2018

The Effectiveness of the Co-Requisite Model in Preparing College Students for Math Courses

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The Effectiveness of the Co-Requisite Model in Preparing College Students for Math Courses

by

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A DISSERTATION

Presented to the Faculty of

The College of Education and Human Services

Department of Educational Studies, Leadership, and Counseling

at Murray State University

In Partial Fulfillment of Requirements

For the Degree of Doctor of Education

P-20 & Community Leadership

Specialization: STEM

Under the supervision of Professor Dr. Mardis Dunham

Murray, KY

June 2018

Abstract

Some form of academic support for underprepared students at the post-secondary level has been around since the 17th century. This academic support has had several names such as tutoring, remediation and developmental education. With the growing need for academic support at the post-secondary level, universities are developing various ways to provide support to their students.

The focus of this study was the Co-requisite Model, particularly within Murray State University's mathematics courses. Following IRB approval, archival data from undergraduate students were collected over three semesters in College Algebra and one semester in Mathematical Concepts courses. The pass rates of students in co-requisite sections were compared to those students who took the developmental course first. Data from five follow-up courses of College Algebra were collected as well to determine any differences in pass rates between the two groups.

The findings of this study show there was a significant ($p < .001$) difference in pass rates between the students in the co-requisite section of College Algebra compared to students who took the developmental course first. There was insufficient data to determine any significant difference between students who took the co-requisite section of Mathematical Concepts and students who took the developmental course first. Only one follow-up College Algebra course had enough data to show any significance ($p = .20$). In the one follow-up course, there was no difference in pass rates between the two groups of students.

Acknowledgements

I could not have finished this degree without the support of my family and friends. I would first like to thank my family, especially my husband Dale and our son Allen. Without their support I would not be where I am today. In addition I want to thank my parents, my sister and her family and my in-laws. Also, thank you to my friends and colleagues. Your support throughout this journey of mine has not gone unnoticed or unappreciated.

The faculty within the Educational Doctoral Degree program has also attributed to the success of my completion. I especially want to thank my advisors Dr. Randal Wilson and Dr. Teresa Clark for their guidance throughout the program. Along with Dr. Mardis Dunham and Dr. Ed Thome for their support on my dissertation.

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CHAPTER ONE: INTRODUCTION

Ideally, students graduate high school ready for the next phase of their life. Whether that is college, military or going directly into the workforce, students rely on their high school education for preparation for post-secondary training or for their career. However, for students entering post-secondary institutions, most are not college-ready (Boylan & White, 1987; Higbee & Dwinell, 1996; Bailey, 2009b). For example, 61% of entering college students have weak academic skills and need to enroll in a developmental course (Bailey, 2009b). Therefore, around 78% of post-secondary institutions have a developmental program to help these underprepared students (Boylan & White, 1987; Brothen & Wambach, 2004).

A large number of students have been underprepared for post-secondary institutions since the 17th century where the first developmental education efforts were labeled as tutoring (Cafarella, 2014). By the late 19th century, over 80% of post-secondary institutions had implemented some type of developmental education program (Brier, 1986). This is due to a combination of factors, including the fact that post-secondary institutions are admitting first generation college students, academically underprepared students and adult students either returning to college or attending for their first time (Arendale, 2002). In the mid to late 20th century, the term developmental education became widely known and used compared to other terms such as remedial or learning assistance (Cafarella, 2014). However, the terms developmental and remedial are still used interchangeably.

With the expansion of developmental education, research began on what makes developmental education programs successful and effective. This research revealed several factors that contribute to success. One significant factor was the recruitment and hiring of developmental faculty (Smittle, 2003). Other factors that characterize successful programs

include a variety of teaching methods, theory-based courses, computer-based instruction, strategic learning for comprehension and thinking strategically, developmental course exit exams and professional training for developmental faculty (Boylan & Bonham, 1998). The Kellogg Institute for the Training and Certification of Developmental Educators was the first professional development and certificate program available for developmental faculty (Cafarella, 2014). Effective teaching is considered to be one of the most challenging jobs for developmental educators (Smittle, 2003).

The growth of developmental education resulted in an increase in research designed to refine what contributes to the effectiveness (or ineffectiveness) of developmental education. Recent research from Complete College America revealed that only 10% of students who take three levels of developmental mathematics courses complete a gateway, or the first credit-bearing, mathematics course within a two year time frame (Vandal, 2014b). Complete College America is a national nonprofit organization established to work with states to help increase the number of students with career certificates and college degrees by closing the gap for underrepresented populations (Complete College America, 2014). Students at post-secondary institutions have paid in excess of $333 million in remediation costs (Vandal, 2014b). Others have reported that 74% of students who take a developmental course during their first year are more likely to drop out of college compared to non-developmental students (Schak et al., 2017). Understandably, these disappointing findings have gained the attention of state legislators and college administration leaders (Cafarella, 2014). Several states are now restricting funding to post-secondary institutions for developmental education prompting college administrators to minimize or eliminate their developmental education programs (Cafarella, 2014).

Due to pressure on developmental education, alternate methods to help underprepared students for gateway courses are surfacing. For example, some post-secondary institutions are simply renaming their developmental courses, while others are re-numbering their developmental courses to have them blend in with other first year courses (Arendale, 2002). In Kentucky, the Council on Post-secondary Education (CPE) is focusing first on developmental mathematics since it has three courses students need to complete compared to two courses for developmental reading and one course of developmental English.

To date, there are a least eight different methods designed to meet the needs of students who are required to take developmental mathematics courses. One method currently being examined is Multiple Assessments. There are several placement exams post-secondary institutions accept. A report mentions instead of offering and accepting a variety of placement exams, the student's high school performance should also be taken into consideration (Vandal, 2014a).

Post-secondary institutions are also offering Supplemental Instruction programs, accelerated courses and summer programs as alternate methods to serve their students. McDaniel and Zerger (2004) created a manual explaining Supplemental Instruction so other post-secondary institutions can implement this method at their universities. Supplemental Instruction is characterized by peer-led review sessions of selected general education courses. These are organized sessions that help students be successful in the general education course. Offering accelerated courses give students the opportunity to move through their needed developmental courses in fewer semesters (Cafarella, 2016). Summer programs offer students an advantage to begin their required developmental courses starting the summer just prior to their freshman year (Borgaonkar, Kam, Vandermark & Hou, 2015).

High school collaboration is also being recognized as an alternate method for developmental education. Programs for high schools seniors permit college administrators the ability to evaluate student preparedness for college-level work and identify which skills students are lacking. These programs are offered by both high schools and post-secondary institutions staff (Schak et al., 2017). The intent is to decrease the number of students needing developmental education once they enter a post-secondary institution.

Learning Centers are also starting to develop and expand at post-secondary institutions (Wurtz, 2015). Learning Centers offer a variety of services for students such as tutoring, study skill workshops, support for classroom instruction, assessment strategies and learning strategies. These centers are often setting specific because they need to incorporate the needs for their students, which can vary across post-secondary institutions; therefore services offered at one post-secondary institution may not be offered at another post-secondary institution.

Another method that is currently receiving a lot of attention in Kentucky is Math Pathways. Because not all majors require the same mathematics course, each program needs to decide what mathematics courses are needed for their major (Couturier & Cullinane, 2015). This redesign causes faculty to redesign the curriculum, although the purpose is to better serve students.

The eighth method and the one which is receiving the most attention is the Co-requisite Model (Vandal, 2014b). The Co-requisite Model has several versions being implemented at post-secondary institutions, although they have one main similarity. Students do not take their developmental course as a pre-requisite for their gateway course. Rather, they learn the material for the developmental course at the same time they are enrolled in their gateway course. As part of a new college completion strategy, 22 states signed a commitment to the White House to

increase gateway course completion for underprepared students within their first academic year (Vandal, 2014b).

With all this attention on changing developmental education, some research indicates that changes to current developmental education programs can be positive but that eliminating developmental education completely is not (Goudas & Boylan, 2012). Most research shows that developmental education is not effective because underprepared students are not outperforming non-developmental students once they enroll in gateway courses (Goudas & Boylan, 2012). However, Goudas and Boylan (2012) argue that the purpose of developmental education is not to have developmental students outperform non-developmental students, but to get students up to the same level in that subject area as the non-developmental students before taking the required gateway course.

Purpose of the Study

As four-year universities are pressured to end traditional remediation (Brothen & Wambach, 2004), new models of remediating students have been and are continuing to be developed. One such model is the Co-requisite Model. Complete College America (2014) explains that the Co-requisite Model requires the student to be enrolled in a remedial course and a college-level course of the same subject simultaneously. Currently, Murray State University is offering a variation of the Co-requisite Model within the Department of Mathematics and Statistics. Instead of a student being enrolled in a remedial course and a college-level gateway course at the same time, students are enrolled in special sections of the college-level gateway course that meets more hours per week than the other sections. Therefore, one purpose of this study was to determine if the students enrolled in the co-requisite sections of College Algebra, as implemented at Murray State University, were as successful as the students in the regular

sections of College Algebra who took the pre-requisite developmental course first. Even though success in College Algebra is important, it is equally important for students to be successful in any follow-up courses that they take after College Algebra. Therefore the second purpose of this study was to determine if the students enrolled in the co-requisite sections of College Algebra were as successful in any of the follow-up courses as the students who took the pre-requisite developmental course before taking College Algebra. Yet, a third purpose of this study was to determine if the students enrolled in the co-requisite sections of Mathematical Concepts were as successful as the students in the regular sections of Mathematical Concepts who took the pre-requisite developmental course first.

Research Questions

This study compared the pass rates of those students in the co-requisite sections of College Algebra to the pass rates of those students who took Intermediate Algebra before enrolling in the regular section of College Algebra. Next this study compares pass rates of the follow-up courses between the students who were enrolled in the co-requisite sections of College Algebra and the students who took Intermediate Algebra before enrolling in the regular section of College Algebra. Lastly, this study compares the pass rates of students in the co-requisite sections of Mathematical Concepts to those students who took Introductory Algebra before enrolling in Mathematical Concepts. Specifically, the following questions will be answered:

Q1. Are there statistically significant differences between the pass rates of students in the co-requisite sections of College Algebra compared to students in College Algebra who took Intermediate Algebra first?

Q2. Are there statistically significant differences between the pass rates of both groups of students in the College Algebra follow-up courses?

Q3. Are there statistically significant differences between the pass rates of both groups of students in Mathematical Concepts?

Limited research was found stating that students taking developmental courses should not do better than non-developmental students but instead developmental courses should get students up to the same point academically as non-developmental students (Goudas & Boylan, 2012). Therefore if a developmental student does not take their needed developmental course, they may not be at the same point academically as non-developmental students.

Significance of the Study

Traditional developmental education is changing at post-secondary institutions. In Kentucky, the Council on Post-secondary Education has taken an interest in changing traditional developmental education at post-secondary institutions as a result of Senate Bill 1. Changing and improving education is the main focus of Senate Bill 1.

The CPE met with representatives from post-secondary institutions to discuss implementing the Co-requisite Model into mathematics courses. A two-year pilot of co-requisite mathematics courses was proposed and agreed upon. Post-secondary institutions also agreed to collect a range of data and report back to the CPE during regular meetings throughout the two year pilot period. With some resistance from the post-secondary institutions about the change and the cost, CPE provided a grant from Senate Bill 1. Post-secondary institutions were also allowed to implement co-requisite mathematics courses that best fit their institution. This meant that post-secondary institutions could modify the Co-requisite Model defined by Complete College America (2014).

Murray State University modified the Co-requisite Model due to staffing and funding. Instead of students enrolling into both a developmental mathematics course and a college-level

gateway mathematics course simultaneously, students enrolled into a special section of the college-level gateway course. Within this special section, the developmental coursework is taught as needed with the college-level coursework rather than taught separately.

With the above rationale, the significance of this study therefore is to satisfy the CPE requirements of the two year pilot program which stems from the Senate Bill 1. These requirements include providing co-requisite courses and analyzing the data collected. This study was designed to determine if students in the co-requisite sections of their mathematics course were successful. In addition, this study sought to determine if students are successful in their required follow-up course. These findings will then be reported back to CPE. From the findings, Murray State University will decide if co-requisite mathematics courses are beneficial to students, if any changes are needed to these courses and if these course will continue at Murray State University.

Terms and Definitions

Co-requisite – When a developmental course is taken simultaneously with a college-level course (Boylan, 1999). For this study co-requisite also means a special college-level course that contains work from both the developmental course and the gateway course.

