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Effectiveness of a Corequisite Delivery Model for Developmental Mathematics

Katherine E. Fair
Eastern Kentucky University

EFFECTIVENESS OF A COREQUISITE DELIVERY MODEL FOR DEVELOPMENTAL MATHEMATICS

By

KATHERINE EILEEN FAIR

Thesis Approved:

Dr. Charles Hausman, Advisory Committee

Dr. Will Place, Advisory Committee

Dr. Daniel Mundfrom, Advisory Committee

Dr. Ryan Wilson, Advisory Committee

Dr. Jerry Pogatshnik, Dean, Graduate School

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Signature Kathleen S Fair

Date 11/13/17

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By

KATHERINE EILEEN FAIR

Master of Science
Michigan State University
East Lansing, Michigan
2008

Bachelor of Science
Michigan State University
East Lansing, Michigan
2005

Submitted to the Faculty of the Graduate School of
Eastern Kentucky University
in partial fulfillment of the requirements
for the degree of
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DEDICATION

This dissertation is dedicated to my husband, Joseph Fair, and my children, Landon and Carson, for their encouragement throughout this process.

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I would like to thank my major professor, Dr. Charles Hausman, for his guidance and patience. I would also like to thank committee member, Dr. Ryan Wilson for his words of encouragement and positive attitude throughout this long process. I appreciate Dr. Will Place for his thoughtful contributions and insight that improved my paper. I am deeply grateful to Dr. Daniel Mundfrom for being my sounding board and mentor, not only during this process but also throughout my career. With his help, I have grown into the educator that I am today. As a devoted educator for thirty-seven years my mother, Lynn Anderson, serves as my role model and inspiration in pursuing a doctorate in education. Through her loving support and commitment, she has helped me reach this finish line. I would also like to express my appreciation to my husband, Joseph, for his understanding and patience during those times when there was no light at the end of the tunnel. He cared for our children and took on managing the house while I was at school. He allowed me to pursue my dream and for that, I will be forever grateful. Finally, I would like to thank my father, Dale Anderson, and my sister, Emily Summers, for helping me keep balance in my life.

ABSTRACT

The purpose of this quantitative quasi-experimental study is to determine the effectiveness of a corequisite delivery model for developmental math students at a 4-year public institution. Nationally, close to fifty percent of incoming college students are placed in non-credit bearing remedial courses (Complete College America, 2012). Students must pass the remedial course before they can take the gateway college-level course. Data show that the traditional delivery of a non-credit-bearing remedial course before taking a credit-bearing course appears to help only a small percentage of students (Complete College America, 2012). The low pass rate of remedial courses supports the current trend to redesign curriculum and delivery of these courses. One redesign model is the use of corequisite courses. Corequisite courses place students into credit-bearing courses with integrated remedial content and support. The corequisite courses have mixed results (Goudas, 2015).

In this study, four classes of developmental students were each randomly assigned to the pilot corequisite liberal arts math class which included embedded Algebraic content, three extra teacher-student contact hours per week, and earned students college credit. The study also included four control liberal arts math classes composed of students who met the prerequisite requirements to take the college-level course. The sample included N = 89 students in the standard mathematics courses and N = 68 students in the corequisite courses. This study assesses the effectiveness of the corequisite delivery model for a liberal arts mathematics course.

When final group course scores were compared there was no significant difference. The adjusted mean overall course grade for the corequisite developmental

students was similar to the course grade for the students in the standard course. Students in the pilot course passed at the same rate as students in the standard course demonstrating the effectiveness of the corequisite model. Six covariates were examined including gender, race, income, first-generation in college, high school grade point average (GPA), and math ACT score. Only the covariates of high school GPA and math ACT scores were significantly correlated with the overall mathematics course scores. As there is a present movement to use corequisite mathematics courses with embedded algebraic content to save students time and money, it is important to explore what kinds of students are likely to succeed and what kinds of educational supports are effective.

Keywords: developmental education; remediation; remedial coursework; corequisite remediation; math education.

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LIST OF ABBREVIATIONS

American College Test ……. .....ACT

Analysis of Covariance ……..... ANCOVA

Accelerated Learning Project …….....ALP

Complete College America ……..... CCA

Center for Community College Student Engagement ……... .....CCCSE

Community College Research Center ……..... CCRC

Council for Postsecondary Education ……..... CPE

Developmental Education …….. ..... DE

Grade Point Average ……..... GPA

National Association for Developmental Education ……..... NADE

National Assessment of Educational Progress ……..... NAEP

Seamless Alignment and Integrated Learning Support ……..... SAILS

CHAPTER 1

INTRODUCTION

A significant challenge facing universities nationwide is the large portion of incoming students who are not college-ready. The current belief is that these students do not have the prerequisite knowledge and skills to successfully complete college courses without remediation. These "developmental students" are required to pay for and successfully complete non-credit-bearing remedial courses before they can enter the credit-bearing gateway courses. Remedial courses are non-credit-bearing because they are designed to teach precollege content; some remedial courses include study skills, critical thinking, and cognitive and affective behaviors (Boylan & Bonham, 2007). The assumption is that students who pass remedial courses will have sufficient skills to successfully complete college-level courses (Gula, Hoessler, & Maciejewski, 2015; Kentucky Developmental Education Task Force, 2007). Nearly 50 percent of incoming students are placed in remedial courses when entering postsecondary institutions (Complete College America, 2012). Forty-one percent of these students do not successfully complete remedial coursework (Chen, 2016). Redesign efforts are occurring across the nation as institutions of higher education look at how best to serve underprepared students.

With almost two-thirds of remedial students at four-year institutions failing to graduate in six years, there is a reason to reform remedial courses (Higher Education for Higher Standards, 2016). However, the reform movement has focused solely on remedial courses as the only cause for student attrition (Boylan, Calderwood, & Bonham, 2017). Only focusing on remedial courses has led policymakers to the conclusion that

developmental education is the primary reason that students do not complete college, when in fact there is a host of factors that contribute to low college completion. These factors include health, family, income, ethnicity, and cognitive ability. All of these factors need to be included in a more comprehensive reform movement to truly increase college completion rates (Boylan et al., 2017).

As described above the majority of underprepared students are not passing remedial courses. Redesigning the delivery of content to underprepared students is one method for trying to improve student success. There needs to be more refined research into which remedial course delivery models are effective in increasing student success. The purpose of this study was to determine the effectiveness of redesigning a remedial course into a corequisite liberal arts math course. Underprepared students were placed directly into a college-level liberal arts math course with embedded remedial content and extra support. These students bypassed the traditional prerequisite remedial course. This quasi-experimental quantitative research study compares the effectiveness of a corequisite delivery model for teaching developmental math versus the prerequisite sequence of a remedial mathematics course followed by a college-level mathematics course.

Background of Developmental Education

Established in 1976, the National Center for Developmental Education came at a time when there was momentum to remove developmental education from higher education (Boylan & Bonham, 2007; Cross, 1976). Legislators talked about eliminating developmental courses from 4-year institutions or limiting remedial courses to only community colleges. Despite this sentiment, developmental education has maintained its

place at universities and colleges. In 1984, the U.S. Department of Education included remedial courses in its research, thus recognizing developmental education's place in higher education. Over the last four decades, about the same number of students have continued to enter developmental courses at postsecondary institutions (Boylan & Bonham, 2007). Even though the enrollment of underprepared students remains steady, developmental education is again in the spotlight as momentum grows nationwide for eliminating or redesigning developmental education, with the goal of saving students' money and shortening the time to graduation.

In an article on the history of developmental education, Boylan & Bonham (2007) state:

> One of the more encouraging signs for the future of developmental education is that many states are taking it very seriously and encouraging their colleges and universities not only to provide developmental education but to provide it using the best available research and practice. These and other actions represent a trend toward state legislators and higher education executive officers recognizing the importance of developmental education to the success of higher education. (p. 4)

Since this statement was written, there has been a dramatic shift in sentiment surrounding the need for developmental education. This change in outlook is linked to the 2012 Complete College America (CCA) report titled *Remediation: Higher Education's Bridge to Nowhere,* which called for the elimination of developmental education based on a few research studies showing developmental students success in credit-bearing courses with

support (2012). Another report states, “Many in the field now acknowledge that developmental education is broken” (Center for Community College Student Engagement, 2016, p. 4). Proponents for developmental education point out the flawed research studies that some critics herald as the crucial evidence against all remedial courses (Bahr, 2008; Goudas & Boylan, 2012). One of the difficulties cited was that these studies looked at students who just missed the cutoff scores necessary to bypass remediation. Therefore, the ability to generalize the results to all students, especially those with much lower scores, should be done with caution, if at all. However, some educational organizations, legislators, and administrators are quick to call for the placement of all students into credit-bearing courses (Complete College America, 2012; Center for Community College Student Engagement, 2016; Bailey et al., 2013).

