical constructs on which those operationalizations are based" (Rovai et al., 2014, p. 45). Validity for the covariate, ACCUPLACER Elementary Algebra scores, is presented in another section. The threat of construct validity for other variables is low because of the dichotomous nature of the variables. Students either remained in the course or not, passed the course or did not, continued or did not continue to the next term, graduated in the term after they took the mathematics pathway class or did not, and transferred out (or not). All of these success indicators are standard in the field of higher education (National Center for Education Statistics, 2019). Course retention was measured as not withdrawing from the class, as is typical in higher education (Frank, 2019). Passage was measured as students having earned a grade of A, B, C, or D, as is typical in higher education (Childers et al., 2019). Continuation was measured as still being enrolled at the college of study a term after enrollment in the mathematics pathway course. Term to term retention (continuance) is a standard measure of retention in higher education. Transfer-out was measured as students from the cohort who are known to have transferred out of the reporting institution the term subsequent to their enrolling in the mathematics pathway course. Transfers are typically not measured as a retained student for the institution, but for this study, transfer was considered a success for the individual student (Frank, 2019). Graduation is a typical success indicator in higher education, even though success goes beyond earning a postsecondary credential (Stout, 2018). For this study, graduation was considered a success for the individual student.

Reliability. The reliability of data is threatened by random data entry error and recoding error. This threat of data entry error is mitigated by the fact that data used for this study was also data reported to the Arkansas Division of Higher Education and to the Integrated Postsecondary Education Data System (IPEDS). To mitigate the error of recoding, I calculate frequency distributions of data by variable both before and after recoding variables and compare distributions for possible discrepancies.

Statistical conclusion validity. Statistical conclusion validity is defined as a measure of how valid the experimental conclusion is. Conclusion validity can tell the investigator how valid that conclusion is (Glen, 2015). According to Trochim (2006b), a threat to conclusion validity can influence the investigator to make an invalid conclusion about an association in the observations. Two types of errors can occur regarding relationships. One is to make a conclusion that no relationship exists when there actually is, and the other is to make a conclusion that a relationship exists when there actually is not. Trochim (2006a) recommended that having good implementation, good reliability, and good statistical power will help improve statistical content validity. Because this study used census sampling, the assumption was that the statistical conclusion validity was strong for the research question and 5 hypotheses.

Ethical Procedures

Measures were taken to protect human rights from harm in compliance with the National Institute of Health (NIH) guidelines and as stipulated by the policies and procedures at Walden University. A letter of cooperation was received from CATC by email stating that I was allowed access to conduct this study at their institution. The institutional effectiveness office at CATC retrieved student data from their student information system database. The letter of cooperation indicated that no personally identifiable information was provided. As indicated in the letter of cooperation, the data collection instrument will be maintained in a locked file cabinet and will be destroyed after one year of obtaining it. Formal consent to obtain data was obtained through the Institutional Review Board (IRB) process, as stipulated by Walden University (IRB Approval # 02-11-20-0610172).

Providing anonymity means that either the study does not gather identifying information of each research participant, or the study cannot connect individual answers with the identity of each participant (Rovai et al., 2014). For this study, I examined archival data that was de-identified. I assigned numbers (student 1, student 2, and so on) to individual student records so that no records of individual student name, student number, or social security number were included in the data analysis. Since de-identified archival data was analyzed and no student interactions occurred, permissions from students or parents were not necessary.

For this study, my role during the research was strictly that of a researcher. I am currently employed as a lead instructor in the mathematics department at a community college in northeast Arkansas. I had no personal contact with the faculty, staff, and administration at CATC. CATC permitted the research solely as the cooperating partner and their interest was the results on whether the five selected variables predicted the appropriate mathematics pathway.

Summary

In this chapter, I have provided the research design and rationale for this study. The methodology, which included the target population and sampling and sampling procedures were discussed. The use of archival data and how it was accessed were explained. I also explained how each variable for this study was measured or manipulated in the operationalization of constructs section. The data analysis plan included the use of the binomial logistic regression and how the results are interpreted. Threats to validity were also discussed. Ethical procedures, including the appropriate permissions and the anonymity and confidentiality of the data, were discussed. In Chapter 4, I provide a discussion the analysis of the data that was collected, the results of the study, and a summary.