College-Level Course – A post-secondary course that offers credit towards a college credential (Miller & Morgan, 1997). For this study college-level course and gateway course will be used interchangeably.

Cut-off Score – The score given on placement tests to determine course enrollment (Boylan, 2011). For this study the cut-off score on the math subtest of the ACT for College Algebra is 21 and Mathematical Concepts is 19. On the SAT test, the math subtest score for College Algebra is 550 and for Mathematical Concepts is 500. On the KYOTE Readiness test,

the score for College Algebra is 27 and the score for Mathematical Concepts is 22. On the KYOTE College Algebra test, the score for College Algebra is 14. On the COMPASS test, the score for College Algebra is 50 and the score for Mathematical Concepts is 36.

Developmental Education – Courses taken at a post-secondary institution to help students bring their skills up to college-level without earning course credit. The term 'developmental' and 'remedial' are often used interchangeably (Bautsch, 2013). For this study developmental education refers to courses students take before their gateway course.

Gateway Course – College credit bearing lower division courses measured by the high number of students enrolled (John N. Gardner Institute, 2017). For this study the gateway course is College Algebra and the Liberal Arts mathematics course, Mathematical Concepts.

Remedial Education - Courses taken at a post-secondary institution to help students bring their skills up to college-level without earning course credit. The term 'remedial' and 'developmental' are often used interchangeably (Bautsch, 2013). For this study the tern developmental education will primarily be used.

Summary

Developmental Education has gained attention over the years due to 61% of students entering post-secondary institutions needing developmental education (Bailey, 2009b). However by post-secondary institutions spending around $5,000 more per developmental student, graduation rates will double (Goudas, 2016). This chapter introduced the different methods post-secondary institutions are implementing due to reduced state-level funding provided to developmental education programs. Due to the fact that 22 states have signed a commitment with Complete College America to increase gateway course completion, the Co-requisite Model is the method receiving the most attention (Vandal, 2014b). However, not all research supports

the Co-requisite Model of providing the preparation needed for underprepared students. Chapter two will provide more detail regarding the need for providing developmental education followed by a comprehensive examination of all the alternate methods.

CHAPTER TWO: LITERATURE REVIEW

History of Developmental Education

Post-secondary institutions began serving underprepared students in the 17th century when Harvard was established. At that time, mainly privileged white males preparing for the clergy attended Harvard (Arendale, 2002). However, some Harvard students were underprepared for post-secondary studies probably because instruction and textbooks were written in Latin, which was the European model of education (Cafarella, 2014). Because so many Harvard students could not read or understand Latin, Harvard provided these students with tutors (Cafarella, 2014). Tutors would spend their entire day with the student guiding and mentoring them (Cafarella, 2014). Usually tutors were young men who had already graduated with their baccalaureate's degree and were preparing to enter the ministry (Cafarella, 2014).

With the election of Andrew Jackson as president in the 19th century, enrollment at post-secondary institutions started to increase because of the growth of the middle class and all levels of education provided to citizens, especially higher education (Boylan & White Jr, 1987). At that time, there were no established entrance requirements for post-secondary institutions (Cafarella, 2014); essentially anyone who could afford an education was admitted (Boylan & White Jr, 1987). However, this led to an influx of underprepared students in post-secondary institutions and as enrollments grew, there were not enough tutors for the high demand of underprepared students as the number of men entering the clergy diminished (Cafarella, 2014).

In 1849, the University of Wisconsin established the first college preparatory program in the nation (Boyle & White Jr, 1987). This program offered reading, writing and arithmetic to students who were not academically ready for college courses. College preparatory programs

provided courses to focus on skills students should already possess when entering post-secondary institutions, therefore, the term remedial education was coined (Arendale, 2005). Within 40 years of the first established preparatory program at the University of Wisconsin, more than 80% of post-secondary institutions were offering college preparatory programs (Boyle &White Jr, 1987). Some post-secondary institutions held their college preparatory program on campus while others held their college preparatory program off campus in the community which eventually lead to the establishment of junior or community colleges (Arendale, 2002).

By 1940, post-secondary institutions offered fewer college preparatory courses because the junior college, or community college, was established (Cafarella, 2014). Junior colleges are 2-year institutions aimed at remediating underprepared students before they enroll at a 4-year institution (Arendale, 2002). With enrollment in both 2-year and 4-year institutions increasing, the placement test was developed in 1959 (Arendale, 2002). Now, institutions would know which students need remedial courses.

In the mid-20th century, Learning Assistance Centers were introduced (Arendale 2005). Learning Assistance Centers offer programs to all students who needed intensive work on reading skills, study skills or preparing for professional exams. Attendance in Learning Assistance Centers was voluntary. Some Learning Assistance Centers offered help to community members as well as local school districts. The Learning Assistance Center was more of a development center as it helped people develop their weaker skills. They introduced alternative ways of delivering instruction, such as audio tapes, video tapes, self-instruction and computer assisted programs. Later, some Learning Assistance Centers also assisted faculty via faculty development programs.

By the end of the 20th century, one focus in education turned to student development rather than just remediation of weak skills (Cafarella, 2014) and institutions changed their remedial education programs to developmental education (Arendale, 2005). As Arendale (2005) explains, remedial education focuses only on specific skills students are lacking whereas developmental education focuses on a more comprehensive development of the student academically. The change from remedial education to developmental education gave developmental education recognition that it was an academic discipline and this recognition ushered in the development of the National Center for Developmental Education (NCDE) (Cafarella, 2014). The NCDE established the Kellogg Institute for the Training and Certification of Developmental Educators which provided the first professional development opportunities for developmental educators. In addition, the NCDE launched two professional journals, the *Journal of Developmental Education* and *Research in Developmental Education*. Grambling State University in Louisiana offered the first doctoral program in developmental education (Cafarella, 2014).

However, with all the new changes surrounding developmental education researchers were starting to determine its efficacy. Some opinions were that course sequences were too long (Cafarella, 2014), and that developmental education was the same as remedial education (Arendale, 2005). Additionally, some found that students taking remedial courses had a lower graduation rate than students who did not take remedial courses (Brothen & Wambach, 2004). Critics of developmental education argued that taxpayers should not have to pay for students to learn material a second time around when students should have already learned the material before enrolling into post-secondary institutions (Bahr, 2008). Because of this, some states

started restricting funding to 4-year institutions for developmental education and this caused 4-year institutions to rethink their developmental programs (Cafarella, 2014).

Reasons for Under-Preparation

With 78% of post-secondary institutions offering some type of developmental education (Koch, Slate, & Moore, 2012), this poses the question of why so many students are entering post-secondary institutions underprepared. More than two-thirds of students need developmental courses (Bailey, 2009a; Koch et al., 2012). Essentially, researchers indicate that many students entering post-secondary institutions have weak academic skills and therefore need developmental education courses (Smittle, 2003; Bailey, 2009a).

One reason students do not possess the skills needed for rigorous college courses is that they have not taken the appropriate courses in high school or just have not learned and understood the material (Bailey, 2009a). Another reason for weak academic skills is that students have been out of school for several years and have not continued to use the skills needed for a college course (Bailey, 2009a). Yet, some students lack the confidence in their academic performance (Koch, et. al., 2012). In general, developmental students have needs that are unique to them which results in a classroom full of diverse learners (Young & Ley, 2003).

Of the three developmental subjects (writing, reading and mathematics) mathematics is the subject where most students are weakest (Koch et. al., 2012). Bailey (2009a) reports that 68% of students needing developmental writing pass their class, while 71% of students needing developmental reading pass. However, only 30% of students needing developmental mathematics pass all of the developmental mathematics courses required for their program.

Currently college readiness is defined by a score students receive from a standardized test (Barnes, Slate, & Rojas-LeBouef, 2010). If a student scores below a certain cut-off number on

the test, they are then placed into the appropriate developmental course. Studies indicate that more than just one standardized test score should represent college readiness and that study skills and maturity along with cognitive reasoning skills, academic knowledge and contextual skills (Conley, 2008; Barnes et. al., 2010) should be factors when considering if a student is college ready and if the student needs developmental courses.

College Efforts to Meet the Needs

In order for institutions to continue or receive state funds, college administrators began essentially disguising them. For example, some 4-year institutions simply renaming their developmental education courses (Arendale, 2005), while others refined their placement tests (Brothen & Wambach, 2004). Still, some 4-year universities re-numbered their developmental course so these courses count as a general elective for graduation requirements (Arendale, 2005).

Besides just disguising developmental education, some post-secondary institutions began creating new ways or programs for underprepared students to be successful in a college-level course. A review of the literature revealed eight programs or options post-secondary institutions are implementing to meet the needs of underprepared students. One new program institutions are implementing are Mathematics Pathways for students to receive credit for the mathematics course needed for their major (Courturier & Cullinane, 2015). Next, some institutions are refining their placement tests with some even offering multiple placement tests (Saxon & Morante, 2015). A third program some institutions are developing is Supplemental Instruction (SI), which is a support class for high-risk courses instead of courses for at-risk students (Brothen & Wambach, 2004). A fourth option institutions are offering is an accelerated developmental course so students can move more quickly into the college-level courses needed (Cafarella, 2016). A fifth approach some post-secondary institutions are implementing is

summer programs for underprepared students (Borgaonkar et al., 2015) and still other institutions are working with local high schools to prepare students (Schak, Metzger, Bass, McCann, & English, 2017). Next, some institutions are providing advising and other support services and are restructuring how they help all students (Wurtz, 2015). The eighth program and focus of this study is the co-requisite mathematics program offered at Murray State University.

Math Pathways

At most post-secondary institutions, after finishing the developmental mathematics course (when required) students enroll in College Algebra. After successful completion of College Algebra, some students then enroll in the required mathematics course for their major. However, the problem with this is College Algebra prepares students for Calculus and not any of the other mathematics courses that students are required for their major (Courturier & Cullinane, 2015). Yet, students must pass College Algebra before enrolling in the mathematics course that is required for their major. However, this is not the case at Murray State University unless College Algebra is a needed prerequisite for that course.

The New Mathways Project at The University of Texas at Austin is a redesign in the sequence of mathematics courses (Courturier & Cullinane, 2015). This redesign helps students move successfully through any developmental mathematic courses and the required gateway mathematics course needed for their major. The principle behind the New Mathways Project is to align required mathematics courses to majors. Not all majors need students to study the material in College Algebra. Some majors only require students to have a statistics course, while other majors require students to have a general concept mathematics course. The required mathematics course needed for these majors matches the mathematics required in the field. By

eliminating College Algebra from these majors, students can successfully move through their mathematics requirements in less time.

The New Mathways Project suggests three different mathematics pathways (Courturier & Cullinane, 2015). The first pathway is statistical reasoning and is for majors where a statistics course is all the mathematics that is required for students. The second pathway is a quantitative reasoning pathway. This pathway is for majors where mathematics is not the primary focus. Instead, students learn a variety of different mathematics skills. The third pathway is a STEM-Prep pathway. This pathway prepares students for Calculus. The STEM-Prep pathway also prepares students in technical majors where strong algebraic skills are necessary. However, not all post-secondary institutions have mathematics pathways set for their students.

As the Montana Task Force (2015) noted, not all students need College Algebra. These students should take a mathematics course that pertains to their major and the mathematics they will use in their career. Brother and Wambach (2004) explain how the developmental mathematics course should align to the mathematics courses required for each major. For example, an art major does not require College Algebra. Therefore, there is a need for different levels of developmental mathematics courses to instruct what level of material students need to acquire. By offering mathematics pathways, students are able to move more quickly through developmental mathematics and into their required gateway mathematics course. In addition, students complete mathematics courses at a higher success rate when they take the pathway they need for their major (Courturier & Cullinane, 2015). However, when students change their major, as they often do, they may have to start at the beginning of a different mathematics pathway resulting in more time completing their required mathematics courses.

Murray State University already has mathematics pathways in their curriculum. However, instead of three pathways, Murray State University offers five mathematics pathways. After the second level of developmental mathematics, Introductory Algebra, either students enroll in the third level of developmental mathematics, Intermediate Algebra, or they enroll in the quantitative reasoning gateway course, Mathematical Concepts. This quantitative reasoning course is a terminal course for many majors. For students who enroll in the third level of developmental mathematics, there are four mathematical pathways to choose from depending on their major. The first pathway to choose from is for students majoring in teaching. There are two levels of Teaching Mathematics for Elementary and Middle School majors. The second pathway to choose from is for students in a technical major. There are three levels of technical mathematics courses offered. Not all technical majors require all three levels. Many technical majors require the first two levels. The third pathway is College Algebra. This may be a terminal class for some majors like Agriculture Science, Public and Community Health, and Elementary Education, but it is also the pathway for business students and students needing Calculus. The fourth pathway to choose from is Statistics. This pathway is for students who need a statistics course. It is also a terminal course for many majors such as Criminal Justice, Sociology, and Geoscience.