With state financial cuts to higher education and a push for performance-based funding, some stakeholders question the necessity of the money spent to reteach college students high school level material. Nationally, close to 50 percent of students will take a remedial course costing students and families across America about $1.3 billion every year (Higher Education for Higher Standards, 2016). A majority of these developmental students will not graduate from a four-year institution within six years (Complete College America, 2012). The cost of developmental education seems high when coupled with the low student success rate. With reform, however, remedial courses could become more effective and promote success in college-level courses for underprepared students. The corequisite model seeks to save students time and money by placing them directly into college-level courses allowing them to bypass the remedial course that traditionally

served as a prerequisite requirement for underprepared students. Underprepared students in the corequisite course receive additional supports to help them learn the material.

Significance of the Study

Over the last decade, there has been a push by educational organizations, state policymakers, and college administrators to redesign or eliminate developmental education. Due to low graduation rates of underprepared students, many are questioning the effectiveness of developmental education (Bahr, 2012; Bailey, 2009). The ongoing debate has resulted in redesign efforts across the nation as universities respond to low remedial student pass rates and retention, coupled with financial pressures linked to state performance funding. Developing the most efficient and effective method for handling these underprepared students is imperative in providing educational opportunities for all. Collins (2010) writes, "There is an extreme shortage of experimental research on developmental education" (p. 3). Identifying effective reform models that improve developmental student outcomes is critical for society and the student. However, there is limited research on effective redesign models for remedial courses. This study hopes to provide a systematic evaluation of a corequisite developmental model controlling for extraneous factors that might influence the results.

The systemic problem with education in America should be addressed at all levels. A higher percentage of students are graduating from high school, yet over 50 percent enroll in remedial courses (Complete College America, 2012). Only 41 percent of 2016 high school students who took the ACT met the math benchmark for college readiness (ACT, 2016). Therefore over half of graduating high school students are considered not ready for college-level mathematics. In a globalized marketplace, America

must cultivate well-educated workers. These workers will be the future backbone of America's ability to produce goods and services that successfully compete worldwide. It starts by facilitating streamlined, effective education that promotes college success.

The economic impact on the individual student's life is also high, with degreed students earning sixty-six percent higher annual salaries compared to their non-degreed counterparts (Kena et al., 2015). This increased earning potential facilitates economic prosperity throughout communities and eventually, the country. Data from 2013 show that individuals with bachelor's degrees or higher were three times less likely to be unemployed compared to high school graduates (Kena et al., 2015). It is imperative to find the most effective method for supporting developmental students through remedial content to graduation.

Many different reform models are being piloted at institutions across the nation, but the corequisite model has earned the most interest from policymakers and educators. The corequisite model places developmental students in credit-bearing courses with added supports. According to Denley (2016), this practice saves the student both time and money; which increases persistence and student outcomes. There is a large population of underprepared college students who are not earning degrees. The goal of this study is to determine the effectiveness of one reform model in supporting underprepared college students. The high percentage of student dropouts demands change, but the change must be well-researched, effective in promoting student success, and implemented correctly.

Purpose of the Research

Researchers (Attewell, Lavin, Domina, & Levey, 2006; Bahr, 2008; Bettinger & Long, 2009; Edgecombe, Jaggars, Baker, & Bailey, 2013) have shown that the current

model of developmental education may work for some students; however, the majority of underprepared students are not successful. Therefore redesigning the delivery of remedial courses is necessary. What remedial delivery model is the most effective and will become mainstream among institutions remains to be seen. It is an exciting and challenging time to be a developmental educator. This study examines one type of delivery model focusing on the use of a corequisite mathematics course which includes remedial content. This course compares a standard sequence of a remedial non-credit bearing mathematics one-semester course followed by the gateway mathematics course. Recent data indicate that two to three times as many students complete the credit-bearing course using the corequisite model compared to the traditional prerequisite sequence (Brown Foundation Grant, 2016).

Poor mathematics preparation is evident when a large number of students come from a rural and impoverished background. Students from affluent families are 78% more likely to earn a bachelor's degree in six years than students from low-income families (Attewell & Lavin, 2007). The Southern university where this study takes place serves a region of students who come from some of the poorest counties in the nation. Most of the underprepared students are first-generation college students from economically depressed areas.

Only 31% of high school students in Kentucky met math ACT benchmarks, compared to 41% nationally (ACT, 2016). In fall 2016, 21percent of incoming freshman at the university in this study needed one or more developmental courses (Office of Institutional Research, 2016). Students at this institution in developmental math work on concepts from arithmetic through Algebra I. The historic mission of this public university

has been a school of opportunity, yet this university like so many others has reached a precipice in which the institution must balance this mission with the realities of performance-based funding.

This study will analyze the results of placing developmental math students into a credit-bearing math class with embedded remedial content instead of a sequence of a remedial non-credit course followed by the gateway mathematics course. An embedded math class is defined by the Kentucky Association for Developmental Education as a class where the remediation content is embedded into the credit-bearing content. Statewide there is a new push for redesigning remedial courses into credit-bearing courses to help developmental students accelerate their time-to-degree. This dissertation will focus on one outcome in that process. The study will explore if completion of an embedded credit-bearing liberal arts math course is a successful approach to educating developmental students. Course scores, as measured by overall percentage score, for developmental students in the corequisite liberal arts math course are compared with course scores for students who met the prerequisite requirements to be in a general liberal arts math course.

The purpose of this study is to use selected variables including overall course grades to compare developmental students (math ACT 18 and lower) who are enrolled in a corequisite liberal arts math course with integrated algebra content (MAT 105E) with students who have met the requirements to take the standard MAT 105 course. A comparison of overall course grade differences while controlling for demographic variables between the two groups will provide valuable information about the effectiveness of the corequisite model. Much of the literature recommends more studies

on the effectiveness of redesign efforts and policies related to developmental education. This study will add to the literature surrounding this discussion. The goal is to assess the effectiveness of a corequisite math course in helping developmental students earn college math credit.

Research Question and Hypothesis

The question is if students who receive some algebraic remediation as part of a credit-bearing course can learn the material concurrently and complete the MAT 105E course with grades similar to those who have met the prerequisite for the standard MAT 105. The MAT 105E corequisite students served as the pilot group while students in the standard MAT 105 course were in the control group. This study explored differences in academic performance of developmental students enrolled in a corequisite credit-bearing liberal arts math course versus students who met the prerequisite by either passing a remedial math course or earning high enough placement test scores. The analysis controlled for six background variables including gender, race, income, first-generation college status, high school GPA, and math ACT score as covariates. The independent variable was the math course that the students completed and the dependent variable was the course grades of that math course.

Null Hypothesis: Developmental students who are placed in a corequisite liberal arts math course with embedded remedial content will earn equal academic outcomes (as measured by course grades) when compared to those students who met the prerequisite requirements for the standard liberal arts math course.

Alternative Hypothesis: Developmental students who are placed in a corequisite liberal arts math course with embedded remedial content will earn lower academic

outcomes (as measured by course grades) when compared to those students who met the prerequisite requirements for the standard liberal arts math course.

Limitations

A true experimental design with a completely random sample was not realistic for this study due to the limitations on selecting students for the pilot sections. While this quasi-experimental study randomly selected students initially and placed them in the corequisite course, some students chose not to remain there after reading the letter of consent (See Appendix A). Students choosing not to participate in the study limited the complete randomness of the sample as more motivated students may have chosen to participate in the pilot thus skewing the results. Also, to allow for adequate correspondence time, students who registered at the beginning of the summer were more likely to be a part of the pilot sample. Registration timing may have introduced some bias as students who registered at the end of the summer or later might have differed on some characteristics. It should be noted that students completing the standard math course were not randomly assigned to sections. Instead, they enrolled using the regular enrollment procedure for this university.