Chapter 4: Results

The purpose of this quantitative study was to determine if mathematics pathways (college algebra or quantitative reasoning) predicted non-STEM student mathematics success indicators such as course retention, course passage, continuation to one semester after mathematics course passage, graduation within 1 year, and transfer-out within 1 semester after mathematics course completion while controlling for preexisting knowledge. To achieve this purpose, I have posed one research question and tested five hypotheses.

RQ: Controlling for placement scores, does mathematics pathways (college algebra or quantitative reasoning) predict student success?

$H_0 1$: Controlling for placement scores, mathematics pathway does not predict retention in course among non-STEM majors.

$H_1 1$: Controlling for placement scores, mathematics pathway does predict retention in course among non-STEM majors.

$H_0 2$: Controlling for placement scores, mathematics pathway does not predict course passage among non-STEM students.

$H_1 2$: Controlling for placement scores, mathematics pathway does predict course passage among non-STEM students.

$H_0 3$: Controlling for placement scores, mathematics pathway does not predict continuation among non-STEM students.

$H_1 3$: Controlling for placement scores, mathematics pathway does predict continuation among non-STEM students.

$H_0 4$: Controlling for placement scores, mathematics pathway does not predict graduation among non-STEM students.

$H_1 4$: Controlling for placement scores, mathematics pathway does predict graduation among non-STEM students.

$H_0 5$: Controlling for placement scores, mathematics pathway does not predict transferring-out among non-STEM students.

$H_1 5$: Controlling for placement scores, mathematics pathway does predict transferring-out among non-STEM students.

In this chapter, I present how data were collected for this study, including the time frame. I present the descriptive characteristics of the sample. Results of the study include descriptive statistics of variables used to test hypotheses and inferential statistical analyses to test hypotheses. I present the results of hypotheses testing for each of five hypotheses posed. I present the appropriate tables for this study. I provide a summary of this Chapter to address the primary research question based on results of hypotheses tests.

Data Collection

In this study, I used deidentified student data that were archival and came from the director of institutional research, planning, and effectiveness at CATC. I obtained the data set after receiving IRB approval from Walden University. The original data set contained 1,988 non-STEM student records from the Fall 2018, Spring 2019, and Fall 2019 academic semesters. The original data set also contained records of non-STEM students who took various placement tests including the ACCUPLACER Elementary Algebra test, the ACT test, and the Compass Math test, and who were enrolled in a variety of math courses. For this study, I used only data from the Fall 2018 and Spring 2019 academic semesters. Additionally, I only included in the filtered data set non-STEM students who took the ACCUPLACER Elementary Algebra placement test and who were enrolled in either college algebra or quantitative reasoning. After filtering data based on the requirements for inclusion in this study, the sample size was 138 non-STEM student records. The census of students meeting criterion consisted of 76 (55.1%) students enrolled in college algebra and 62 (44.9%) students enrolled in quantitative reasoning. The sorted raw data was coded and was imported from Microsoft Excel into IBM SPSS version 25. I computed descriptive statistics and then performed binary logistic regression analyses for five criterion variables. IBM SPSS output and data files were then saved in password protected files for reference.

Data Analysis

The census of 138 student records consisted of 76 non-STEM students enrolled in college algebra and 62 non-STEM students enrolled in quantitative reasoning for the 2018–2019 academic year. In terms of semester and course breakdown, more students were enrolled in college algebra for the Fall 2018 semester (n = 45, 32.6%) and the Spring 2019 semester (n = 31, 22.5%) than the number of students enrolled in quantitative reasoning for the Fall 2018 (n = 38; 27.5%) and Spring 2019 (n = 24; 17.4%) semesters. In terms of the five criterion variables, the majority of students were in the categories of those who retained in the course (n = 128, 92.8%), passed the course (n = 107, 77.5%), continued to next semester (n = 101, 73.2%), did not graduate (n = 122, 88.4%), and did not transfer (n = 133, 96.4%).