The redesign of mathematics pathways and the New Mathways Project is working well at many institutions, such as colleges in California, Texas, Nevada, Colorado, Montana, Missouri, Indiana, Ohio, and Georgia. According to the Texas Higher Education Coordinating Board with the implementation of mathematics pathways, 30% of students with developmental requirements completed a gateway mathematics course within one year compared to previous 4% student completion (Courturier & Cullinane, 2015).

Multiple Assessments

Multiple measures to assess students regarding course placement is becoming more popular (Saxon & Morante, 2015). Post-secondary institutions take the scores from student's entrance exams to place them in a mathematics course. If scores are below a criterion, then that student enrolls in a developmental course. For example, at Murray State University if a student scores below 18 on the mathematics subtest of the American College Test (ACT), then that student must enroll in a developmental course. However, Murray State University accepts several placement tests (such as the ACT, SAT, KYOTE, COMPASS, ACCUPLACER, and the ALEKS) and the highest score from each test determines which course students need to enroll. Therefore, a student can submit other placement tests rather than just their entrance exam. This allows students the opportunity to take other tests in case they did not meet the cut off score on the ACT exam. Scores for all subjects do not have to come from the same test either. For example, if a student meets the English benchmark score on one test but not the mathematics benchmark score, then the English score will be used but not the mathematics score. Then on a second test, if the student meets the mathematics benchmark score, then the mathematics score from the second test will be used. In this case, the student will not need to take an English or a mathematics developmental course. Because there are so many different placement exams students can choose from, some schools are mandating one placement exam for all of their entering students (Saxon & Morante, 2015).

Many also argue that placement tests just show deficient skills of students and not a student's potential for success (Brothen & Wambach, 2004; Vandal, 2014a; Saxon & Morante, 2015). As a result, Vandal (2014a) noted that many states are also incorporating student's high school GPA along with their transcript and their placement test scores to determine the need for a

developmental mathematics course. Schak et al., (2017) state post-secondary institutions should also consider the number of years since the student's high school graduation as a determining factor for student success. The goal of using multiple assessments is to determine student's academic goals, motivation, and effort along with the student's academic skills for their success (Joint Statement, 2012). When combining all of these factors together to determine the correct course placement for a student, faculty advising is very crucial. Faculty advisors will need to sit with each student individually to process all of the given information and advise each student correctly into the appropriate courses. By having more information about each student, faculty advisors can guide students more effectively about the student's career choice. Faculty advisors can use the student's strengths and weaknesses to advise students into an appropriate major (Joint Statement, 2012). This requires great planning, staffing and resources and some post-secondary institutions are not able to offer multiple assessment approaches (Saxon & Morante, 2015).

Basing a student's future only on one test score, while discounting any other information is challenging to justify (Brothen & Wambach, 2004). Research suggests that post-secondary institutions offer pre-test preparation to help students recall material they may be struggling with in English, reading and mathematics (Schak et al., 2017). This gives students the opportunity to retest often. The more often students test, the more reliable and valid their placement scores are in determining which level, if any, developmental course students should enroll in (Brothen & Wambach, 2004; Schak et al., 2017).

Research shows that multiple placement testing alone is not a good indicator of student success in developmental courses (Courturier & Cullinane, 2015). However, including other factors such as high school GPA, motivation, life experiences, prior learning, and outside of

school obligations are better indicators of student success. Many institutions are including more of these factors along with placement testing to determine if a student should start in a developmental course (Courturier & Cullinane, 2015).

Supplemental Instruction

Supplemental Instruction is an approach to help increase student's academic performance in difficult academic courses (Arendale, 1994). Difficult courses are defined as courses having 30% or higher failure rate (Arendale, 1994). Supplemental Instruction sessions regularly are scheduled outside of the class time and are peer-led.

Even though the University of Missouri at Kansas City created Supplemental Instruction in 1973, it has been more popular over the last 15 years or so (McDaniel & Zerger, 2004). Supplemental Instruction consists of review sessions conducted by peers, not faculty, for selected classes. The Supplemental Instruction Leader organizes these review sessions. The leaders are peers who have attended training and have already taken the class receiving a high grade. The leader attends each class session and takes notes. From this, the leader can construct review sessions that are beneficial to other students. Leaders do not re-lecture or give away their notes; instead, they help students become better note takers and learners. Leaders prepare activities for students to work together and learn useful study strategies. Supplemental Instruction sessions are helpful in case a student has part of their notes missing or if a student has a question over something the instructor covered.

McDaniel and Zerger (2004) also describe the administrative duties for the Supplemental Instruction leader. Leaders have more responsibilities that just attending all class sessions, organizing, and conducting the review sessions. Leaders need to hold office hours for students and need to conduct surveys at the beginning, middle and end of the semester to determine

motivation and to ask for feedback. Leaders need to observe other Supplemental Instruction leaders to conduct peer-evaluations, attend on-going training sessions, and meet with the instructor of the course regularly. At the end of the semester, leaders need to collect data and prepare reports explaining the Supplemental Instruction sessions for that semester and about the progress of the students who attended.

One reason Supplemental Instruction is gaining popularity is that these sessions help all students, not just developmental students (Arendale, 1994). This is because the focus of Supplemental Instruction is on at-risk courses and not on at-risk students (Brothen & Wambach, 2004). However, since Supplemental Instruction sessions are voluntary the students who need the most support do not always attend. Therefore, some post-secondary institutions are implementing their own variation of Supplemental Instruction.

Murray State University is one of the post-secondary institutions that is implementing their own version of Supplemental Instruction. Realizing there are many responsibilities of the Supplemental Instruction leader, a faculty member, different from the instructor of the course, is the Supplemental Instruction leader rather than a student. In addition, since the biggest challenge is getting students to attend voluntarily, a class was created in which the students could enroll. The benefits from creating a class are to give students a one-hour elective credit course and a grade that will factor into their GPA. Since the developmental faculty advises many of the most at-risk students, advisors can enroll students into these Supplemental Instruction courses when enrolling students into the paired elective course. In addition, the chair of the department of the elective courses, informs their faculty about the offered Supplemental Instruction courses to encourage students to enroll in them as well.

Regardless of the variation of how the Supplemental Instruction course is developed, studies show Supplemental Instruction is effective (Center, 1997; Ning & Downing, 2010). Students who participate in Supplemental Instructions courses have a higher course grade than their peers who did not participate. In addition, students tend to have around a 27% higher GPA than the students who did not participate in the Supplemental Instruction courses (Center, 1997). Supplemental Instruction courses include biology, chemistry, economics, engineering, history, psychology and sociology to name a few (Center, 1997; Ning & Downing, 2010). One study even points out how Supplemental Instruction is effective in mathematics courses (Kenney & Kallison, 1994).

Accelerated Developmental Courses

With one major focus of developmental education being the lengthy course sequence students must complete, accelerated courses were developed. Accelerated developmental courses condense the material taught in a traditional 16-week course and teaches the material in an intensive five-week course (Boylan, 2004). This provides students the option of then enrolling into their required gateway course or enrolling into the next needed developmental course all in the same semester.

One model of accelerated developmental courses state that students enroll in an 8-week developmental course (Hu et al., 2014). With successful completion, students then enroll in the next developmental 8-week course needed. Students are able to move through these two developmental courses at a faster rate by being able to complete two developmental courses in one semester instead of the traditional two semesters.

The lengthy course sequence of developmental courses tend to put students behind in their four-year graduation plan. This is the reason why many post-secondary institutions are

offering accelerated developmental mathematics courses (Schak et al., 2017). By taking accelerated developmental mathematics courses, students can enroll in courses for their major sooner. The quicker students can enroll in courses for the major, the more involved and interested students will be in the courses they are taking. This contributes to student success and student retention (Schak et al., 2017). However, extensive planning at post-secondary institutions needs to exist before offering accelerated developmental courses to their students.

Post-secondary institutions offering accelerated developmental courses are noticing an increase in success rates of around 18% for these students (Cafarella, 2016). Accelerated developmental courses tend to use the support of an online mathematics program that goes along with the book for the course. Students are responsible for completing a great deal of the course work outside of the class time. Accelerated developmental courses are not for everyone. For example, Cafarella (2016) describes three characteristics students in accelerated developmental courses need, along with some faculty perspectives of accelerated developmental courses. Accelerated courses are not the best fit for all students or for all faculty. One characteristic students in accelerated courses need is to be comfortable with the use of computers. Most accelerated developmental mathematics models incorporate some use of computer programs. Therefore, the stronger computer and internet skills students possess the smaller the learning curve with any online program. These computer programs are used either as a supplement to the instructor's lecture or as the lecture itself. A second characteristic students in accelerated developmental mathematics courses also need is to have a higher mathematics skills level (Cafarella, 2016). Accelerated courses move at a rapid pace and students have to be able to keep up. If a student has low mathematics skills, it will be hard for them to maintain the pace of the class while understanding the material. A third characteristic of students in accelerated

developmental mathematics courses is their learning style. Students need to have self-discipline and need to be able to work independently in a quiet atmosphere.

In addition to identifying characteristics of students who could benefit by enrolling in accelerated developmental mathematics courses, instructors need to be comfortable in instructing a non-traditional classroom. Not all instructors enjoy teaching an accelerated developmental mathematics course, although some thrive in an accelerated developmental mathematics courses. Also, while some students may not need or want much help, other students find themselves with several questions for the instructor. Due to this, instructors of accelerated developmental mathematics courses suggest screening students to determine which students will benefit from accelerated developmental mathematics courses and which students will benefit from the traditional lecture-style classroom (Cafarella, 2016).

If students are able to enroll in more than one sequential course in a semester (accelerated developmental courses), research finds that students do enroll in the second course (Schak et. al., 2017). This not only improves retention rates, but also promotes persistence and student success by reducing the amount of semesters students take a developmental course. Studies also show for accelerated developmental writing courses, positive effects on student credit accumulation (Hadara & Jaggars, 2014).

Summer Programs

The creation of summer programs is another method post-secondary institutions are using as a change to their developmental education programs. Students who have developmental needs can now attend their post-secondary institution the summer before they start their freshman year. By attending their post-secondary institution during the summer before their first year, students are able to start their developmental course sequence that they need. Summer programs are

another option some post-secondary institutions are offering to help students get back on track of their 4-year graduation plan.

The New Jersey Institute of Technology (Borgaonkar et al., 2015) requires all entering freshman to take a placement mathematics test. Based on the student's score, students are enrolled in a "boot camp" (Borgaonkar et al., 2015) of sorts. During the camp students do not only work on their developmental mathematics skills, they also are acquainted with the post-secondary institution and college life. Rutgers University (Borgaonkas et al., 2015) offers a similar program called Bridge to Success. Again, developmental mathematics students can start the summer before their freshman year on the developmental mathematics courses. This in turn raises student's success rates and lowers student's tuition costs (Borgaonkas et al., 2015).

The main goal of the summer programs is to give students an earlier start on their developmental courses. By starting their developmental coursework earlier, this decreases the amount of time before students can start on their required gateway course. Another goal of summer programs is to improve student retention. Bir and Myrick (2015) conducted a study about the effects summer programs can have on student success rates. The study shows that students who participated in summer programs have a higher retention rate of 77% for their first year compared to other developmental students' retention rate of 68% for the first year. In addition, students have a higher rate of completing their gateway mathematics course as well. One reason for this was the level of engagement students had with each other and with the faculty. Students form friendships with others before the start of the new academic year and become familiar with the campus.

Summer programs are an option for developmental students to start their college career with a better foundation. Many developmental students become frustrated with the number of

developmental mathematics courses they have to take or the fact that they struggle with their mathematics skills. Because of this, some developmental students drop out of college or simply cannot afford to pay for all of the developmental courses. The study shows that students who attended these summer programs have higher GPA's on average of 2.65 compared to 2.48, better retention rates and are 10% more likely to graduate than their fellow developmental colleagues (Bir & Myrick, 2015). Intensive academic help for developmental students along with the social and emotional side of learning about college life is why summer programs are successful (Bir & Myrick, 2015).