Another limitation includes the fact that the pilot and control groups did not continue to be equal in size, with 68 of the corequisite pilot group students completing the college level course while 89 of the control group students completed the standard math course. The study started with 89 students in the corequisite group and 111 students in the standard group. However, in the corequisite group 4 students withdrew, 9 students failed for non-attendance, and 8 students were dropped from the analysis for incomplete data. In the standard group 7 students withdrew, 7 students failed for non-attendance, and

8 students were dropped from the analysis for incomplete data. The student data not included in the analysis is a limitation. Did the population of students who withdrew or stopped attending have certain characteristics? The mortality rate was high, but comparable across groups. Lastly, data used in this study was collected during the fall semester of 2016. The short duration of data collection, one semester, is another limitation that restricts the ability to generalize results. One semester of data was used in order to control for changes from semester to semester.

Assumptions

The researcher assumed that the teacher differences in style and ways of presenting content were relatively constant because each of the four teachers involved taught one corequisite course and one standard math course. All four instructors also used the same textbook, power points, assignments, quizzes, and tests. The grading scale was the same with five tests accounting for 75 percent of the overall course grade and the other 25 percent from assignments and quizzes. Another assumption was that those students who dropped out of either the corequisite or standard sections were relatively equal in their perceived inability to pass the course. The reasons for these perceptions could have included many variables from lack of academic preparation to lack of money, time, home life, etc.

Definition of Terms

Academic Outcomes: "represent the skills, knowledge, and abilities that students develop through their coursework and other educational experiences" (Academic Outcome Goals, 2017).

Borderline Students: Developmental students who have placement scores just below the cutoff requirements for college-level courses.

College Readiness: "the acquisition of knowledge and skills a student needs to enroll and succeed in credit-bearing first-year courses at a postsecondary institution" (ACT, 2016).

Corequisite Remediation: Providing remediation simultaneously with college-level content in a single semester (Boylan, Bonham, & Calderwood, 2017).

Developmental Education: "Developmental education is a comprehensive process that focuses on the intellectual, social, and emotional growth and development of all students" (NADE, 2017).

Developmental Student: students who are underprepared for the postsecondary educational content.

Non-developmental student: students who have demonstrated competency based on test scores to enter college-level courses.

Non-credit bearing course: a course that does not count for credit towards graduation.

Performance-based funding: state funding formula based on college and university performance and student outcomes.

Remediation: "refers to stand-alone courses addressing pre-college content" (Boylan, Bonham, & Calderwood, 2017).

Remedial coursework: sequences of courses in basic subjects intended to help students advance their skills up to the level expected of a new college student (Bahr, 2012).

CHAPTER 2

LITERATURE REVIEW

Viewpoints on Developmental Education

The goal of this literature review was to examine the relevant literature to describe the viewpoints and variables related to the effectiveness of developmental education. A systematic review of the main research studies on the effectiveness of remedial math courses was performed to produce a narrative synthesis**.** A frequency analysis of articles written by researchers and experts on developmental education is shown in Table 2.1. After clustering main research articles by content area and main contributors, I developed an overall understanding of different opinions and research studies that explored various aspects of developmental education.

From Table 2.1 it is evident that researchers Attewell, Lavin, Domina, and Levey (2006), Bahr (2008), and Boylan, Bonham, and Rodrequez (2000) support the need for remedial courses and their effectiveness for students who complete and go on to take the subsequent college-level math course. These researchers found that the courses help borderline students who pass the remedial course go on to complete a college-level course, but improvements can be made to help more students pass the remedial course. Critics of the traditional delivery of developmental education include Bailey (2013), Boatman (2010), and multiple reports from Complete College America (CCA) (2012, 2015). CCA calls for the redesign or elimination of developmental education, so underprepared students are placed directly into credit-bearing pathway courses. The research shows that traditional remedial courses are not working for a lot of developmental students, but there are mixed results on what reform methods are the most

effective. Collins (2010), Calcagno and Long (2008), and Martorell and McFarlin (2011) note that there needs to be a variety of course offerings and developmental supports to help the diverse developmental student population.

Table 2.1

Frequency Analysis by Remediation Topic

	Against Remedial Courses			**For Remedial Courses**			**Mixed**
Reason	**Outcomes**	**Cost**	**Borderline**	**Outcomes**	**Placement**	**Flawed Research**	**Need variety**
Attewell et al. (2006)				X			
Bailey et al. (2013)	X	X	X				
Bailey et al. (2010)	X						
Bahr (2008)				X	X	X	X
Bettinger & Long (2007)				X			X
Boatman & Long (2010)	X		X				X
Calcagno & Long (2008)							X

Table 2.1 (continued)

	Against Remedial Courses			For Remedial Courses			Mixed
Reason	**Outcomes**	**Cost**	**Borderline**	**Outcomes**	**Placement**	**Flawed Research**	**Need variety**
Collins (2010)							X
CCA (2012)	X	X					
CCA (2015)	X						X
Edgecombe et al. (2013)	X			X			X
Goudas & Boylan (2012)				X		X	X
Goudas (2015)				X		X	X
Levin & Garcia (2013)				X			
Martorell & McFarlin (2011)	X						
Saxxon et al. (2014)				X	X		

The brief frequency analysis in Table 2.1 was used to identify main contributors on either side of the debate regarding whether developmental education is a worthwhile endeavor at postsecondary institutions. The majority of articles reviewed were quantitative studies on the outcomes for underprepared students in remedial math. The literature shows a great deal of diversity among results. Developmental education has been shown to have a negative influence (Matorell & McFarlan, 2011), no influence (Calcagno and Long, 2008), or a positive influence (Bettinger & Long, 2009). Thus, it remains unclear as to the influence of remedial courses and the processes that are most effective for underprepared students.

In spite of conflicting research, a growing trend centers on redesigning developmental education to reduce course sequences and accelerate students through remedial content (Center for Community College Student Engagement, 2016; Complete College America, 2012). Students with developmental needs have been shown to have lower retention and graduation rates than the general student population (Bailey, Jeong, & Cho, 2009; Zientek et al. 2013). A 2006 study found that only 28 percent of students who took at least one remedial course graduated with a credential in 8.5 years (Attewell, Lavin, Domina, & Levey, 2006). This outcome draws national attention as the role of postsecondary institutions begins to shift from an enriched educational experience to a consumer-driven business model with performance-based funding (Kentucky's Guiding Principles, 2015). The positive development that is occurring as a result of this public focus on the low retention and graduation rates of developmental students has been the increased research on how to improve student outcomes (Bahr, 2008; CCA, 2012;

Denley, 2016). Figure 2.1 below shows the increasing trend of publications on topics in developmental education over time.