In terms of the ACCUPLACER Elementary Algebra test, the covariate, college algebra students had a higher mean test score (*M* = 55.05, *SD* = 26.42) than the quantitative reasoning students (*M* = 34.84, *SD* = 18.45). However, the minimum ACCUPLACER Elementary Algebra test score was the same for both pathways (*Min* = 21) during the academic year, while the maximum test score was higher for students enrolled in quantitative reasoning (*Max* = 119) than for the students enrolled in college algebra (*Max* = 113). In terms of semester breakdown, the college algebra students had a slightly higher mean test for the Fall 2018 semester (*M* = 57.09, *SD* = 28.05) than in the Spring 2019 semester (*M* = 52.10, *SD* = 24.01), but the quantitative reasoning students had a slightly lower mean test score for the Fall 2018 semester (*M* = 34.32, *SD* = 19.91) than in the Spring 2019 semester (*M* = 35.67, *SD* = 16.25). Table 1 presents frequencies and percentages of the predictor variable. Table 2 presents frequencies and percentages of criterion variables. Table 3 presents the ranges, means, and standard deviations of the covariate for the 2018 – 2019 academic year. Table 4 presents the ranges, means, and standard deviations of the covariate by semester.

Table 1

Frequencies and Percentages of Predictor Variable

Variable	Frequency	Percent
College Algebra		
Fall 2018	45	32.6%
Spring 2019	31	22.5%
Quantitative Reasoning		
Fall 2018	38	27.5%
Spring 2019	24	17.4%

Table 2

Frequencies and Percentages of Criterion Variables 2018 – 2019

Variable	Frequency	Percent
Course retention		
not retained	10	7.2%
retained	128	92.8%
Course passage		
failed	31	22.5%
passed	107	77.5%
Continuation		
did not continue	37	26.8%
did continue	101	73.2%
Graduation		
did not graduate	122	88.4%
did graduate	16	11.6%
Transfer		
not transferred	133	96.4%
transferred	5	3.6%

Table 3

Descriptive Statistics of Covariate, ACCUPLACER Elementary Algebra Test Scores, 2018-2019

Math Pathway	*n*	Min	Max	*M*	*SD*
College Algebra	76	21.00	113.00	55.05	26.42
Quantitative Reasoning	62	21.00	119.00	34.84	18.45

Table 4

Descriptive Statistics of Covariate, ACCUPLACER Elementary Algebra Test Scores, Fall 2018 and Spring 2019 Semesters

	Fall 2018					Spring 2019				
Math Pathway	*n*	Min	Max	*M*	*SD*	*n*	Min	Max	*M*	*SD*
College Algebra	45	21.00	113.00	57.09	28.05	31	22.00	107.00	52.10	24.01
Quantitative Reasoning	38	21.00	119.00	34.32	19.91	24	21.00	83.00	35.67	16.25

Results

In order to answer the research question in this study, I performed a binary logistic regression for each null hypothesis being tested. This analysis was appropriate because according to Rovai et al. (2014), the predictor variable and the criterion variables were both categorical. The criterion variables were course retention, course passage, continuation, graduation, and transfer. The predictor variable was the mathematical pathway in two categories: college algebra and quantitative reasoning. Five binary logistic regression analyses were performed with the same predictor variable, mathematics pathway and the covariate, ACCUPLACER Elementary Algebra test scores. Prior to conducting the binomial logistic regression analyses, the predictor and criterion variables satisfied the four assumptions required for using binomial logistic regression (Lund Research, 2018a). The five criterion variables were dichotomous. The ACCUPLACER Elementary Algebra test scores, used as a covariate, were measured on a continuous scale. Observations were independent of each other. Categories of the dichotomous criterion variables and the predictor variable were mutually exclusive and exhaustive. The study contained a minimum of 15 cases for each category of the mathematical pathway (college algebra and quantitative reasoning).

The main research question for this study was: Controlling for placement scores, does mathematics pathways (college algebra or quantitative reasoning) predict student success? I tested the five hypotheses and provided the results for each of these five hypotheses in separate subsections.

Hypothesis 1

The first null and alternative hypotheses that I addressed in this study were:

> $H_0$1*:* Controlling for placement scores, mathematics pathway does not predict retention in course among non-STEM majors.
>
> $H_1$1*:* Controlling for placement scores, mathematics pathway does predict retention in course among non-STEM majors.

To test the first null hypothesis, I performed a binary logistic regression to determine the effect of mathematics pathway on the likelihood that students retain in the course. The logistic regression model was not statistically significant (χ^2 = 8.123, *p* = .520). The model explained 1.6% (Nagelkerke R^2) of the variance in course retention and correctly classified 92.8% of all cases. Enrollment in mathematics pathway was associated with an increased likelihood of course retention [Exp(B) = 1.588, 95% CI (.388, 6.496)]. The results of the binary logistic regression were not significant indicating that the predictor variable, mathematics course, did not significantly predict course retention. Thus, I failed to reject the first null hypothesis. Table 5 presents the Hosmer and Lemeshow test for the criterion variable, course retention. Table 6 presents the results of the binary logistic regression predicting course retention.