High School Collaboration

When post-secondary institutions implement changes to any of their degree programs, especially if it effects the mathematics requirement, communication to the area high schools is important. Area high schools are preparing students to be college and career ready. Therefore, when changes are made at the college level, high schools need to be informed so they can also make the necessary changes needed as well.

High schools, along with the involvement of post-secondary institutions, are assessing their students to see who meets the college and career readiness requirements and who does not. Early assessment gives high schools the opportunity to help students in areas they are weak in, which is typically mathematics (Schak et al., 2017). This early intervention is to help students so when they attend a post-secondary institution they will not need to enroll in any developmental mathematics courses. Murray State University has also started working with area high schools to help students become college and career ready. Developmental faculty proctor assessment tests at the different area high schools and report the students' scores. This is a pro-active step for the high schools so then they can work with students who do not meet benchmark scores.

In the state of Montana, the Montana Task Force (2015) put together three key initiatives for a better communication between high schools and post-secondary institutions. The first initiative is to encourage students to enroll in the correct mathematics course their junior and senior years based on the mathematics requirement for their major they are interested in pursuing. This requires communication between high schools and the post-secondary institutions to ensure students are being advised correctly. The second initiative is to create a task force or committee consisting of members from both the high schools and the post-secondary institutions. The third initiative is to create, and keep updated, a mathematics placement document explaining enrollment into gateway mathematics courses.

Murray State University is already using these three key initiatives put together by Montana. Murray State University has a document explaining mathematics placement scores into all of their mathematics courses offered. This document also explains the scores needed for English and reading courses as well. This document is updated once a year and then posted on the Murray State University website. This is convenient for area high school students, and students who are not local, to access the document. Murray State University along with area high schools have already created a task force or learning community committee. This learning community was grant funded from Senate Bill 1. Several high school teachers, along with Murray State University faculty, came together to discuss the needs and expectations of students at each grade level. Understanding what each grade level was currently doing, and what they were expecting from their students, helped teachers and instructors re-structure their curriculum to better align it to the next grade level.

Since this model (that is, collaboration between post-secondary institutions and high schools) is new, there are no data available to show how the effectiveness of this collaboration

(Schak et. al., 2017). In addition, there has not been any follow-up reports to know if the learning community between Murray State University faculty and area high school teachers was effective.

Support Services

Another way post-secondary institutions are assisting their developmental students are with the creation of Learning Centers (Wurtz, 2015). Learning Centers can have a variety of names and offer different services at each post-secondary institution such as tutoring, mathematics skills labs, computer-aided instruction, classroom instruction support and a variety of workshops (Wurtz, 2015; Hu et al., 2014). Workshops can range from strategies with questioning and probing, study skills, test taking and learning (Wurtz, 2015). Learning Centers are provided free to students and are operated by faculty and other students who have been trained to work with developmental students (Hu et al., 2014).

Some of the benefits of learning centers mentioned by Wurtz (2015) are three times higher success rates in courses receiving tutoring along with twice the retention rates into the next course. By attending a learning center and receiving any of the support available, it is shown that there is an increase in student's persistence and motivation to do well in their courses. That same persistence and motivation exists throughout the student's college career. Hu et al. (2014) had found similar results to Wurtz's study that is, students who attended learning centers are more academically prepared and had higher college GPA's. Specifically, according to Hu et al. (2014), tutoring increases test scores in mathematics along with increasing retention rates to the next mathematics course.

There are two main challenges for Learning Centers. The first challenge is not all students who need support attend Learning Centers (Wurtz, 2015). Attending a learning center is

strictly voluntary unless it is incorporated into an assignment for a class. Because of this, the students who need the most support tend not to go to learning centers to receive that support. The second challenge for learning centers is awareness (Hu et al., 2014). If students are not aware of the learning center and all of the available support, students will not attend. Making sure students are aware of such support is important. This is where advisors, and instructors, are essential. Advisors and learning centers need to collaborate with each other to help support awareness.

Hu et al. (2014) mentions not only should advisors work with learning centers, they have five other important functions to perform. The first function for advisors is integration. This is when advisors need to explain to students to help them understand how their classes and their campus involvement connects to and could have an impact on their career goals. The second function for advisors is referral. This involves informing students about all of the services offered on campus. Many students do not always know where to go if they have questions except for their advisors. Advisors need to be knowledgeable about all campus services provided whether for support, for admission, or financial issues. The third function for advisors is information. Advisors need to be knowledgeable about policies and procedures for the college. In addition, advisors need to be knowledgeable about different degree programs along with graduation requirements. The fourth function for advisors is individuation. Advisors need to know their students. This includes their strengths, weaknesses, their likes and their dislikes. This is to help students with a college plan tailored for them. The goal is to help each student to be successful. The fifth function for advisors is shared responsibility. Advisors are to help and to guide their students, but ultimately the responsibility should be placed on the student.

To help advisors know and understand their functions as advisors, training is essential. It is critical for faculty and advisors to have training so they can better serve their students; also, campus collaboration is important too. Faculty and advisors need to be aware of what services are available for students. The Montana Task Force (2015) mentions there needs to be clear communication between advisors and campus services. Without accurate information, advisors cannot advise students efficiently or appropriately. From such training sessions, one recommendation for undeclared students is to enroll students in a non-algebra intensive course. This provides both their mathematics credit and motivation to students who view mathematics negatively. With the creation of mathematics pathways at many post-secondary institutions, this is a good route for students. Even if the student decides on a major that needs a different mathematics pathway, their confidence in a college mathematics course has increased already by taking one and passing a college mathematics course.

Just as one challenge for Learning Centers is student attendance since it is voluntary (Wurtz, 2015), the main challenge for advisors is not all students attend their advising sessions (Vander Schee, 2007). According to a study about advising under-prepared students by Vandar Schee (2007), advising sessions are effective in increasing student's success when students attend their advising sessions. It was found that at least three advisor sessions throughout the semester is needed for such results. However, the more advisor sessions students attend, the better performance students have in their courses.

Co-requisite Model

Besides mathematics pathways, the Co-requisite Model is an alternative to developmental mathematics that is receiving considerable attention throughout post-secondary institutions (Vandal, 2014b). The Co-requisite Model is when a student takes a developmental course

simultaneously with the college-level gateway course (Boylan, 1999). The developmental course is a co-requisite course rather than being a pre-requisite course. Another version of the definition for co-requisite is to mainstream students who need remediation with students who do not need remediation into the same course section (Schak et al., 2017).

Most developmental mathematics sequences have two or three level of courses students must pass before enrolling into their required gateway mathematics course. According to Vandal (2014b), only 10% of students starting in the first level of the developmental mathematics sequence complete their required gateway course with two years. In addition, students are discouraged when placed into any of the three levels of the developmental mathematics sequence. This results in only a little more than 50% of developmental students earning a "C" or better in their required gateway course. Due to these data (Vandal, 2014b), post-secondary institutions are very interested in changing their developmental mathematics programs. As mentioned previously, there are several alternatives being implemented into changing developmental mathematics programs. Complete College America (2014) focuses on the Co-requisite Model.

Complete College America (2014) is a nonprofit organization established in 2009. Their goal is to close the attainment gap for underrepresented students and to increase the number of students who earn a career certificate or college degree. College enrollment has doubled over the past 30 years; however, the graduation rate has remained the same. Complete College America (2014) focuses on five programs to increase student success. Mathematics Pathways, Co-requisite Remediation, 15 to Finish, Structured Schedules and Guided Pathways to Success are the five programs Complete College America (2014) will help states and post-secondary

institutions put into place. This section of the study is going to focus on the co-requisite remediation.

Students can succeed in gateway mathematics courses with additional support (Complete College America, 2014). At two-year post-secondary institutions, 51.7% of entering college-level students enroll in a remediation course. While only 22.3% of those students complete the required remediation and their gateway course over a two-year period. Of these 22.3%, only 9.5% graduate in three years from the two-year post-secondary institution (Complete College America, 2014).

Students place into developmental courses due to their score on any number of placement exams. Depending on the student's score, either they enroll in one of the three levels of developmental mathematics or they enroll in their required gateway mathematics course. Complete College America (2014) suggests using a range for the placement score instead of just a single number for the cut-off score. In other words, have only two cut-off ranges. Students with a placement test score under the lowest cut-off score would then place into a developmental course their first semester and the co-requisite gateway course their second semester. Students with a placement test score in between the two cut-off scores would directly enroll into their co-requisite mathematics gateway course their first semester. While students with a placement test score higher than the high cut-off score would enroll directly into their required gateway mathematics course. Complete College America (2014) also suggests that the placement exam post-secondary institutions are using be made available to students ahead of time so they can practice and be prepared for the exam.

Once students have taken their placement exam and it is determined which course they should enroll in, there are varieties of different co-requisite mathematic options. Post-secondary

institutions need to design and create the Co-requisite Model that will best suit the needs of their students and fit into their mission of their post-secondary institution. Complete College America (2014) suggests the top three most effective Co-requisite Models: a one-semester model, a one-year model and a parallel remediation model.

One semester model. One version of the mathematics model is the one semester model. In one semester, students can develop their mathematics remediation skills all while earning credit for the required gateway mathematics course. There are varieties of methods post-secondary institutions are using to offer the one semester model approach to their students.

Aligned remedial-gateway courses is one approach to the mathematics Co-requisite Model (Joint Statement, 2012). This approach is when students enroll in the developmental mathematics course they were placed in according to their placement scores, along with enrolling in their required gateway mathematics course. Students get the full benefits of the developmental mathematics course while being able to apply those skills in their gateway mathematics course. This helps students understand why the skills they are learning are important and when those skills will need to be applied.

Additional time or extending instruction is a second approach to the mathematics Co-requisite Model (Joint Statement, 2012; Vandal, 2014b). There are two different versions of this model. The first version is by extending instruction (Joint Statement, 2012). This is when a three-hour course becomes a four-hour or a five-hour course. By just adding more hours to the course makes this the simplest strategy to the mathematic Co-requisite Model to implement. Only students with scores of one or two points below the benchmark score for the course are eligible to enroll in these special sections. All students in this course would receive the additional developmental coursework. Murray State University is currently offering this model

for some sections of both their College Algebra and their Liberal Arts mathematics courses. The second version is by allowing additional time (Vandal, 2014b). This version is when the same class is offered with two different sections numbers. The first section number is for students who meet or exceed the benchmark scores. These students make up half of the class and only attend the original amount of credit hours that the course offers. The second section number is for students below the benchmark scores. These students make up the other half of the class. Students in this section meet an extra hour with the instructor to receive their additional developmental instruction. Students still only receive the original amount of credit hours that the course lists for even though they are meeting additional hours.

Mandatory tutoring or laboratory work is a third approach to the mathematics Co-requisite Model (Vandal, 2014b). Students who do not meet benchmarks scores enroll in their gateway mathematics course, but are required to attend the mathematics lab or mathematics tutoring. Usually two hours per week is mandated. If students do not attend their required lab or tutoring sessions, their gateway mathematics course grade will reflect their absence. Customized mathematics labs or tutoring is required for each student. This individualizes student learning to help improve the mathematics skills where students are the weakest.

Sequenced courses is a fourth approach to the one-semester mathematics Co-requisite Model (Vandal, 2014b). This is when students first enroll in their developmental mathematics course that they need. However this curse is an accelerated, shorten course during the first five or six weeks of the semester. Instead of attending class three hours per week, students will attend class for six or seven hours per week. After successfully completing this required developmental course, students then enroll in their required gateway mathematics course for the

remainder of the semester. In this intensive gateway mathematics course, students will similarly meet more hours per week than the normal 16-week gateway mathematics courses.

These approaches to the mathematics Co-requisite Model are the only four approaches currently reported at several post-secondary institutions. Variations of these four approaches as well as other approaches in general are also being incorporated (Vandal, 2014b). Post-secondary institutions need to determine if any of the approaches, or variations of these approaches, would be appropriate for their students. If determined so, then the decision of which faculty and what other resources are available for the creation of a successful mathematics Co-requisite Model.

One-year model. Another version of the mathematics Co-requisite Model is the one-year co-requisite approach. This one-year co-requisite approach is designed for all students; however, it is designed more specifically for students with the most significant developmental needs (Joint Statement, 2012). These students would normally have to take all three developmental courses before enrolling into their gateway mathematics course. This could take two years assuming students pass all of their developmental courses after only one attempt. Instead, students now can cut that time in half to only one year.