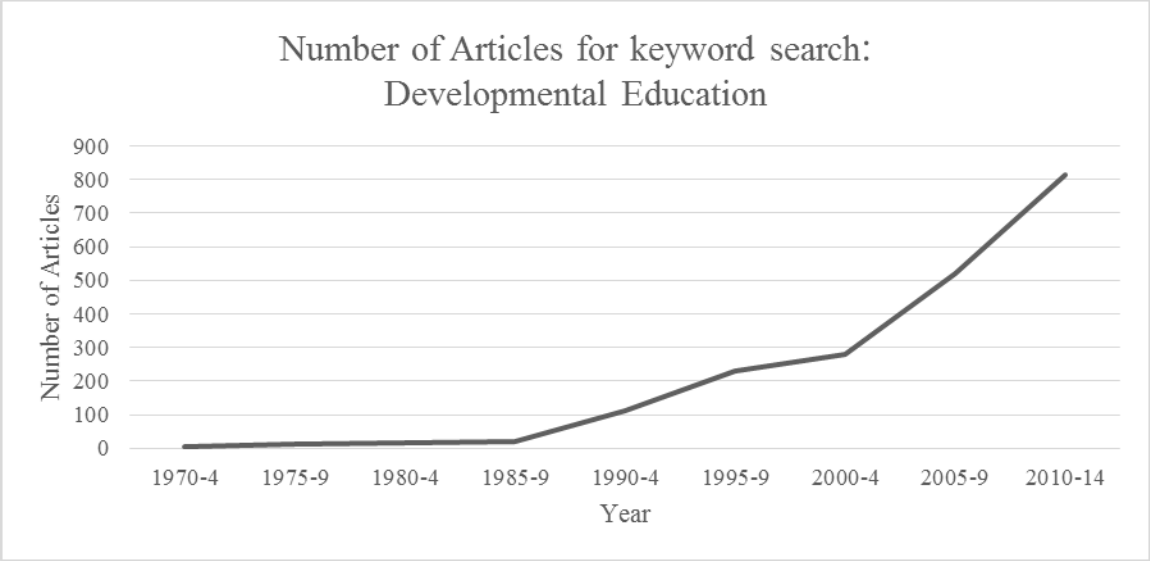

Figure 2.1. Number of articles published on developmental education over time

Major educational organizations and policy advocates have increased exploration of ways to improve developmental education at postsecondary institutions in recent years. The percentage of degree-granting postsecondary institutions offering remedial services has dropped less in the last decade in comparison to the previous decade, demonstrating the need for developmental services (National Center for Education Statistics, 2014). Figure 2.2 is a line graph showing the change in the percentage of 4-year institutions offering remedial courses since 1994. In 1994, 85.3 percent of public 4-year institutions offered remedial courses compared to 74.8 percent still offering these courses in 2014. From 1994 to 2004 the percentage of public 4-year institutions offering remedial courses dropped 8.0 percent, while from 2004 to 2014 the drop was only 2.5 percent. Thus, the overall rate of the drop has slowed in the last decade. The majority of 4-year public institutions are still admitting underprepared students and administering remedial courses.

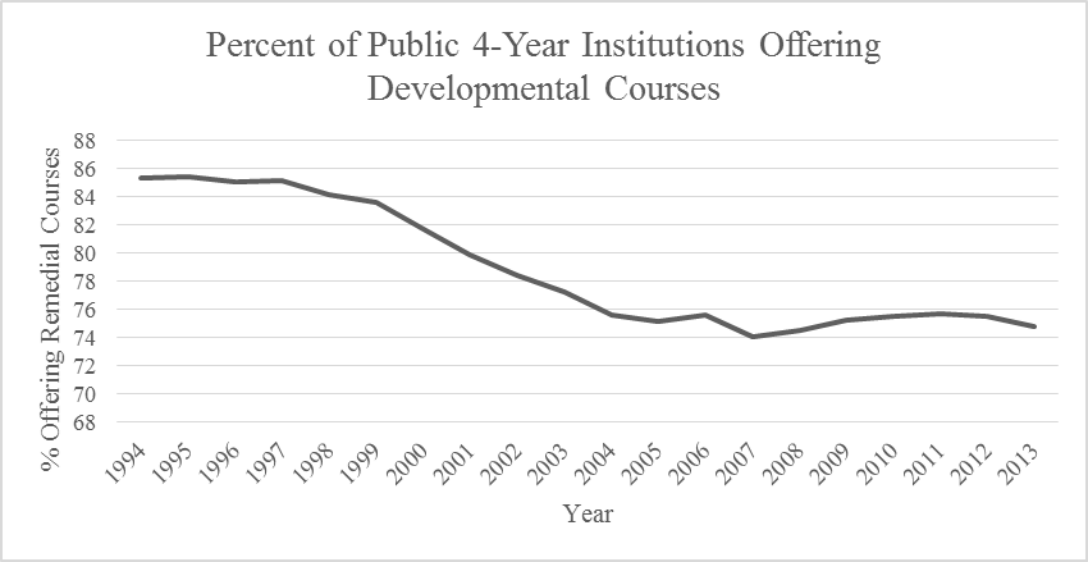

Figure 2.2. Change in the percentage of 4-year institutions offering remedial courses since 1994

Debate over the Effectiveness of Developmental Education

There is a continuing debate over the effectiveness of developmental education at postsecondary institutions. Michael Collins, Program Director at Jobs for the Future, states, "Researchers are divided over whether or not developmental education helps academically underprepared students enter and be successful in college-credit courses" (2010, p. 2). Researchers need to be careful when using the term developmental education. According to Boylan, Calderwood, & Bonham (2017), the term developmental education includes not only remedial courses but also support services that help at-risk students navigate college. However, many researchers are referring to remedial courses when they use the words developmental education. Traditional remedial courses lengthen students' course sequences, increase the financial burden on students, and may not prepare students for college-level work (Bailey et al. 2013). The low pass rates for

remedial courses justify the need for reform of the curriculum and pedagogy but not the entire elimination of developmental education.

There are a few rigorous studies that have evaluated the effectiveness of developmental education. However, results are mixed and limited due to the many nuances that factor into student outcomes (Boatman & Long, 2010; Calcagno & Long, 2008; Goudas & Boylan, 2012). Consistent measurement of gatekeeper course pass rates, retention, and graduation rates should be analyzed in a longitudinal study to determine the effectiveness of developmental education (Collins, 2010). In his presentation at the National Association for Developmental Education (NADE) conference, Goudas (2015) took a critical look at the reform models and warned that despite the headlines and push for reform improvements, research findings on student outcomes are small or null. National educational research centers, such as Complete College America (CCA) and Community College Research Center (CCRC), publish findings that have titles and abstracts that emphasize positive outcomes of credit-bearing models without mentioning limiting factors. This omission may lead policymakers and novice researchers to generalize the ineffectiveness of developmental education and press for reform.

The ongoing debate over the effectiveness of developmental education rests on conflicting research. Some argue that there is a lack of quality quantitative research studies with sound research methodologies (Bailey, 2009; Bahr, 2009; Calcagno & Long, 2009; Goudas & Boylan, 2012). Many regression-discontinuity (RD) studies look at students just above and below placement cut-off scores controlling for student differences (Bettinger & Long, 2009; Boatman & Long, 2010; Calcagno & Long, 2008). These studies provide insight on placement and remediation for borderline students but cannot

be generalized for all developmental students. Some researchers and politicians take findings from research on borderline students and make broad statements on the ineffectiveness of developmental education (Center for Community College Student Engagement, 2016; Complete College America, 2012).

A regression-discontinuity (RD) research design used by Boatman & Long (2010) analyzed data from Tennessee's postsecondary institutions and found that students who were borderline developmental and took the remedial Algebra II course had lower persistence and degree completion compared to those students who took college-level math. Bailey & Cho (2010) summarized the mixed results on developmental education stating, "We know very little about the effectiveness of developmental education for students who score well below the cutoff score" (p. 47). The RD research studies make a note of this limitation, yet some policymakers and organizations, such as Complete College America (CCA) and the Community College Research Center (CCRC), call for the end of separate developmental courses based on this restricted data. The results do not identify ways to help very low scoring developmental students pass redesigned remedial courses. These authors point to the large proportion of students who are unsuccessful in the current remedial math courses without identifying if borderline developmental math students (ACT 17-18) complete courses more frequently than those with lower ACT scores. Another limitation of the cited RD studies is the use of data from multiple colleges which have varying levels of support services which introduce outside factors that could influence the results. Those who believe in placing developmental students directly into credit-bearing courses (Bettinger & Long, 2009) may need to define what

kind of developmental students are most likely to succeed in combined college-level courses, as well as what kinds of support systems are most helpful.

There are many benefits to understanding mathematics no matter how the content is delivered. Former President of NADE, Marcella Davis, once wrote: "NADE leaders and practitioners have long realized the truth of research data which show that mathematics is the academic area of most difficulty for the greatest percentage of underprepared postsecondary students" (Boylan, 2011). Bettinger & Long (2009), reported positive results for a limited sample of students who took remediation in Ohio. They found math remediation increased the likelihood of completing a degree within six years for marginal students. However, more research is needed for extremely underprepared students. Only 17 percent of students at the lowest level of remedial math complete the sequence of courses compared to 45 percent of students in the highest level of math remediation completing the required course sequence (Bailey, Jeong, & Cho, 2010).

University faculty in Texas and Florida had reported data showing that students who took remediation before college-level work had comparable results to similar students who only took the college-level course (Calcagno & Long, 2008). Goudas & Boylan (2012) argue that similar outcomes for underprepared students should mean that developmental education is effective in remediating prerequisite skills. Another benefit of remediation is the fact that knowledge of basic mathematics has been shown to lead to success in college-level math courses (Gula et al., 2015; Martorell & McFarlin, 2011; Bahr, 2009). Developmental courses can establish a solid foundation that supports the future study of mathematics. Even supporters of corequisite college-level courses

highlight the need for more research before sweeping changes to developmental education that affects all students, especially the most underprepared, vulnerable students (Camara, 2003; Bettinger & Long, 2009).