Table 5

Hosmer and Lemeshow Test for Course Retention

Chi-square	df	Sig.
8.123	8	0.422

Table 6

Results of the Binary Logistic Regression Predicting Course Retention

	B	S.E.	Wald	df	Sig.	Exp(B)
Math Pathway (1)	0.463	0.719	0.414	1	0.52	1.588
APL Elem Alg	0.013	0.016	0.714	1	0.398	1.014
Constant	1.765	0.873	4.084	1	0.043	5.843

Hypothesis 2

The second null and alternative hypotheses that I addressed in this study were:

> $H_0 2$: Controlling for placement scores, mathematics pathway does not predict course passage among non-STEM students.
>
> $H_1 2$: Controlling for placement scores, mathematics pathway does predict course passage among non-STEM students.

To test the second null hypothesis for the research question, I performed a binary logistic regression to determine the effect of mathematics pathway on the likelihood that students pass the course. The logistic regression model was not statistically significant ($\chi^2 = 7.656$, $p = .932$). The model explained 0.9% (Nagelkere R^2) of the variance in course passage and correctly classified 77.5% of all cases. An increase in enrollment in mathematics pathway was associated with a reduction in the likelihood of passing the course [Exp(B) = .963, 95% CI (.402, 6.496)]. The results of the binary logistic regression were not significant indicating that the predictor variable did not significantly predict course passage. Thus, I failed to reject the second null hypothesis. Table 7 presents the Hosmer and Lemeshow test for the criterion variable, course passage. Table 8 presents the results of the binary logistic regression predicting course passage.

Table 7

Hosmer and Lemeshow Test for Course Passage

Chi-square	df	Sig.
7.656	8	0.468

Table 8

Results of the Binary Logistic Regression Predicting Course Passage

	B	S.E.	Wald	df	Sig.	Exp(B)
Math Pathway(1)	-0.038	0.445	0.007	1	0.932	0.963
APL Elem Alg	0.007	0.009	0.607	1	0.436	1.007
Constant	0.93	0.565	2.708	1	0.1	2.534

Hypothesis 3

The third null and alternative hypotheses that I addressed in this study were:

$H_0$3*:* Controlling for placement scores, mathematics pathway does not predict continuation among non-STEM students.

$H_1$3*:* Controlling for placement scores, mathematics pathway does predict continuation among non-STEM students.

To test the third null hypothesis for the research question, I performed a binary logistic regression to determine the effect of mathematics pathway on the likelihood that students did continue to the following semester. The logistic regression model was not statistically significant (χ^2 = 12.018, p = .427, = .009). The model explained 0.9%

(Nagelkerke R^2) of the variance in continuation and correctly classified 73.2% of all cases. An increase in enrollment in mathematics pathway was associated with a reduction in the likelihood of continuation [Exp(B) = .713, 95% CI (.310, 1.641)]. The results of the binary logistic regression were not significant indicating that the predictor variable did not significantly predict continuation. Thus, I failed to reject the third null hypothesis. Table 9 presents the Hosmer and Lemeshow test for the criterion variable, continuation. Table 10 presents the results of the binary logistic regression predicting continuation.

Table 9

Hosmer and Lemeshow Test for Continuation

Chi-square	df	Sig.
12.018	8	0.15

Table 10

Results of the Binary Logistic Regression Predicting Continuation

	B	S.E.	Wald	df	Sig.	Exp(B)
Math Pathway(1)	-0.338	0.425	0.631	1	0.427	0.713
APL Elem Alg	-0.006	0.008	0.595	1	0.44	0.994
Constant	1.456	0.542	7.219	1	0.007	4.29

Hypothesis 4

The fourth null and alternative hypotheses that I addressed in this study were:

$H_0$4*:* Controlling for placement scores, mathematics pathway does not predict graduation among non-STEM students.

$H_1$4: Controlling for placement scores, mathematics pathway does predict graduation among non-STEM students.