One version of the one-year mathematics co-requisite approach is to have students enroll in a specially designed developmental mathematics course during the student's first semester before enrolling in their gateway mathematics course during their second semester (Vandal, 2014b). Within this specially designed developmental mathematics course, students will focus on only the mathematics skills they will need for their gateway mathematics course. For example, if the requires gateway mathematics course is a statistics course then the developmental mathematics course will focus on the mathematics skills students will need to be successful in their statistics course rather than on mathematical skills that will not be used in a statistics

course. By being able to relate the developmental mathematics skills to their gateway course, students are more receptive to understanding and learning such needed mathematics skills.

Another version of this one-year mathematics co-requisite approach is a uniquely designed yearlong gateway mathematics course (Joint Statement, 2012). Students enrolled in this course will study their gateway mathematics course material along with having developmental instruction delivered at the same time. This instruction is commonly referred to as 'just-in-time' learning. Incorporated into the lesson is the mathematics skills students need for their gateway material. Again, students have a better understanding as to why they need to know certain mathematics skills. Along with learning the needed developmental mathematics skills, one-year courses can also incorporate time management skills, study skills and other useful college success strategies (Vandal, 2014b). Incorporating student success strategies is important for these students, since most developmental students are also weak within their success strategies.

Parallel support. Yet another version of the mathematics Co-requisite Model is parallel remediation (Joint Statement, 2012; Vandal 2014b). Similar names for parallel remediation are aligned support or embedded remediation. Parallel remediation is the mathematics Co-requisite Model that is common for career or technical certificate programs. Instead of students completing developmental courses before enrolling into technical certificate program, students can attend a basic mathematics skills lab while enrolled in a technical certificate program (Vandal, 2014b). By attending a mathematics skills lab, students are able to engage in the career or technical program of study that is of interest to them. Studies have shown that this approach works best for students with the greatest amount of measurable remedial mathematics needs, including students applicable for adult education programs (Joint Statement, 2012).

In Tennessee, the Tennessee Colleges of Applied Technology requires that all students must show proficiency in basic mathematics skills (Vandal, 2014b). Here all students attend a mathematics skill lab where the content is competency-based mathematics instead of structured into courses that students must pass, regardless of their mathematics placement scores. Technology-based programs used in the mathematics skills lab group mathematics skills into modules for students to show mastery and complete. Students work through the material as quickly or as slowly as they need to depending on their mathematics skill level. Students have to complete and show mastery in the mathematics skills program in order to receive their technical certificate. Students enrolled in the parallel support for mathematics at the Tennessee Colleges of Applied Technology have over a 70% graduation rate.

Murray State University

As mentioned previously, Murray State University is offering a version of the one-semester mathematics Co-requisite Model to their students. They are in their second full academic year and are increasing the offering of courses sections as co-requisite. During the first year, only College Algebra was a mathematics co-requisite option. For the second academic year, the offering of College Algebra is continuing along with the Liberal Arts mathematics course and the beginning statistics course.

At Murray State University, the benchmark score for students to enroll in College Algebra is an ACT math sub score of 21 or an equivalent score. Currently College Algebra is a 4-hour credit course. At other Kentucky post-secondary institutions, students need a benchmark score of 22 or an equivalent score to enroll in the 3-hour credit course. Starting in the fall of 2016, students with an ACT math sub score of 19 or 20 could enroll in special sections of College Algebra. Instead of attending the required four hours a week as in the traditional

College Algebra course, students attended five hours a week however still only earning four credit hours. There were two co-requisite sections of College Algebra offered in both the fall and the spring semesters. During the spring semester, students with an ACT math sub score of 19 or 20 could enroll in one of the special sections of College Algebra along with students who received a grade of an A in the second developmental mathematics course. This allowed students to skip over the third developmental mathematics course. The mathematics faculty instructed their co-requisite sections differently, so there was no continuity to the courses.

Beginning in fall 2017, the Liberal Arts mathematics course was also offered as a co-requisite course. The benchmark score for the Liberal Arts mathematics course is an ACT math sub score of 19 or an equivalent score and the course is a three credit hour course. There were two special sections created for students with an ACT math sub score of 17 or 18. Instead of meeting three hours per week, students meet for four hours per week while earning three credit hours. The two faculty instructors for these two sections offered are conducting their courses as cohesively as they possibly can. They have the same daily lecture schedule, they use the same online homework program and they have the same lab schedule. For their fourth hour per week, the instructors are using it to have their students work on individualized developmental mathematics skills. There is an online program set up in modules for the students to work though. The modules connect to the lecture of the week similar to the 'just-in-time' learning (learning the mathematic skills needed that are required to evaluate the current mathematics problems).

Starting in spring 2018, one section of the gateway Statistics course will be offered to students as a co-requisite course. Currently students with an ACT math sub score of 20 or an

equivalent score can enroll in the four credit hour course. Now students with an ACT sub score of 18 or 19 can enroll in the co-requisite section of Statistics.

Summary

Not all students enrolling in post-secondary institutions are prepared for the level of instruction taught by faculty in reading, writing and mathematics. Some form of developmental education has been around for centuries. Students are underprepared in reading, writing, and mathematics (Boyle & White Jr, 1987) with mathematics being the most needed developmental course (Bailey, 2009a). As more students are underprepared when entering post-secondary institutions, developmental education programs are being over-hauled. There are currently eight different alternate methods that developmental education programs are provided. Research supports Mathematics Pathways, Multiple Assessments, Supplemental Instruction, Accelerated Developmental Courses, Summer Programs, Collaboration with High Schools, Student Services and Co-Requisite Model.

At Murray State University, the department of Mathematics and Statistics recognizes that some students are underprepared in mathematics for courses in College Algebra and Liberal Arts. As such, Murray State University offers a version of the one-semester Co-requisite Model. Instead of the College Algebra class meeting 4-hours per week, the course meets 5-hours per week. Similarity the Liberal Arts course will meet 4-hour per week rather than 3-hours per week.

CHAPTER THREE: METHODS

This chapter describes methodology used to answer the three research questions listed in Chapter One, provides a description of the participants, and explains how their group selection was determined. A detailed explanation regarding the College Algebra and Mathematical Concepts classes is explained, followed by the hypotheses and how the data was collected and analyzed.

Participants

There were a total of 1,348 participants for this study. The participants over the three semesters of the College Algebra study are students who have completed College Algebra or have completed Mathematical Concepts over the course of one semester at Murray State University. Students range from freshman to seniors in classification. Their mathematical skill level ranged from those needing the pre-requisite developmental course to those not needing the pre-requisite developmental course (i.e., non-developmental students).

Student data from College Algebra during fall 2016, spring 2017 and fall 2017 were the three semesters of focus. Likewise, student data from the follow-up courses were also included in this study. Three of the follow-up courses were in Chemistry, while two of the follow-up courses were in Mathematics. These classes include Introductory Chemistry (CHE 105), Essentials of Chemistry and Biology (CHE 111), General College Chemistry (CHE 201), Trigonometry (MAT 145) and Business Calculus (MAT 220). The Mathematical Concepts course provides student data only from fall 2017. For this course, no follow-up data were available because fall 2017 was the first time the co-requisite section for Mathematical Concepts was offered and because Mathematical Concepts is not a pre-requisite for any other Murray State University course.

Participants were placed into three groups. The first group, Group 1, were students who took College Algebra because their placement score (that is, an ACT score above 21 in math) put them into the course. These students did not take the pre-requisite developmental course. The second group, Group 2, were students who took College Algebra after taking the developmental pre-requisite course because of their placement scores (that is, an ACT score below 21 in math). The third group, Group 3, were students whose placement test scores put them into the pre-requisite developmental course but they took the co-requisite section of College Algebra instead of taking the pre-requisite developmental course. These three groups were categorized similar for the students who took Mathematical Concepts instead of College Algebra. All students' ACT scores in mathematics in Group 2 and Group 3 placed them into the pre-requisite developmental course. The three research questions focus on students in Group 2 and Group 3 because all of these students belong to the same category of being a developmental student. Due to this, students in Group 1 are not used for this study. Therefore, changing the total number of participants to 498 for this study. For the three semesters in College Algebra, Group 2 had 95 freshman, 123 sophomores, 43 juniors and 30 seniors. Group 3 had 117 freshman, 18 sophomores, eight juniors and seven seniors. For Mathematical Concepts, Group 2 had one freshman, 17 sophomores, three juniors and 12 seniors. Group 3 had 16 freshman, three sophomores, one junior and one senior.

For College Algebra, over the three semesters under study, there were 172 male students and 272 female students for a total of 444 students in groups 2 and 3. In Group 2, there were 116 male students and 178 female students for a total of 294 students who took the pre-requisite developmental course before enrolling into College Algebra. For Group 3, there were 56 male students and 94 female students for a total of 150 students who took the co-requisite section of

College Algebra. Class enrollments ranged differently in size as well. For the non-co-requisite sections of College Algebra, class sizes ranged from 36 to 47 in fall 2016, while the co-requisite sections of College Algebra ranged from 26 to 31 in enrollment. In spring 2017, the non-co-requisite sections of College Algebra ranged from 31 to 42 enrollment and the two co-requisite sections of College Algebra both had a total of 15 for their student enrollment. In fall 2017, the non-co-requisite sections of College Algebra had a wider range of student enrollment from 18 to 35. The three co-requisite sections of College Algebra ranged from 20 to 23 in student enrollment.

For the College Algebra follow-up courses in both Chemistry and Mathematics, a total of 94 students enrolled in one of the courses the semester after completing College Algebra. This included 61 students from Group 2 (31 males and 30 females) and 33 students from Group 3 (13 males and 20 females). For the two Mathematics follow-up courses, there were 56 students enrolled (32 males and 24 females). For the three Chemistry follow-up courses, there were a total of 38 students (12 males and 26 females).

For one of the Mathematics follow-up course of MAT 145, there were 21 students from Group 2 (13 males and eight females) and 21 students from Group 3 (seven males and 14 females). For the other Mathematics follow-up course of MAT 220, there were 11 students from Group 2 (nine males and two females) and three students from Group 3 (all males).

For CHE 105, there were 22 students from Group 2 (nine males and 13 females) and four students from Group 3 (two males and two females). For CHE 111, there were seven students from Group 2 (all females) and four students from Group 3 (one male and three females). For CHE 201, there were no students from Group 2 and one female student from Group 3.

For Mathematical Concepts, there were 21 male students and 33 female students for a total of 54 students enrolled during fall 2017 from groups 2 and 3. There were 33 students in Group 2 (17 males and 16 females) and 21 students in Group 3 (four males and 17 females). Class enrollments ranged differently in size as well. For the non-co-requisite sections, class size ranged from 21 to 36 students while the two co-requisite sections had six students in one section and 15 students enrolled in the other section.

The course enrollment data for the participants is provided in Table 1. The test scores for students in College Algebra for the participants are provided in Table 2. The test scores for students in Mathematical Concepts for the participants are provided in Table 3.

Course Descriptions

During the three semesters under study, the Department of Mathematics and Statistics offered 27 sections of the regular College Algebra and seven co-requisite sections of College Algebra. For enrollment into the regular sections of College Algebra, students must either score a 21 on the math subtest of the ACT or an equivalent score on another placement test. Other placement test scores Murray State University accepts are the SAT, the KYOTE Readiness, the KYOTE College Algebra and the Accuplacer test. If students do not score an equivalent of 21 or higher on any of the placement tests, they must enroll in one of the three developmental courses first depending on their test placement score. The third developmental course, and the pre-requisite course for College Algebra, is Intermediate Algebra. A score of 19 or 20 on the math subtest of the ACT, or an equivalent score from another test, automatically places students into this pre-requisite developmental course. For enrollment into the co-requisite College Algebra sections, students must have a score of 19 or 20 on the math subtest of the ACT or an equivalent score from one of the other placement tests. Therefore, one purpose of this study was to

determine if the students enrolled in the co-requisite College Algebra sections were as successful as the students who took the pre-requisite developmental course before enrolling in any of the regular sections of College Algebra.

The regular sections, or non-co-requisite sections, of College Algebra, are offered four days a week for 50 minutes per day with students receiving four credit hours. All instructors use the same text and cover the same material, but homework, quizzes and tests vary by instructor. The co-requisite sections of College Algebra are offered five days a week for 50 minutes per day. This is one day, or 50 minutes, more than the regular sections. However, students receive four credit hours for College Algebra. Instructors teaching the co-requisite College Algebra sections also taught the course in different ways. Some instructors took the first few weeks and had the students work on the mathematical skills they would need for the College Algebra material (these are some of the same mathematical skills students would have learned or reviewed in the pre-requisite developmental course) while some instructors took one class period each week throughout the semester to review the needed mathematical skills.