Student Placement in Remedial Education

One difficulty with student placement into developmental math rests on how to design course sequences and support systems that are most effective for all levels of students. Placement into developmental courses needs to take a multi-faceted approach integrating test scores, past academic performance, and personal characteristics (Boylan, 2009; Saxxon, D. P. & Morante, E., 2014). Relying on a single test score cut-off is not the best strategy for placing students in courses. "Moreover, there is no obvious point of discontinuity in the distribution of the cutoff scores that might provide a meaningful point to distinguish between "remedial" and "college-ready" students" (Bailey & Cho, 2010, p. 47). Institutions need to develop a multilayered approach to placing, supporting, and instructing developmental students based on the level of preparedness (Bailey & Cho, 2010). Consideration should be given to standardized test scores as well as high school GPA, attendance, and lifestyle issues when placing students into developmental courses.

Much of the research focuses on the use of standardized test scores as an admissions criteria. Using standardized test scores as the main component of college admissions has been disputed for years. Opponents argue that students can prepare for tests by improving their test-taking abilities without gaining intellectual ability (McArdle, Paskus, & Boker, 2013). Proponents state that standardized tests provide a common platform to judge applicants' knowledge equally (Winters & Gurney, 2012). Placement using high school GPA has also become a controversial strategy. According to research

by Geisinger (2009), high school GPAs have become so inflated that they no longer serve as a good measurement of cognitive ability. Winters' (2012) study comparing GPA and test scores found that high school GPAs were similar despite significant differences in basic academic skills. The results show that students marked as having similar academic abilities based on GPA, in fact, differed greatly in word recognition, sentence comprehension, and spelling skills. Standardized tests scores were found to more accurately depict students' basic skills and college readiness compared to high school GPA (Winters & Gurney, 2012). This finding contradicts a multilevel multivariate analysis done by McArdle, Paskus, and Boker (2013), which showed that high school grades are the best available predictors for college freshman grades (p. 57). Due to the conflicting results a combination of ACT score, high school GPA, and other factors need to be used when placing students in college courses.

Other variables may impact success in a college-level mathematics course such as gender, race, income, and first-generation college status. Research shows that student characteristics that contribute to attrition include low-income, ethnic minority, and first-generation (Attewell & Lavin, 2007; Camara, 2003). Students of color or low-income enroll in remediation at higher rates than their white and higher income peers (Chen & Simone, 2016; Higher Education for Higher Standards, 2016). Nationally, only 13 percent of African American high school students who took the ACT in 2016 met math benchmarks, compared to 50 percent of white students meeting benchmark (ACT, 2016). According to the National Assessment of Educational Progress (NAEP), twelfth-grade students with parents who graduated from college earn 24 points more on standardized assessments than their peers who would be first-generation college students (Kena et al.,

2015). First-generation students are 14 percent less likely to persist in college beyond three years compared to students with parents who have a four-year degree (Camara, 2003). The factors of math ACT score, high school GPA, gender, race, income, and first-generation status discussed above will be covariates in this study. Exploration of the impact of these on final course scores will help determine issues of student placement as well as success in courses.

Non-cognitive characteristics are also important factors in placement and college success. Advising takes on a critical role in assessing student affective traits. A 2013 study by Zientek et al. found that affective variables predict 41 percent of grade variance for developmental math students. Study skills, motivation, and self-efficacy had a substantial impact on academic success. Saxxon and Morante (2014) recommend aligning high school skills with placement testing, providing practice material for the placement test to students beforehand, using summer bridge programs, using test cut score ranges, and including high school performance as a proxy for effective skills. According to Barry and Dannenberg (2016), there is a public misconception that the all remedial students are low income. In fact, 45 percent of remedial students come from middle and high-income families (defined as household income $48,000 and up). This finding further emphasizes the breadth of students served by developmental services and the need to include a variety of indicators in placing students.

Costs of Remedial Education

The cost of developmental education has two components: the cost to the student and the cost to society. Regarding societal costs, policymakers and institutions are currently questioning the resources and energy devoted to helping remediate

academically underprepared students when outcomes are much less than expected (Collins, 2010). For the individual, Levin and Garcia (2013), found that educational attainment has a large impact on the financial prospects for graduates as well as society. However, with only one-third of developmental students graduating within six years, many students who do not complete college will not reap these benefits (Higher Education for Higher Standards, 2016).

According to the U.S. Department of Education's annual report entitled "The Condition of Education" in 2009, 76 percent of high school graduates took Algebra II/ Trigonometry during high school. However, Bailey (2009) reports that 40 percent of students enter college in need of mathematics remediation, so there is an obvious difference between high school "success" in an algebra course and the prerequisite knowledge for first-year college courses. The cost of having to reteach students material already taught in high school is certainly one of the factors considered in the debate over the need for developmental education at postsecondary institutions.

Student Costs

A recently published study by the nonprofit organization Education Reform Now finds that there is a widespread failure in the K-12 system in preparing high school students for college (Barry & Dannenberg, 2016). One in four recent high school graduates, or half a million students, enroll in a developmental course their freshman year (Barry & Dannenberg, 2016). First-time bachelor degree-seeking students placed in remedial courses are 74 percent more likely to drop out from college compared to students without developmental needs (Barry & Dannenberg, 2016). Students entering college remediation come from all financial backgrounds and face the extra cost of

learning content they did not learn in high school (Barry & Dannenberg, 2016). These new college freshmen spend 1.3 billion dollars annually in out-of-pocket expenses on developmental courses (Higher Education for Higher Standards, 2016). In other words, each student spends about an additional $2,600 on learning material that was not mastered in high school thus prolonging their educational experience. When remediation is designed as separate non-college credit courses, it prolongs the time to graduation and keeps the student out of the workforce for a longer period. The U.S. Department of Education reports that in 2012-13, 85 percent of students at 4-year institutions received financial aid (Kena et al., 2015). With over 13 percent of students on these loans defaulting within three years of repayment, prolonging time-to-graduation can cost students and society immensely (Kena et al., 2015).

On top of the obvious cost of remedial courses, developmental students incur secondary opportunity costs regarding loss of income while in school (Barry & Dannenberg, 2016). Underprepared students who persist take an average of eleven months longer to graduate; almost a year of lost earnings compared to their prepared counterparts. Lifetime income loss is much higher for those students who do not persist past remedial courses and thus never obtain higher paying jobs. According to data, students who do not the complete college will live shorter, unhealthier lives, be more likely to be unemployed, and have limited economic opportunities (Kentucky Developmental Education Task Force, 2007).

The U.S. Department of Education's annual report for 2015 found that young adults with bachelor's degrees earn on average $48,500 annually compared to high school graduates annual earnings of $30,000 (2015). "Workers with more education are valued

more highly in the workplace because they tend to be more proficient at jobs, benefit more from additional training, and make better and more productive decisions in the allocation of resources, including the use of their own time" (Levin & Garcia, 2013, p. 23). The economic impact of completing a college degree can change a developmental student's life, thus highlighting the importance of effective remediation.

Societal Costs

Legislators and taxpayers are concerned with the estimated $1.3 billion annual cost of administering developmental education at postsecondary institutions (Higher Education for Higher Standards, 2016). Resources and money are used to teach students the same material twice, first in high school and again in remedial college courses. The redundancy combined with the ineffectiveness of remedial courses supports a drastic overhaul, if not elimination, of developmental education (Complete College America, 2012). Others believe that with sufficient remedial coursework (either before or within a course) and other support systems underprepared students can benefit from developmental education (Boylan, Calderwood, & Bonham, 2017; Bahr, 2008).

Without increasing the educational attainment of Kentucky's citizens, the per capita income will remain below the national average, and tax revenues will flat line (Kentucky Developmental Education Task Force, 2007). As mentioned above, college graduates have higher annual salaries contributing to society by paying higher income taxes (Levin & Garcia, 2013). Society also benefits from a reduction in public assistance, health needs, and crime. (Levin & Garcia, 2013). Effective developmental education that increases student success can have a substantial impact on the economic benefit of higher education for individuals as well as society.