To test the fourth null hypothesis for the research question, I performed a binary logistic regression to determine the effect of mathematics pathway on the likelihood that students graduated. The logistic regression model was not statistically significant (χ^2 = 8.312, p = .976). The model explained 0.1% (Nagelkerke R^2) of the variance in graduation and correctly classified 88.4% of all cases. An increase enrollment in mathematics pathway was associated with an increase in the likelihood of graduation [Exp(B) = 1.017, 95% CI (.323, 3.210)]. The results of the binary logistic regression were not significant indicating that the predictor variable did not significantly predict graduation. Thus, I failed to reject the fourth null hypothesis. Table 11 presents the Hosmer and Lemeshow test for the criterion variable, graduation. Table 12 presents the results of the binary logistic regression predicting graduation.

Table 11

Hosmer and Lemeshow Test for Graduation

Chi-square	df	Sig.
8.312	8	0.404

Table 12

Results of the Binary Logistic Regression Predicting Graduation

	B	S.E.	Wald	df	Sig.	Exp(B)
Math Pathway(1)	0.017	0.586	0.001	1	0.976	1.017
APL Elem Alg	0.003	0.011	0.094	1	0.759	1.003
Constant	-2.2	0.731	9.05	1	0.003	0.111

Hypothesis 5

The fifth null and alternative hypotheses that I addressed in this study were:

$H_0$5*:* Controlling for placement scores, mathematics pathway does not predict transferring-out among non-STEM students.

$H_1$5*:* Controlling for placement scores, mathematics pathway does predict transferring-out among non-STEM students.

To test the fifth null hypothesis for the research question, I performed a binary logistic regression to determine the effect of mathematics pathway on the likelihood that students transfer. The logistic regression model was not statistically significant (χ^2 = 11.30, p = .254,). The model explained 4.2% (Nagelkerke R^2) of the variance in transfer and correctly classified 96.4% of all cases. An increase in enrollment in the mathematics pathway was associated with a reduction in the likelihood of transfer [Exp(B) = .259, 95% CI (.025, 2.643)]. The results of the binary logistic regression were not significant indicating that the predictor variable did not significantly predict transfer. Thus, I failed to reject the fifth null hypothesis. Table 13 presents the Hosmer and Lemeshow test for the criterion variable, transfer. Table 14 presents the results of the binary logistic regression predicting transfer.

Table 13

Hosmer and Lemeshow Test for Transfer

Chi-square	df	Sig.
11.298	8	0.185

Table 14

Results of the Binary Logistic Regression Predicting Transfer

	B	S.E.	Wald	df	Sig.	Exp(B)
Math Pathway(1)	-1.351	1.185	1.299	1	0.254	0.259
APL Elem Alg	-0.007	0.019	0.123	1	0.726	0.993
Constant	-2.53	1.116	5.141	1	0.023	0.08

Summary

For this quantitative study, I performed a binary logistic regression to investigate if mathematical pathways (college algebra or quantitative reasoning) predicted five criterion variables (course retention, course passage, continuation, graduation, and transfer) while controlling for ACCUPLACER Elementary Algebra test scores. I analyzed a census sample of 138 non-STEM student records using IBM SPSS version 25. Based on the results for each binary logistic regression, I failed to reject the null hypothesis for each of the five criterion variables. Based on the results, I concluded that mathematics pathways do not predict any of the five criterion variables after controlling for preexisting knowledge. In Chapter 5, I provide an interpretation of the findings, the limitations of the study, recommendations for further research, and implications for positive social change.

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this quantitative predictive study was to determine if mathematics pathways (college algebra or quantitative reasoning) predicted non-STEM student mathematics success indicators such as course, retention, course passage, continuation to one semester after mathematics course passage, graduation with 1 year, and transfer-out within one semester after mathematics course completion while controlling for preexisting knowledge. The covariate for this study was the ACCUPLACER Elementary Algebra test scores of non-STEM students. Because I used a predictive design, I used binary logistic regression analyses to achieve the purpose and to answer the research question and test the five null hypotheses. The study was necessary to conduct because it might inform the problem of the low passing rate of college algebra and the need for an alternative gateway mathematics course. The offering of different mathematics pathways might improve the progress of college students through their course sequence and toward graduation.