Though being successful in College Algebra is important, it is equally important for students to be successful in any follow-up courses where College Algebra is the pre-requisite course. At Murray State University, follow-up courses from College Algebra include Trigonometry, Business Calculus, Introductory Chemistry, Essentials of Chemistry and Biochemistry and General College Chemistry. Therefore, the second purpose of this study was to determine if the students enrolled in the co-requisite sections of College Algebra were as successful in any of the follow-up courses as the students who took the pre-requisite developmental course Intermediate Algebra before taking College Algebra.

During fall 2017, the Department of Mathematics and Statistics offered six lecture sections, one online section and two co-requisite sections of Mathematical Concepts. Mathematical Concepts is a liberal arts mathematics course taken by students in certain majors (e.g., art, music, history, psychology, non-profit leadership studies and organizational communication) as their mathematics required course. In order for students to enroll in the regular sections of Mathematical Concepts, students must score at least 19 on the math subtest of the ACT or an equivalent score on any of the other placement tests. If students score below a 19 then they enroll in the developmental pre-requisite course of Introductory Algebra. Introductory Algebra is the second developmental mathematics course in the three developmental mathematics course sequence. For enrollment in the co-requisite sections of Mathematical Concepts, students need a score of 17 or 18 on the math subtest of the ACT or an equivalent score from another placement test. Therefore, the third purpose of this study was to determine if the students who took the co-requisite section of Mathematical Concepts were as successful as the students who took the pre-requisite developmental course before enrolling in any of the regular sections of Mathematical Concepts.

The regular sections, or non-co-requisite sections, of Mathematical Concepts are offered three days a week for 50 minutes per day. Students receive three credit hours for this mathematics course. Instructors use the same text although only four of the five chapters taught in this course were covered by all instructors. For the fifth chapter, instructors selected one of the remaining chapters of the text to cover. In effect, this made every section of Mathematical Concepts unique. Additionally, some instructors used the online program from the book in different or individual ways. For example, some instructors used the online program for all of the homework assignments, while others used the online program for part of the homework

assignments with the rest of the homework assignments being assigned from the text. The co-requisite sections of Mathematical Concepts met four days a week for 50 minutes each day. Students in the co-requisite sections also earned three credit hours for this mathematics course. The two co-requisite instructors also used the same text and materials for this course. They met often to discuss how they were teaching the material, the schedule of the class and what supplemental material they were using in the class. These two instructors agreed that the co-requisite sections needed to be taught as similar as possible. They collaborated on the tests they gave to the students and used the approach of taking one day in each week to have the students work on supplemental mathematics material important for this course. In summary, the courses covered for this study differed in how they were taught. Instructors in College Algebra covered the same material, however, homework was assigned differently. The instructors in the co-requisite sections of College Algebra did not present the supplemental material in the same way. Instructors in Mathematical Concepts all cover four out of five topics the same, with the fifth topic their choice. However, in the co-requisite sections of Mathematical Concepts, the instructors covered the supplemental material in the same way.

Research Questions

Not all students are ready for college level mathematics courses or possess the mathematical skills needed for the material taught in these mathematics courses. Therefore, some students are required to take a developmental mathematics course before they enroll in their required gateway mathematics course. Developmental courses were created to help students with the skills they were lacking so they could enroll and succeed in a college level gateway course (Boyle & White Jr, 1987). This is the purpose behind developmental courses

and why they originated. Developmental courses review the skills in which students are deficient so they can compete at the same academic level as their peers in subsequent courses.

Research suggests students who take developmental courses should perform better than their peers who did not need to take the developmental course in the required gateway course (Arendale, 2005). However, developmental courses were designed to help students catch up academically to their peers and not to exceed their peers academically (Goudas & Boylan, 2012). Thus, students taking a co-requisite course are skipping and not taking the needed developmental course.

The difference in what the research suggests about students in developmental courses and what developmental courses were actually designed for leads to question if students are becoming as academically prepared in their co-requisite course since they did not take the required developmental course. In addition, are these students as academically prepared for any follow-up courses that are required where their co-requisite mathematics course is a pre-requisite course? With the stated research that the developmental courses will prepare students to be academically equal to their peers, the following three questions were generated:

Q1. Are there statistically significant differences between the pass rates of students in the co-requisite sections of College Algebra compared to students in College Algebra who took Intermediate Algebra first?

Q2. Are there statistically significant differences between the pass rates of both groups of students in the College Algebra follow-up courses?

Q3. Are there statistically significant differences between the pass rates of both groups of students in Mathematical Concepts?

Procedures

The data for this study were obtained from two sources, MSU's student database and departmental files, and covered three semesters of College Algebra and one semester of Mathematical Concepts. The researcher chose a quasi-experimental design as random assignment was not feasible for determining the findings. Students' final grades from both mathematics courses of non-co-requisite and co-requisite sections were collected. Other information about the students was then obtained through the university's student database. All data were uploaded to SPSS for analysis. All data collection procedures and data handling were managed in accordance with the approved IRB protocol.

Student data from all of the College Algebra mathematics classes were compiled and placed into an Excel spreadsheet. Data included each student's ACT math test scores, along with other scores if the student took the SAT, KYOTE Readiness, KYOTE College Algebra or the COMPASS test. Also included in the data spreadsheet was the student's sex, group number, whether they passed College Algebra or not, and whether they passed any of the follow-up courses. Most of the same data were compiled for the students who took Mathematical Concepts except for information about follow-up courses (the Mathematical Concepts course only included the last semester of the study).

Regarding the research questions, two of the questions pertained to College Algebra while the third pertained to Mathematical Concepts. Specifically, for College Algebra, the pass rates for College Algebra and the follow-up courses between Group 2 (students with an ACT score below 21 in math and took the pre-requisite developmental course first) and Group 3 (students with an ACT score below 21 in math who enrolled in the co-requisite section) were

compared. For Mathematical Concepts, the pass rates between Group 2 and Group 3 were compared. Essentially, these data are categorical.

Pearson's Chi-square Test is used to compare proportions among categorical variables (Field, 2013) and was deemed appropriate for the data collected. Specifically, Pearson's Chi-square tests the independence of two categorical variables by forming a contingency table. A contingency table is a table that represents two or more levels of observations of each variable in a grid (Field, 2013). For this study, one variable was the pass rates of the students in Group 2, while the other variable was the pass rates of students in Group 3. Pass rates for students in Group 1 were not a variable, due to the research questions not including Group 1. Since all three research questions had the same two variables, Pearson's Chi-square was used to address all three research questions. Probability levels of 0.05 or less were chosen as the criteria for statistical differences for this study.

While analyzing categorical data, Pearson's Chi-square Test has two assumptions (Field, 2013). The first assumption is that the data consist of independent variables; meaning each variable has only one data entry in each space of the contingency table. In this study, there are no students who were enrolled in two different sections of College Algebra in the same semester. Students have only one grade for one section of their mathematics class per semester. This is also true for Mathematical Concepts. Students are only enrolled in one section of Mathematical Concepts. However, some students may have enrolled in two different follow-up classes in the same semester; for example, one of the two mathematics and one of the three Chemistry courses, but not in two different sections of the same class. The second assumption of Pearson's Chi-square Test is that within the contingency tables, there are not less than five data values (Howell, 2012). With values less than five, the data cannot be meaningful analyzed. Sections of College

Algebra and Mathematical Concepts all had more than five students enrolled; however, one comparison had less than five members and could not be used.

CHAPTER FOUR: FINDINGS AND ANALYSES

Findings

Over the three semester period, there was a total of 498 student grades collected for the study. Of these 498 students, 171 or 34.3% of the total students were enrolled in a co-requisite mathematics course. College Algebra (MAT 140) and Mathematical Concepts (MAT 117) were the two mathematics courses used in this study. College Algebra is a mathematics class required for many majors, while Mathematical Concepts is the mathematics course required for the liberal arts majors. Trigonometry (MAT 145), Business Calculus (MAT 220), Introductory Chemistry (CHE 105), Essentials of Chemistry and Biology (CHE 111) and General College Chemistry (CHE 201) were the follow up courses of College Algebra used in this study.

Research Questions

One of the primary focuses of this study was to determine if pass rates of students in co-requisite mathematics courses were different from the pass rates of students who take the pre-requisite developmental mathematics course first. Specifically, the three research questions were:

Q1. Are there statistically significant differences between the pass rates of students in the co-requisite sections of College Algebra compared to students in College Algebra who took Intermediate Algebra first?

Q2. Are there statistically significant differences between the pass rates of both groups of students in the College Algebra follow-up courses?

Q3. Are there statistically significant differences between the pass rates of both groups of students in Mathematical Concepts?

Research Question 1. Research Question 1 was designed to determine if students in Group 3 (who enrolled in the co-requisite section of College Algebra) pass at the same rate as

students in Group 2 (who took the pre-requisite developmental course). Students in Group 2 are half of the students under study for Research Question 1. These students did not place into College Algebra with their test scores. Students had to first take developmental courses before enrolling in College Algebra. Some of these students may have taken all three developmental courses, while some of these students may have only taken two of the developmental courses first. However, all of these students took the pre-requisite developmental course, Intermediate Algebra, before enrolling into College Algebra. Table 4 summarizes the characteristics of the students in Group 2.

Students with test placement scores above 21 are able to enroll directly into College Algebra. However, there are different reasons students take a pre-requisite course first instead of taking the course they have placed into. One reason is because students failed College Algebra so they decided to take the pre-requisite developmental course before trying to take College Algebra again. Another reason is that some students are returning to the university after several years and apparently want to improve or refresh their mathematics skills by taking the pre-requisite developmental course before enrolling in College Algebra. Yet another reason is that students get misplaced into their mathematics course. Their first placement test scores may put them into the pre-requisite developmental mathematics course, but their second set of scores may put them into College Algebra. Sometimes it is too late by the time the university receives these scores or advisors just over look them. Test scores for students taking the alternate placement tests are summarized in Table 5.

Students in Group 3 are the other half of the students under study for Research Question 1. These students' placement test scores were in the range where they *should have* taken the pre-requisite developmental course before enrolling in College Algebra. However, these students

enrolled in the co-requisite sections of College Algebra instead of taking the pre-requisite developmental course. Students need to have scored a 19 or 20 on their mathematics portion of the ACT or an equivalent score on an alternate placement test for eligibility to enroll in the co-requisite section of College Algebra. Table 4 summarizes the characteristics of the students in Group 3.

Similar to Group 2, some students in Group 3 placed into a regular section of College Algebra however, still enrolled in the co-requisite section instead. Some of these students may be returning students who thought the co-requisite section was a better fit for them instead of taking the pre-requisite developmental course first. Some of these students were students who had failed the regular section of College Algebra and were in need of some help in their mathematics skills but did not want to take the semester long pre-requisite developmental course first. The mean ACT score for students in Group 2 was less than the mean ACT score for students in Group 3 by 1.4. A T-test revealed no statistically significant differences between the ACT scores for Groups 2 and 3 ($t = -2.08$, $df = 442$).

Students who qualified for the co-requisite sections of College Algebra still were given the opportunity to take a placement test and test into the regular section of College Algebra. While some students tested into the regular section, some students did not. Table 5 summarizes the characteristics of the placement tests that students in Group 3 took.

Research Question 1 was designed to compare pass rates of students in Group 2 to the pass rates of students in Group 3 for College Algebra. For this study, a passing grade was considered an A, B or C while a failing grade was considered D, E, Audit, Withdraw or an Incomplete. The number of students who passed or failed within each group are summarized in the contingency table in Table 6.

The Chi-square test revealed a significant difference in the pass rates between students in Group 2 and students in Group 3, χ^2 (2, N = 444) = 35.55, p < .001. Students in Group 3 were more likely to pass than those in Group 2. The odds of a student in Group 3 passing the course compared to a student in Group 2 passing the course is 3.5 times greater. Both assumptions for Pearson's Chi-square test were met.

Research Question 2. Research Question 2 was designed to determine if students in Group 3 (who enrolled in the co-requisite section of College Algebra) pass at the same rate in the follow-up courses to College Algebra as students in Group 2 (who took the pre-requisite course). It is important to make sure that students are not only passing College Algebra in the co-requisite sections, but are also learning the needed mathematics to be able to pass in the follow-up courses. There are several follow-up courses required of students, including MAT 145, MAT 220, CHE 105, CHE 111 and CHE 201.