Alternative Delivery Models for Remediation

The need for alternative delivery models for remediation arose as states began pushing to eliminate developmental courses at universities, while universities were still allowing underprepared students to enroll. The ultimate goal was, and still is, to improve the success of remedial students. Delivery options being touted as solutions include accelerated course sequences, redesigned course options, or the elimination of developmental courses entirely (Saxxon, D. P. & Morante, E., 2014). Many organizations and researchers argue that redesigning developmental courses should include the delivery of content in a credit-bearing college course (Boatman & Long, 2010; Complete College America, 2015; Center for Community College Student Engagement; 2016). A limitation of the current research is the lack of consistency among delivery models, support services, student populations, and even terminology. Establishing pathways to help streamline students' coursework and provide a clear direction to graduation is a technique popularized at community colleges (Bailey, Smith Jaggars, & Jenkins, 2015). Boatman (2012) found students in redesigned developmental math courses were more successful than students in non-redesigned developmental courses. Redesign efforts should focus on identifying what students need to know for a future career or academic major, instead of past skill deficits (Boatman, 2012). Below is an overview of the different types of delivery models being used nationwide to remediate student deficiencies while providing college credit.

Accelerated Models

The accelerated model, also known as fast-tracking or compressing courses, allows students to complete more than one class in a semester. The FastStart math

program is an accelerated developmental program model at the Community College of Denver. A regression analysis on student outcomes found that FastStart developmental students progressed at an accelerated pace but completed the developmental sequence with the same level of preparedness as students who took the traditional developmental math courses (Edgecombe, et al., 2013). A highly touted accelerated delivery model known as the Accelerated Learning Project (ALP) began at the Community College of Baltimore County in Maryland. Students in ALP take remediation with the college-content material in the same semester. In West Virginia, students in the ALP program improved their pass rates in gateway math courses by 48 percent, while scores increased by 50 percent in Tennessee (Boylan, Calderwood, & Bonham, 2017). Since 2009, other states using ALP include Indiana, Michigan, Virginia, and Colorado.

Other researchers are hesitant to applaud acceleration and other models pointing to data that single classroom interventions do not necessarily improve long-term outcomes such as retention and college completion (Boylan, Calderwood, & Bonham, 2017; Cho, Kopko, Jenkins, & Jaggars, 2012). Despite the success of accelerated learning, former NADE president Rosemary Karr warns, "The opportunity to accelerate should be available to students, and some students will be able to do so; however it cannot be forced acceleration. Underprepared students will not always be able to "learn it faster!" (Diaz, 2010, p. 25). Edgecombe et al., (2013) recommends incorporating many academic and non-academic practices into accelerated or integrated courses to support student achievement.

Corequisite Models

One of the main issues related to developmental education is the fact that students are paying for non-credit bearing courses. Corequisite courses were designed to address this issue by placing developmental students in credit-bearing college-level courses while remediating student deficiencies. The method for corequisite remediation varies among institutions. It ranges from a linked parallel non-credit bearing developmental course to embedded remediation within the corequisite course using extended contact time. In the linked parallel corequisite delivery, students take the college-level course and developmental course the same semester. Students save time by taking both courses in one semester but do not save money since they are still paying for both courses.

Another method for delivering corequisite courses are embedded models that have learning support competencies taught throughout the course content providing what is called “just-in-time” remediation. The student only needs to register for the embedded corequisite course to earn college-credit in one semester. The topics from the developmental course are aligned with the college course. The goal for redesigning remedial courses into corequisite courses is to help students successfully pass a credit-bearing course their first semester, thus reducing their time-to-degree and costs.

Tennessee converted all developmental courses to a corequisite format in 2012 and reported positive student outcomes. Pioneered in 2007 at Austin Peay University, the corequisite delivery model improved outcomes for developmental math students (Denley, 2016). In the corequisite model, over 70 percent of students completed a credit-bearing math course in one semester compared to less than 10 percent completing a credit-bearing math course over multiple semesters using the traditional prerequisite model

(Denley, 2016). In Tennessee, any student who earns a "D" in the corequisite college course passes the class, even if the student fails to learn the remedial material. Complete College America (2015) has touted data from Indiana, Tennessee, and West Virginia with results showing students in corequisite entry-level math courses five to six times more successful than students following the traditional developmental math sequence. As a major advocate for the corequisite delivery model, CCA does stress the need for mandatory tutoring or extended instructional time to support students (Smith, 2015). The most recent data from 2016 shows the corequisite model has improved pass rates for gateway mathematics courses in West Virginia community colleges from 14 percent to 62 percent and from 12.3 percent to 63.3 percent in Tennessee (Complete College America, 2016).

Despite the many changes occurring in developmental education, there are still gaps in the literature surrounding the effectiveness of delivery models. Further research is needed to verify the effectiveness of the corequisite delivery model for all developmental students. A pilot study at Ivy Tech reported that when running parallel courses the sections needed to be connected and taught by the same instructor for the best results (Goudas, 2015). Corequisite models have been shown to have limited success for mostly borderline students (those with ACT scores in the 16-18 range) thus; it is not necessarily the solution for all developmental students (Goudas, 2015).

Comprehensive Reform Models

Developmental education is more than just the delivery of remedial material. One model will not serve all developmental students well; instead, comprehensive services should be coordinated and deliver the best remediation possible (Boylan, Bonham, &

Rodriguez, 2000; Goudas, 2015). In Collins' article, *Bridging the Evidence Gap in Developmental Education,* there are recommendations for longitudinal studies measuring student progress, incentives for institutions to refine remedial courses, and policymakers who understand the need for innovation by removing institutional barriers (2010). There should be a broad reform of all services offered to underprepared students to improve the success rate of this vulnerable population.

There are a few reform movements that have seen positive results using a more comprehensive, systematic approach. The Accelerated Study in Associate Programs (ASAP) of the City University of New York offers free tuition, books, transportation, and small classes, helping to alleviate outside factors that play a role in student attrition (Boylan, Calderwood, & Bonham, 2017). Wraparound services include monthly advisor meetings, mandatory tutoring, block scheduling, and a career specialist meeting. Results from Levin and Garcia (2013) using data from ASAP support comprehensive reform for underprepared students. The sample included 896 developmental students over 2.5 years. The ASAP cohort had a 33 percent graduation rate compared to the 18 percent rate in the control group.

The Integrated Basic Education and Skills (I-Best) in Washington is another program that supports developmental students in career programs through mentoring, advising, and social services to support the student outside of the classroom. These programs support students throughout college with curriculum design, pathways, and support services structured with the student in mind. In contrast, many other reforms only focus on remedial course delivery or curriculum in an isolated, short-term fashion (Boylan, Calderwood, & Bonham, 2017).

Theories of Student Development

Student development theory applies to the current landscape of developmental education. The main vector of student development theory according to Chickering (1993) is competence. Remedial courses can provide students with substantial growth in intellectual competence by providing a "repertoire of skills to comprehend, analyze, and synthesize" content (Chickering & Reisser, 1993, p 1). Basic assumptions of student development theory rely on the individuality of students, the college environment, and student responsibility for learning (Astin, 1984). Within the broad student development theory are the subject-matter theory, resource theory and individualized theory that each play a role in the remediation redesign efforts that are underway. These theories provide the basis for many decisions made at universities regarding student learning.

Subject-matter theory (also known as content theory) emphasizes that learning occurs by exposing students to subject matter through expert lecture and notes (Astin, 1984). Currently, this traditional delivery of developmental education has been found to be ineffective, thus establishing the need for various course redesign efforts. Passive learning regarding subject-matter theory has resulted in non-engaged, non-motivated developmental students (Astin, 1984). Redesigning the delivery of content has shown some early success (Complete College America, 2016; Higher Education for Higher Standards, 2016). However, many factors affect a student's performance besides the delivery of coursework. Administrators and educators agree that too many students are failing developmental courses, dropping out, and not earning credentials. Administrators tend to follow the resource theory believing that improved facilities, support services, and financial aid will benefit student learning (Astin, 1984).