The research question posed for this study was: Controlling for placement scores, does mathematics pathways (college algebra or quantitative reasoning) predict student success? Based on the binary linear regression analyses, I failed to reject any of the five null hypotheses; the mathematics pathways did not predict course retention, course passage, continuation, graduation, or transfer. In this chapter, I provide the interpretation of the findings, limitations of the study, recommendations for future research, implications for social change, and a conclusion.

Interpretation of the Findings

Little understanding exists on whether different mathematics pathways predict non-STEM student mathematics success indicators. In recent years, researchers have published studies regarding the effectiveness of quantitative reasoning (Pierce, 2015; Piercey, 2017; Stump, 2017; Todd & Wagaman, 2015; Tunstall & Bossé, 2016). However, this study is the first predictive study that I know of in a community college setting. This research was necessary to fill the gap in practice. The research question focused on whether the mathematics pathways predict the five non-STEM student mathematics success indicators while controlling for preexisting knowledge.

The results from the first hypothesis test indicated that mathematics pathways did not predict course retention despite 128 students (92.8%) of the sample size being retained in the course. The results are a contradiction of a study by Van Dyken et al. (2015) in which student's first mathematics course, along with grade, predicted retention, except for students with low grades who were less likely to retain in engineering majors. The results also contradicted a study by Kimbark et al. (2016) in which a significant relationship was evident between a student enrolled in a student success course and retention. However, the results support another study where no significant differences in retention between students enrolled in a mathematics course with a learning support unit and students in the same mathematics course (Dula et al., 2018).

The results from the second hypothesis test indicated that mathematics pathways did not predict course passage despite that 107 students (77.5%) from the sample size completed and passed the course. The results were a contradiction of a study where two variables, ACT math score and high school GPA, were significant predictors of achieving at least a grade of C in a similar quantitative reasoning course (Morrison & Schmit, 2010).

The results from the third hypothesis test indicated the mathematics pathways did not predict continuation despite that 101 students (73.2%) from the sample size would continue to one semester after passing their mathematics course. A study from Babes-Vroman et al. (2018) was included because this was the only available study that was related to retention based on ethnicity. The results would add support to the study where no significant differences were evident between ethnic groups in relation to continuation rates (Babes-Vroman et al., 2018). However, another study revealed that seven out of 10 students continued to take another mathematics course after using a technology-enhanced acceleration remediation tool (Brinkerhoff & Sorensen, 2015).

The results from the fourth hypothesis test indicated that mathematics pathways did not predict graduation which supports that 16 students (11.6%) of the sample size graduated. The percentage is less than the 21% of full-time, first-time students at CATC who graduated within three years to completion (National Center for Education Statistics, 2018). The results of the fourth hypothesis contradict a study by Cohen and Kelly (2019) indicating that students who complete mathematics courses were almost six times more likely to graduate and students who did not require mathematics remediation were almost twice as likely to graduate.

The results from the fifth hypothesis indicated that mathematics pathways did not predict transfer, which supports that 133 students (96.4%) from the sample size did not transfer. The small percentage of students who did transfer (n = 5, 3.6%) is in line with the three-year transfer-out rate of 14% for CATC (National Center for Educational Statistics, 2018). The results of the fifth hypothesis from this study contradicted a study by Cohen and Kelly (2019) concluding that course completion, course enrollment, and remediation were significant predictors of transfer. Additionally, Sheldon (2009) cited age, part-time enrollment, and grade point average were strong predictors of transfer.

The findings to the research question conflicted with Holland's personal-environment fit theory. The theory was created so that students have the opportunity to choose majors or careers that would provide them the best chance to succeed in the future. Porter and Umbach (2006) cited research suggesting that congruence between the individual and the environment is important to the success of the college student and that it is associated with advanced levels of the educational stability, satisfaction, and achievement. The findings of this study were based on controlling for the ACCUPLACER Elementary Algebra test scores. Dula, et al. (2018) conducted a study on undergraduate retention rates while controlling for ACT Mathematics test scores with no significant differences. The results of this study failed to predict success; however, it does have its limitations that might have produced the findings.