MAT 145. MAT 145 is Trigonometry and is a 3-credit hour course in which College Algebra is a pre-requisite. Trigonometry is a study of plane trigonometry which includes topics in angles, right triangle trigonometry, trigonometric functions and their graphs, identities, solving trigonometric equations, and applications of trigonometry. Not every major that requires College Algebra also requires Trigonometry; however, some majors do require both courses. The contingency table containing the pass rates for Group 2 and Group 3 students is summarized in Table 7.

The Chi-square test revealed no significant difference in the pass rates between students in Group 2 and students in Group 3, χ^2 (1, N = 42) =1.62, p = .20. Both assumptions for Pearson's Chi-square test were met. Furthermore, the data revealed that the odds of a student in

Group 3 passing the course compared to a student in Group 2 passing the course was 2.3 times greater.

MAT 220. MAT 220 is Business Calculus and is a 3-credit hour course in which College Algebra is a pre-requisite. Business Calculus is an introduction to calculus with applications in various fields of business and a primary emphasis on differential calculus. Most business majors require Business Calculus. Both assumptions for Pearson's Chi-square test were not met. Two of the four data entry values were less than five. More data values are needed to validate Pearson's Chi-square test.

CHE 105. CHE 105 is Introductory Chemistry and is a 4-credit course in which College Algebra is a pre-requisite. Introductory Chemistry is a beginning course in general chemistry designed for students who plan to take additional chemistry courses. This course consists of three hours of lecture and two hours of laboratory per week. Again, both assumptions for Pearson's Chi-square test were not met. Both of the data entry values for Group 3 were less than five. More data values are needed to validate Pearson's Chi-square test.

CHE 111. CHE 111 is Essentials of Chemistry and Biochemistry and is a 5-credit hour course in which College Algebra is a pre-requisite course along with one of the following Transitions courses: Exercise Science, Health or Nutrition. Essentials of Chemistry and Biochemistry covers the essentials of general chemistry, organic chemistry and biochemistry with an emphasis on health-related topics. This course consists of three hours of lecture, two hours of recitation and two hours of laboratory per week. Yet again, both assumptions for Pearson's Chi-square test was not met. Both of the data entry values for Group 3 were less than five while one data entry for Group 2 is less than five.

CHE 201. CHE 201 is General College Chemistry and is a 5-credit hour course in which College Algebra is a pre-requisite. General College Chemistry is a thorough course in inorganic chemistry emphasizing atomic structure, stoichiometry and thermochemistry, along with the gaseous state of matter, periodic classification, nuclear chemistry, and chemical bonding. This course consists of three hours of lecture, two hours of recitation and two hours of laboratory per week. Neither assumption from Pearson's Chi-square test is met. Therefore, a contingency table could not be created.

Due to the assumptions for Pearson's chi-square test not being met for four of the five follow-up courses, the researcher combined the data of those four courses to determine in general if there were any significant differences in the pass rates between group 2 and group 3. The Chi-square test revealed no significant difference in the pass rates between students in Group 2 and students in Group 3, χ^2 (1, N = 52) = .02, p = .05. Both assumptions for Pearson's Chi-square test were met.

Research Question 3. Research Question 3 was designed to determine if students in Group 3 (who enrolled in the co-requisite sections of Mathematical Concepts) pass at the same rate as students in Group 2 (who took the pre-requisite developmental course). Students in Group 2 are half of the students under study for Research Question 3. These students did not place into Mathematical Concepts with their test scores. Students had to first take a developmental course before enrolling in Mathematical Concepts. Some of these students may have taken two developmental courses, although all of these Group 2 students took the pre-requisite developmental course, Introductory Algebra, before enrolling into Mathematical Concepts. Table 8 summarizes the characteristics of the students in Group 2. The mean ACT score for students in Group 2 was less than the mean ACT score for students in Group 3 by 1.4. A T-test

revealed no statistically significant differences between the ACT scores for Groups 2 and 3 ($t = -0.63$, $df = 52$).

Students with placement scores above 19 are able to enroll directly into Mathematical Concepts. However, there are different reasons students take a pre-requisite course first instead of taking the course they have placed into. One reason is because students failed Mathematical Concepts so they decided to take the pre-requisite developmental course before trying to take Mathematical Concepts again. Another reason is that some students are returning to the university after several years and apparently want to improve or refresh their mathematics skills by taking the pre-requisite developmental course before enrolling in Mathematical Concepts. Yet another reason is that students get misplaced into their mathematics course. Their first placement test scores may put them into the pre-requisite developmental mathematics course, but their second set of scores may put them into Mathematical Concepts. Sometimes it is too late by the time the university receives these scores or advisors just over look them. Test scores for students taking the alternate placement tests are summarized in Table 9.

Students in Group 3 are the other half of the students under study for Research Question 3. These students' placement test scores were in the range where they *should have* taken the pre-requisite developmental course before enrolling in Mathematical Concepts. However, these students enrolled in the co-requisite sections of Mathematical Concepts instead of taking the pre-requisite developmental course. Students need to have scored a 17 or 18 on their mathematics portion of the ACT or an equivalent score on an alternate placement test for eligibility to enroll in the co-requisite section of Mathematical Concepts. Table 8 summarizes the characteristics of the students in Group 3.

Similar to Group 2, some of the students in Group 3 may be returning students who thought the co-requisite sections was a better fit for them instead of taking the pre-requisite developmental course first. Some of these students were students who had failed the regular section of Mathematical Concepts and were in need of some help in their mathematics skills but did not want to take the semester long pre-requisite developmental course first.

Students who qualified for the co-requisite sections of Mathematical Concepts still were given the opportunity to take a placement test and test into the regular section of Mathematical Concepts. While some students tested into the regular section, some students did not. Table 9 summarizes the characteristics of the placement tests that students in Group 3 took. Only seven students from Group 3 took an alternate placement test.

Research Question 3 was designed to compare pass rates of students in Group 2 to the pass rates of students in Group 3 in Mathematical Concepts. For this study, a passing grade was considered an A, B or C while a failing grade was considered D, E, Audit, Withdraw or an Incomplete. With the small number of data, both assumptions for Pearson's Chi-square was not met. Therefore, Research Question 3 cannot be answered.

Summary

For Research Question 1, in determining pass rates between students in Group 2 and Group 3 for College Algebra, there was a significant difference between the two groups of students. It is more likely for students in Group 3 to pass College Algebra compared to students in Group 2. Students in Group 3 have 3.5 times greater odds to pass College Algebra then students in Group 2.

For Research Question 2, in determining pass rates between students in Group 2 and Group 3 for the follow-up courses, only one course had enough information to run Pearson's

Chi-square test. Students in Group 3 were more likely to pass MAT 145 than students in Group 2. Students in Group 3 have 2.3 times greater odds to pass MAT 145 than students in Group 2. For the follow-up courses of MAT 220, CHE 105, CHE 111 and CHE 201, there were not enough data to determine significance or not.

For Research Question 3, in determining pass rates between students in Group 2 and Group 3 for Mathematical Concepts, there were not enough students or data entry values to run Pearson's Chi-square test.

Analyses

The results of this study are similar to the results of Complete College America. The Complete College America website states that students can succeed in their gateway course with some type of additional support. Only 10% of students starting in a developmental course finish their gateway course within two years (Vandal, 2014b). The results of this study show students were more likely to pass their gateway course without taking the pre-requisite developmental course. Therefore, the findings form the current study are consistent with those obtained by Complete College America.

Data collected from this study were reported back to CPE. Upon collection of data from post-secondary institutions from across the state, it was determined that the two-year pilot program was successful. Council of Post-Secondary Education is requiring all 4-year post-secondary institutions to phase out developmental courses for students over the next year. Instead of developmental courses, students will be offered co-requisite mathematics courses. Therefore, completing their gateway mathematics course within their first semester.

CHAPTER FIVE: DISCUSSIONS & CONCLUSIONS

Unfortunately, not all students who enroll in post-secondary institutions are college ready. Some students need to enroll in some type of support course before being able to enroll in their required gateway course. These support courses are called developmental courses. However, some post-secondary institutions are introducing alternate programs in the place of offering developmental courses. One of the programs gaining the most attention is called the Co-requisite Model where students do not take the needed developmental course (Vandal, 2014b) but instead enroll in the required gateway mathematics course simultaneously with a developmental course or enroll into a special section of the required gateway course where the developmental support is built into the course. The primary purpose for this study was to determine if the pass rates of students in the co-requisite sections of mathematics courses differed from the pass rates of students who took the developmental course first.

Summary of Literature Review

Developmental Education has changed over the past several years. First developmental education started out as a tutoring program to help students who were underprepared for post-secondary studies. Next it grew into a program to help students of all backgrounds with their weak academic skills. Lastly, it changed from remediating weak academic skills to the development of the student. Currently, there are a variety of ways to enhance the development of the student, including offering students various placement tests to assure they are in the correct mathematics course, offering support instruction for high-risk courses and offering various workshops along with tutoring in Learning Centers.

There are several reasons why students are underprepared for post-secondary institutions. Some students did not take the appropriate classes in high school, while others

returning to post-secondary institutions have been out of school for an extended period of time (Bailey, 2009a). Still others lack the academic confidence needed to be successful (Koch, Slate, & Moore, 2012). With more than two-thirds of students needing some type of developmental education (Koch et al.), States across the U.S. started taking a closer look at the cost of developmental education and started restricting funds to 4-year post-secondary institutions (Cafarella, 2014). This has caused post-secondary institutions to become creative regarding how to offer and how to change developmental education to their students. For example, Math Pathways, multiple assessments, Supplemental Instruction, accelerated developmental courses, Summer Programs, collaboration with local high schools and Learning Centers have been developed to address the developmental education needs of students.

The change that is receiving considerable attention in post-secondary institutions is the Co-requisite Model (Vandal, 2014b). The Co-requisite Model requires students to receive their developmental instruction at the same time they are enrolled in their gateway course (Boylan, 1999). However, post-secondary institutions provide the required developmental instruction differently. One version is when students enroll in the gateway course and enroll in a developmental course at the same time (Schak, Metzger, Bass, McCann, & English, 2017), while another version is when students enroll in a course with extended instruction time to incorporate the developmental material needed (Joint Statement, 2012). Yet another version of the Co-requisite Model is when students are required to attend a skills lab or tutoring (Vandal, 2014b). This allows each student to receive individualized instruction with the material. Another version of the Co-requisite Model is accelerated developmental courses (Vandal, 2014b). This is when students take the required developmental course during the first five weeks of the semester and then enroll in the gateway course for the rest of the semester. With many different versions of

the Co-requisite Model, post-secondary institutions can determine which version works best for them and alter it so it will best serve their students.

Summary of Methodology ad Data Analysis

Murray State University began offering co-requisite mathematics courses to their students beginning in fall 2016. Therefore, it was important to determine if students in the co-requisite sections were as successful as the students in the regular sections of College Algebra and Mathematical Concepts. It was also important to determine if students who took the co-requisite mathematics courses were successful in any follow-up courses they enrolled in.

Participants in this study were Murray State University students who had completed either College Algebra or Mathematical Concepts over the span of one and a half years. Students' mathematical skill levels ranged from needing the pre-requisite developmental mathematics course to having the skills needed to already having the skills needed to directly enroll into the required mathematics course. Mathematical skill level is how students were placed into the three different groups. Group 1 consisted of students who could directly enroll into their mathematics course based on their placement test score. Group 2 consisted of students who took the pre-requisite developmental before enrolling in their mathematics course. Group 3 consisted of students who should have taken the pre-requisite developmental course but instead took the co-requisite section of their mathematics course.

There were three research questions for this study.

Q1. Are there statistically significant differences between the pass rates of students in the co-requisite sections of College Algebra compared to students in College Algebra who took Intermediate Algebra first?

Q2. Are there statistically significant differences between the pass rates of both groups of students in the College Algebra follow-up courses?

Q3. Are there statistically significant differences between the pass rates of both groups of students in Mathematical Concepts?

Students' final grades from all the mathematical sections, along with placement tests scores were collected for this study. Grades were obtained from MSU's student database and departmental files. All collection procedures were in accordance with the approved IRB protocol. Student data was entered into Pearson's Chi-square non-parametric test to determine the results to the research questions.

Summary of Findings

Research Question 1. Are there statistically significant differences between the pass rates of students in the co-requisite sections of College Algebra compared to students in College Algebra who took Intermediate Algebra first? The results from Pearson's Chi-square test showed there is a significant difference in pass rates between students in Group 3 (who took the co-requisite section) and students in Group 2 (who took the pre-requisite developmental course). These results concur with the results from Complete College America which stated that students in a co-requisite section of mathematics had a better pass rate than students who took the developmental course first.