The individualized theory focuses on the proper support services needed for student success (Astin, 1984). Burnett (2011) points to four components: placement, tutors, advising, and evaluation as factors for success in developmental education. According to Burnett, these support services are more important in determining student success than the design of developmental courses (2011). Self-paced learning, pathways, and proper placement all fall under the individualized theory. Students who have a clear, focused pathway towards their degree see value in learning applicable content and persisting to graduation (Burnett, 2011).

Self-efficacy in cognitive development theory is also emerging as an important basis for corequisite credit-bearing courses. Self-efficacy has been shown to be an important contributor in motivation and academic development (Bandura, 1993; Zientek, 2013). One study concluded that self-efficacy has almost the same impact on mathematics achievement as intellect (Pajares & Miller, 1995). According to Bandura (1993), an individual's actions are influenced by observing the actions of others. The cognitive development theory suggests that there will be an increased success if all students are placed into credit-bearing courses their first semester with added support. By being placed in a credit-bearing class, students avoid the stigma of being in remedial courses and are motivated to earn credit towards their degree. This cognitive theory rests on student's improved self-efficacy and motivation in a general course allowing them to avoid the stigma of a remedial course.

According to Boylan, Calderwood, and Bonham (2017), three phases are needed to create drastic improvements in college completion rates. The first phase is ensuring students are successful in their first courses with quality instruction. Development theory

suggests that students can develop the necessary skills for college success given support. Faculty members need to approach curriculum development with a focus on engaging students (Center for Community College Student Engagement, 2016). Faculty who incorporate learning goals, self-regulated learning opportunities, engaging activities, and positive feedback will support student learning (Bandura, 1993; Boylan, Calderwood, & Bonham, 2017). The second phase involves strategically working across the college to support students in all facets of their lives. The last phase Boylan, Calderwood, and Bonham (2017) recommend is engaging high schools in preparing students for college. Collaboration between secondary and postsecondary institutions is evident in the TN SAILS program. In 2012, Tennessee introduced Seamless Alignment and Integrated Learning Support (SAILS) to identify and remediate math deficiencies in high school students so they would meet college-ready benchmarks (Higher Education for Higher Standards, 2016). Students who had math ACT scores below 19 enrolled in the remediation course as high school seniors. Using online learning software, community college instructors provided personalized learning solutions that have helped close achievement gaps for underprepared students. By the 2015-16 school year, 14,000 high school students took the SAILS course with a 92 percent completion rate. Tennessee has shown a promising method for helping students prepare for college through collaboration between K-12 and higher education personnel (Higher Education for Higher Standards, 2016). Partnerships between high schools and colleges have been shown to increase enrollment, college-readiness, and college persistence (Barnett & Hughes, 2010).

Summary of the Research

There is a systemic problem with education in America at all levels. A higher percentage of students are graduating from high school and entering post secondary institutions, yet half of all undergraduates take one or more remedial courses (Scott-Clayton & Rodriguez, 2012). Developmental education was established to serve as the bridge to college for underprepared students. However, low pass rates in developmental classes cause some to question how well these classes are remediating basic skills.

The research on developmental education points to mixed results from studies in the field. Developmental education encompasses not just the coursework but support services and student characteristics as well. This complexity makes it difficult to conduct a large-scale unbiased, experimental study that confirms or denies the effectiveness of only one factor in the success of developmental students. Some contradictions among the findings exist. When the focus has been on the courses themselves, some quantitative studies had mixed findings (Burnett, 2011; Peak, 2012) while the others indicated that changes (redesign) in instructional delivery of developmental math courses increased student success (Boatman, 2012; Butler, 2014). Boatman (2012) and Butler (2014) support the effectiveness of redesigning developmental math. Each found positive student outcomes from changing instructional techniques in the delivery of developmental math content. As there is still lack of consensus among available research, there is support for this study on the effectiveness of the corequisite delivery model for a developmental math course. Given the issues above in developmental education, this writer has developed Figure 2.3.

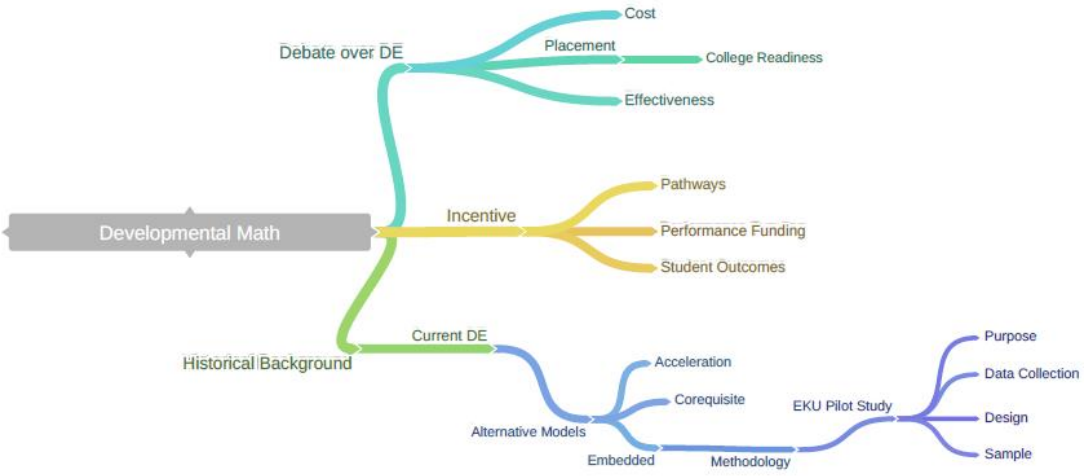

Figure 2.3. Concept map

The debate surrounding developmental education was motivated by research published on poor student outcomes which has led to various redesign models to help address the problem. The concepts that frame the present study focus upon creating pathways that use the alternative model of embedded remedial material in a corequisite course compared to the current two-course remediation sequence in developmental education. It uses college readiness as measured by math ACT scores to place students in either the corequisite course or two-semester remedial and standard mathematics course.

The discussion around the need for developmental education at postsecondary institutions has intensified. The Center for Community College Student Engagement (2016) states that the "current design of developmental education produces too few successful students, and this high failure rate urgently needs to be fixed" (p. 20). CCA (2012) released a report titled *Remediation: Higher education's bridge to nowhere* (http:www.completecollege.org/docs/CCA-Remediation-final.pdf). These strong

statements draw criticism of developmental education. In contrast, former NADE president Rosemary Karr states, “Developmental education is a vital part of higher education, of open access, and of increased opportunities for all students” (Diaz, 2010, p. 24). There is a need for unbiased, specific research on the effectiveness of developmental education courses and sequence designs.

There is inconsistent data for or against developmental education. Some students exhibit such profound deficiencies that despite remediation they do not pass the remedial course, let alone the college-level course. These students struggle with more than basic math; they may have food insecurity, financial hardships, and family situations that serve as barriers to success (Boylan, Calderwood, & Bonham, 2017). The importance of lifestyle issues emphasizes the need for a careful analysis of support services as well as course redesign. Wraparound services in coordination with course curriculum are crucial to helping students succeed in the classroom (Levin & Garcia, 2013). Redesigning remedial courses is only one aspect in promoting student completion.

The many factors that affect underprepared students’ success need to share in the blame that is currently placed solely on remedial course delivery. Promoting a single method for developmental reform is ineffective at handling all the complex issues facing developmental education. A multifaceted approach needs to be taken to address the differing needs of underprepared students. Proper placement, support, and curriculum design play an integral role in the level of success for each student (Collins, 2010). Bahr (2012) stresses the importance of having alternative pathways to credentials or certificates for a fraction of students who will not complete remediation. Collins (2010) states that examination of the available research on developmental education led to the

conclusion that instead of viewing the research as weak versus robust, one must consider various sources which provide evidence that can guide policymakers. The research that supports the effectiveness of various models of out of classroom support are also important to include in policymaker's legislation around developmental education (Boylan, Calderwood, & Bonham, 2017).

CHAPTER 3

METHODOLOGY

The purpose of this study was to assess whether developmental students who enroll in a liberal arts mathematics course (MAT 105E) with integrated remedial algebra content differ on final course scores from those students who completed a prerequisite algebra mathematics course before completing the standard liberal arts mathematics class (MAT105). This cross-sectional study compared four groups of developmental (pilot) students (N=68) who took a credit-bearing corequisite math class which integrated the remedial algebra content. Data from four groups of (control) students (N=89) were also collected. The control students entered the credit-bearing math class based on either a high enough test score or from passing the prerequisite remedial algebra course. The pilot students had not completed a prerequisite algebra course but instead received the content as integrated corequisite course material with three additional contact hours per week as part of MAT 105E.