Limitations of the Study

The first limitation of this study was that the target population was from a single community college. While other community colleges in Arkansas offered both college algebra and quantitative reasoning, CATC offered more sections of quantitative reasoning so that an adequate sample size could be obtained. The second limitation of this study was that it focused only on two mathematics pathways: college algebra and quantitative reasoning. Other course pathways are also available to students, such as: applied technical mathematics, business calculus, and introduction to statistics and probability. Those were not examined in this study. The third limitation of this study was that the timeframe was restricted to the Fall 2018 and Spring 2019 semesters, even though I was provided data for three semesters including the Fall 2019 semester. The fourth limitation was that the ACCUPLACER Elementary Algebra test scores were used as a covariate. The original data set contained records of students who took the ACT Math test, the SAT Math test, and the COMPASS Algebra test. Other test scores indicating previous knowledge could be tested individually or somehow combined for a more reliable indicator of prior knowledge.

The fifth limitation was that quantitative reasoning was first implemented in the Fall 2018 semester. I was informed that quantitative reasoning was offered to students for the first time and the mathematics department was fine-tuning the curriculum (director of institutional research, planning, and effectiveness, personal communication, February 14, 2019). The final limitation was that I used a census as a sample. Lodico et al. (2010) recommended that the entire population should be sampled if fewer than 200 individuals make up the population. While a census can be used to obtain data from one community college, the results cannot be generalized to other community colleges (Lodico et al., 2010).

Recommendations

Future studies may explore the research questions using a different sampling approach. Lodico et al. (2010) recommended to use a sample size large enough to fully represent the population from which it was drawn so results can be generalized back to the entire population. Other studies may explore the research question used in this study by using a covariate, like the ACT Math test scores, the COMPASS Algebra test scores, or the ACCUPLACER Next Generation Arithmetic test scores. The study may be conducted without the use of a covariate. The mathematics pathways may have predicted one or more of the five success indicators if a covariate had not been used. This study might be explored by using mixed-methods or qualitative approaches. Interviews with students enrolled in college algebra and quantitative reasoning may provide perceptions and perspectives of the course content. Additionally, this study may be replicated by analyzing student records over a longer period of time, preferably at least two academic years. Finally, this study may be replicated by determining whether the mathematics pathways predict the five selected success indicators at more than one community college. By using more than one community college, the results may be generalized to other community colleges in the state or country that offer a course in quantitative reasoning.

Implications

I conducted his study to determine if mathematics pathways predicted success indicators like course retention, course passage, continuation, graduation, and transfer. The findings may have an impact for positive social change because they help fill the gap in literature about practice. The findings may also have an impact for positive social change because they can help in identifying students who have taken prior mathematics courses and investigate the specific factors or skills that contribute to current success (O'Connell et al., 2018). According to Schwartz (2014), providing an alternative course, like quantitative reasoning, would be of greater benefit for students not pursuing STEM related majors.

Although the results of this particular study, which was limited to one community college, did not find a predictive relationship between mathematics pathways five success indicators, positive social change might occur if postsecondary institutions implement mathematics pathways for their students. The Charles A. Dana Center (2016) mentioned that students are three times more likely to be successful in rigorous, challenging, and relevant courses that are part of well-designed mathematics pathways. A significant positive impact on student success might occur if mathematics pathways are implemented at the institutional and state levels through the alignment of mathematics courses to the students' programs of study. Additionally, students should be allowed to enter into college-level courses quickly (The Charles A. Dana Center, 2016).

Conclusion

In this quantitative predictive study, I determined whether mathematics pathways (college algebra or quantitative reasoning) predicted student success indicators, like course retention, course passage, continuation, graduation, and transfer, while controlling for preexisting knowledge. In this study, I used a census of 138 student records consisting of students who were enrolled in college algebra or quantitative reasoning and who took the ACCUPLACER Elementary Algebra test. I presented descriptive statistics that are relevant to this study. I conducted binary logistic regression analyses to test five hypotheses posed in this study and to inform the research question about whether mathematics pathways predicted the five student success indicators. I failed to reject each of the five null hypotheses based on statistical analyses; therefore, I conclude the mathematics pathways did not predict the five success indicators. Past researchers had indicated that the five success indicators used in this study were good predictors. Results may differ in other community colleges. This study was limited to one community college in central Arkansas.

This study also failed to support Holland's personal-environment fit theory, which posits that congruence of the individual and the environment is associated with advanced levels of education stability, satisfaction, and achievement (Porter et al., 2015). Even though results indicated that mathematics pathways did not predict the success indicators that I used in this study, mathematics pathways may still improve success by addressing the two drivers of the problem: the mismatch of the content and long multi-semester course sequences (The Charles A. Dana Center, 2016).

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