Research Question 2. Are there statistically significant differences between the pass rates of both groups of students in the College Algebra follow-up courses? Complete College America research only states success in gateway courses and not in follow-up courses. Likewise, there was no other research found about student pass rates in follow-up courses. However, Murray State University was interested with the pass rates of students in the follow-up courses as

well. MAT 145 showed no significant difference in pass rates between students in Group 2 and Group 3. Meaning students from both groups were equally likely to pass MAT 145. The remaining follow-up courses, MAT 220, CHE 105, CHE 111 and CHE 201, did not have enough student data for analysis. Therefore, the Chi-square test could not be used to determine any differences in pass rates between the two groups and the research question could not be answered for these four follow-up courses.

Research Question 3. Are there statistically significant differences between the pass rates of both groups of students in Mathematical Concepts? Pearson's Chi-square test could not be used to compare the pass rates of students in Group 3 (who took the co-requisite section) to students in Group 2 (who took the pre-requisite developmental course). There were not at least five students in each category to use as data values for the contingency table. Therefore, the Chi-square test could not be used to determine any differences in pass rates between the two groups and the research question could not be answered for Mathematical Concepts. Since the research question could not be answered, it cannot be compared to Complete College America's research.

Conclusion

One purpose of this study was to determine if students enrolled in co-requisite sections were as successful as students who took the pre-requisite developmental course first. The results of this study indicated that the co-requisite students performed better in College Algebra than those who took the pre-requisite course first. However, there is not enough data to determine if there is statistically significant differences for students in Mathematical Concepts. A second purpose of this study was to determine if students enrolled in the co-requisite sections were as successful as student who took the pre-requisite developmental course first in the follow-up courses. The results of this study show there was no significant difference for one of the follow-

up courses, MAT 145 meaning there is no difference in the pass rates between students in Group 2 and Group 3 however, there were insufficient data to answer this question for the other follow-up courses, MAT 220, CHE 105, CHE 111 and CHE 201.

For Research Question 1, the results show that students pass the co-requisite sections of College Algebra at a greater rate than students who took the pre-requisite developmental course first. This is a reassuring result since the state of Kentucky will not be offering developmental courses at four-year post-secondary institutions next year. However, there were still some students who do not pass either section of College Algebra. Only having one model or one choice of class instruction may not fit all students' learning styles. Instead of not offering developmental courses and only offering co-requisite sections, a variety of instruction perhaps still needs to be offered so all students can be successful no matter their learning style.

For Research Question 2, the results were mixed. The follow-up courses were of a greater concern to the researcher due to the fact that there is no extra support provided to students in these courses the same as there was extra support in the co-requisite sections of College Algebra. The findings for MAT 145 were reassuring because students in the co-requisite sections of College Algebra passed the same rate as students who took the pre-requisite developmental course first. However, the other four follow-up courses (MAT 220, CHE 105, CHE 111 and CHE 201) did not have enough student data to support Pearson's Chi-square test. Therefore, there were no results about the significance difference of pass rates between Group 2 and Group 3.

For Research Question 3, the results were not conclusive because there was insufficient student data to support Pearson's Chi-square test. Therefore, there were no results about the significance difference of pass rates between Group 2 and Group 3.

Discussion

From the results of this study, the researcher can conclude that students are successful in the co-requisite sections of College Algebra at Murray State University. The current version of the embedded Co-requisite Model is the right option for Murray State University's faculty and students. Even with students passing the co-requisite mathematics course at 3.5 times greater than students who took the pre-requisite developmental course first, not all students are passing the course. An evaluation of the curriculum and of the embedded version still needs to be evaluated.

The results from the follow-up courses, show there were no significant differences in the pass rates. This result states that students in the co-requisite mathematics sections are not missing any vital mathematics evaluations needed for the follow-up courses. Since there was not any research found about any differences in pass rates for follow-up courses, the results from this study are important for noting student success.

The Mathematical Concepts course did not have enough data to determine if there were any significant differences between the students in the co-requisite sections and the students who took the pre-requisite developmental course first. Collecting data over a longer period of time will be important to determine if the embedded version of the Co-requisite Model works for Mathematical Concepts or if revisions need to be made.

Limitations

As in most studies, there are limitations that need to be considered. These include the limited time span of data available and individualization of each course section. An obvious

limitation is the limited time span of data provided for this study. This study only contained students within three semesters of College Algebra. Even though there was over 1,200 students in College Algebra, only 13% of these students were enrolled in the co-requisite section of College Algebra. By having a greater number of student enrolled in College Algebra and a higher percentage of students in the co-requisite sections, this would provide for a more valid result for this study. Another limitation on the time span for this study is with the follow-up courses. Only two semesters of data was collected from the follow-up courses. This resulted in only 93 students in four different follow-up courses. One follow-up, CHE 201, did not have enough students enrolled within the two semesters to run in the statistical Pearson's Chi-square test. Being able to have more data than just two semesters would help validate this study with the follow-up courses. Mathematical Concepts only provided one semester of data in this study. Therefore, the validity of the findings could be questioned.

Another limitation of this study is the individualization of each course section. In both College Algebra and Mathematical Concepts, instructors use the same book and online program. However, the delivery of the material and the use of the online program is very different. This is especially true in the co-requisite sections of College Algebra. Instructors did not collaborate and set up all co-requisite sections in the same way. Some instructors used the first few weeks to have students work through the supplemental material, while other instructors had students work through the supplemental material throughout the semester. For this study, it was not determined if the follow-up courses were all taught with the same book and content. When courses are not taught the same, some students may have advantages that were not made available to other students. This does not create an even playing field. The instructors for the co-requisite sections in Mathematical Concepts did collaborate with each other. Both instructors met often to discuss

the content and the calendar of the class. Both sections offered the same material and the online program had the same guidelines. Instructors chose to incorporate the supplemental material in the same way during one day each week.

Recommendations for Future Research

From the findings in this study, further questions have developed. As discussed, the instructors in the co-requisite sections of College Algebra did not instruct the supplemental material in a uniform manner. Some sections provided the supplemental material during the first few weeks of the semester, while other sections provided the supplemental material one day per week. Therefore, how would the results to this study change if the co-requisite sections provided the supplemental material all in the same way? One recommendation is for the co-requisite sections to teach the supplemental material in the same way to determine if there are any effects on the outcome.

Also, the study did not collect data over an extended period of time. For this study, College Algebra collected three semesters worth of data while Mathematical Concepts only collected one semester worth of data. Over a longer period of time and a greater sample size, there would be more statistical power which would increase the confidence in the findings. A second recommendation is to collect data over a longer period of time to determine if there are any effects on the outcome. One semester worth of data is not a good predictor.

For this study, the College Algebra data from all three semesters was combined to determine the results to the research questions. However, post-secondary institutions use fall to fall semester comparisons in reports such as retention. Semester to semester comparisons could provide valuable insight to connections within semesters. Therefore, by comparing fall to fall

semesters, would the study show certain similarities or connections between students, grades, and the outcomes? A third recommendation is to compare fall to fall semesters.

Implications for the Findings

Based on the results of this study, the researcher would recommend universities decide which version of the Co-requisite Model will work best for their faculty and for their students. At first, universities need to be willing to adapt the co-requisite courses each semester based from their collected data. The collected data will help provide universities with information about what part of the Co-requisite Model is working for their students and what part of the Co-requisite Model needs to change to best fit the needs of their students. At Murray State University, the embedded version of the Co-requisite Model is the best version for their students. The findings for College Algebra concur with the findings of Complete College America.

Similarly, the researcher would recommend universities to study the pass rates of students in follow-up courses. As stated, there was not any research found about follow-up courses from co-requisite courses. Student success in their co-requisite mathematics course is important, however, if students cannot pass their follow-up course then how successful really is the co-requisite mathematics course? Collecting data from the follow-up courses can help guide the curriculum for the co-requisite mathematics courses to ensure student success.

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Tables

Table 1

Enrollment for Participants

	Group 2	Group 3	Male	Female
College Algebra	294	0	116	178
Co-req College Algebra	0	150	56	94
MAT 145	21	21	20	22
MAT 220	11	3	12	2
CHE 105	22	4	11	15
CHE 111	7	4	1	10
CHE 201	0	1	0	1
Mathematical Concepts	33	0	17	16
Co-req Mathematical Concepts	0	21	4	17

Table 2

Test Scores for Students in College Algebra

	Group 2	Group 3
ACT < 21	224	137
ACT ≥ 21	7	3
SAT < 550	34	4
SAT ≥ 550	0	0
KYOTE R < 27	98	15
KYOTE R ≥ 27	0	0
KYOTE CA < 14	23	18
KYOTE CA ≥ 14	0	0
COMPASS < 50	67	9
COMPASS ≥ 50	0	0
No Scores	17	9

Table 3

Test Scores for Students in Mathematical Concepts

	Group 2	Group 3
ACT < 19	26	19
ACT ≥ 19	0	1
SAT < 500	2	0
SAT ≥ 500	0	0
KYOTE R < 22	14	6
KYOTE R ≥ 22	0	0
COMPASS < 36	5	0
COMPASS ≥ 36	0	0
No Scores	3	0

Table 4

Characteristics of Students in MAT 140

Variable		
	Group 2	Group 3
Number of Students	294	150
Male	116	56
Female	178	94
Mean ACT	17.8	19.2
ACT Standard Deviation	1.76	1.21

Table 5

Characteristics of Alternate Placement Tests for Students in MAT 140

	Alternate Test	
	Group 2	Group 3
SAT number of tests	34	4
SAT Mean	438.8	462.5
SAT Standard Deviation	53.5	38.6
KYOTE Readiness number of tests	98	15
KYOTE Readiness Mean	13.3	16.0
KYOTE Readiness Standard Deviation	5.1	5.1
KYOTE College Algebra number of tests	23	18
KYOTE College Algebra Mean	9.8	12.0
KYOTE College Algebra Standard Deviation	4.3	2.8
COMPASS number of tests	67	9
COMPASS Mean	36.2	34.2
COMPASS Standard Deviation	8.5	7.6

Table 6

Contingency Table of Grades for MAT 140

MAT 140	Pass	Fail	Total
Group 2	123	171	294
Group 3	107	43	150
Total	230	214	444

Table 7

Contingency Table of Grades for MAT 145

MAT 145	Pass	Fail	Total
Group 2	11	10	21
Group 3	15	6	21
Total	26	16	42

Table 8

Characteristics of Students in MAT 117

Variable		
	Group 2	Group 3
Number of Students	33	21
Male	17	4
Female	16	17
Mean ACT	16.2	17.6
ACT Standard Deviation	1.22	0.73

Table 9

Characteristics of Alternate Placement Tests for Students in MAT 117

	Alternate Test	
	Group 2	Group 3
SAT number of tests	2	0
SAT Mean	435.0	0
SAT Standard Deviation	30	0
KYOTE Readiness number of tests	14	6
KYOTE Readiness Mean	12.6	19.0
KYOTE Readiness Standard Deviation	3.4	3.7
KYOTE College Algebra number of tests	2	1
KYOTE College Algebra Mean	7	7
KYOTE College Algebra Standard Deviation	1	0
COMPASS number of tests	5	0
COMPASS Mean	26	0
COMPASS Standard Deviation	4.9	0

Appendix A

Institutions Review Board Approval Letter

MURRAY STATE UNIVERSITY

Institutional Review Board

328 Wells Hall
Murray, KY 42071-3318
270-809-2916 • msu.irb@murraystate.edu

TO: Mandis Dunham
Dept. of Educational Studies, Leadership, and Counseling

FROM: Institutional Review Board
Jonathan Baskin, IRB Coordinator

DATE: November 27, 2017

RE: IRB # 18-012

Determination: Individuals not Identifiable - Activity does not involve human subjects as defined in 45 CFR 46.102(f)(2)

The MSU IRB has reviewed your student's application entitled, *The Effectiveness of the Co-Requisite Model in Preparing College Students for Math Courses*. Based on the information supplied on this application, it has been determined that your student's project does not involve activities and/or subjects that would require IRB review and oversight. Your IRB application will be kept on file in the IRB office for a period of 3 years.

Please note that there may be other Federal, State, or local laws and/or regulations that may apply to your project and any changes to the subjects, intent, or methodology of your project could change this determination. You are responsible for informing the IRB of any such changes so that an updated determination can be made. If you have any questions or require guidance, please contact the IRB Coordinator for assistance.

Thank you for providing information concerning your student's project.