The American College Test (ACT) is a college entrance exam used to help determine college readiness with minimum benchmark scores. The minimum math ACT benchmark score of 22 is used to predict that a student will earn a C or higher in a first-year, credit-bearing college math course. The ACT is a common placement tool at the institution in this study. Students with math ACT scores of 18 or lower are required to take developmental math courses. Some students in the control group had a high enough math ACT score (19 or above) and thus did not need to complete the remedial course before completing the MAT 105 course. Students' math ACT score is a covariate in the analysis done for this study.

Research Question and Hypothesis

Null Hypothesis: Developmental students who are placed in a corequisite liberal arts math course with embedded remedial content will earn equal academic outcomes (as measured by course scores) when compared to those students who met the prerequisite requirements for the standard liberal arts math course.

Alternative Hypothesis: Developmental students who are placed in a corequisite liberal arts math course with embedded remedial content will earn lower academic outcomes (as measured by course scores) when compared to those students who met the prerequisite requirements for the standard liberal arts math course.

The independent variable was the MAT 105 section that the student was assigned to complete. The section was either the pilot corequisite MAT 105E course or the standard MAT 105 course. Covariates included the demographic and background variables of gender, race, income, first-generation college student, math ACT score, and high school (HS) GPA. These covariates were chosen because they are known to influence math course grades, then ANCOVA is ideally suited to remove the bias of these variables. The dependent variable was the final course score students earned for either the MAT 105E corequisite course or the standard MAT 105 course. The course scores were analyzed using a one-way Analysis of Covariance.

Research Setting

Located in the South Central United States, this public regional comprehensive university is known as a school of opportunity, serving some of the poorest counties in America. Of the students who enter the university with one or more developmental needs only 34 percent return for their second year. In comparison 70 percent of students without

developmental needs return the next year (Office of Institutional Research, 2016). Only 12 percent of students with four or more developmental needs from this South Central regional comprehensive university graduated in the six years from 2008 to 2014. A major hurdle for these students are developmental math courses. The Kentucky Council on Postsecondary Education (CPE) was created by House Bill 1 in 1997 to coordinate and oversee Kentucky's postsecondary institutions. CPE has adopted the core principles for transforming developmental education proposed by the Charles A. Dana Center, Complete College America, Inc., Education Commission of the States, and Jobs for the Future. There is emphasis on embedded remediation, mathematics placement into a credit-bearing pathway course, and students with low placement indicators being able to take a credit-bearing course by the beginning of the second semester (Kentucky Association for Developmental Education, 2015).

In 2007, the Kentucky Developmental Education Task Force released the plan *Securing Kentucky's Future: A Plan for Improving College Readiness and Success*, promoting a variety of research-based best practices. Some of the recommendations made by the Kentucky Developmental Task Force (2007) include implementing common statewide placement exams, creating an integrated accountability system tied to performance funding, and aligning college readiness standards tied to professional development for K-12 educators as well as postsecondary instructors. An estimated $25 million each year is spent on developmental education in Kentucky, with members of the state task force writing "that investment must pay greater dividends for students and the state" (p. 6). In 2016, only 31 percent of Kentucky high school students met the math benchmark compared to 41 percent nationally (ACT, 2016). Fifty percent of the first-time

freshman at Kentucky community colleges and universities are underprepared in at least one subject. These students are two times as likely to drop out of college within the first year, compared to academically prepared students (Kentucky Developmental Task Force, 2007).

Performance-based funding for higher education allocates funds to postsecondary institutions who meet or exceed established metrics such as graduation, retention, and time-to-degree. The 2016-2020 Strategic Agenda Objectives and Performance Metrics cover three categories: opportunity, success, and impact (Kentucky Council on Postsecondary Education, 2017). One metric under the priority area opportunity provides funding based on the "percent of first-time, full-time, degree-seeking undergraduates who are underprepared in mathematics who complete a credit-bearing course in mathematics or quantitative reasoning within a year of entry" (Kentucky Council on Postsecondary Education, 2017). Four-year and six-year graduation rates of first-time, full-time undergraduate students, as well as first to second-year retention rates, are other metrics listed in the success priority area. The impact is measured based on the number of degrees and credentials conferred in total, by minority status, and by low-income status. The historic mission of the university has been a school of opportunity, yet this university, like so many others, has reached a precipice in which it must balance a service mission with the realities of performance-based funding. As this study will explore the success rate of those students who complete a credit-bearing course in mathematics within a year of entry, it addresses percent of first-time, full-time, degree-seeking undergraduates who are underprepared in mathematics who complete a credit-bearing

course in mathematics or quantitative reasoning within a year of entry (Kentucky Council on Postsecondary Education, 2017).

The instructors assigned to teach the four pilot corequisite sections and four standard mathematics sections worked together with the primary researcher to develop the curriculum and pedagogy. The tests, activities, and homework assignments were the same for the pilot sections as well as the control sections. Since the pilot and control sections had common activities, homework assignments, and tests; there is the rationale for comparing the course scores between these two groups. Comparison of group course scores between the pilot group and control groups allowed for interval level statistics.

Research Participants

The pilot sample consisted of four groups of randomly chosen students who were labeled "developmental" (math ACT scores 18 and below) and had enrolled in the developmental algebra non-credit bearing course (MAT 095) at the university. These students received a letter (see Appendix A) explaining that they had an option to enroll in a credit-bearing course MAT 105E instead of the two-course sequence that included the MAT 095 followed by the MAT 105 standard math course. Students were informed that the MAT 105E section would include integrated algebraic content and thus have "more work," as well as three more teacher contact hours for support. The informational letter described the option to participate in a corequisite MAT 105E course their first semester with embedded MAT 095 content. Students who responded to the initial email were assumed to be giving consent to participate so they were then given an override to register for the corequisite MAT 105E. Full participation included registering for the corequisite course and completing the five tests given throughout the semester.

Students from four corequisite math classes made up the pilot group, while students in four standard math classes comprised the control group. Four faculty members were selected to each teach one corequisite class and one standard class. The goal in assigning both a pilot class and a control class to each teacher was to decrease the confounding variable of instructor style and skill at teaching the concepts. To maintain consistency, the instructors worked together to ensure the lecture material and assignments were the same. The instructors all used the same materials in both the corequisite and control classes to allow comparison of course grades at the end of the semester. The pilot courses had an additional three contact hours per week with faculty for the same three college credit hours that they would have earned upon completion of the standard MAT 105 course. Students who passed the corequisite course earned college-level credit for MAT 105 without having to complete the prerequisite MAT 095, thus saving time and money.

The control group had non-developmental students (ACT scores of 19 and above) or those developmental students (math ACT 18 and below) who had completed the MAT095 algebra content as a separate prerequisite course. Neither the registrar's office nor the students in these sections were aware of registering for the control sections of MAT 105. The control courses each met three contact hours per week for three credit hours. Control students were not given any special information about the study as only their course scores and demographic information were collected after the semester's completion. This information was available to the researcher as an employee of the university and coordinator of developmental programming.

Descriptive Statistics

Calculations of means and standard deviations for each group based on gender, race, first-generation college, income level, high school GPA, and math ACT scores were calculated before putting them into the ANCOVA as covariates. Also, as math ACT scores and high school GPAs showed a significant relationship as covariates, Pearson Product Moment correlations on these two covariates were run.

The researcher used a computer-generated random selection process to choose students who would receive a letter inviting them to join the pilot corequisite course**.** However, the researcher was unable to completely randomly assign students to groups due to these students needing to volunteer to be a part of the pilot corequisite group. The students in the standard group went through the self-enrollment process and also were not chosen randomly from a larger population. Six covariates were selected to explore their influence on the final course scores. The six covariates examined through the ANCOVA included student background (gender, race – white/ nonwhite, low-income, and first generation) and high school performance (high school GPA and math ACT score). These variables have been shown to have an effect on college mathematics scores in previous studies (Attewell & Lavin, 2007, Camara, 2003, Kena et al., 2015). By controlling for these covariates, this study was better able to determine the effectiveness of the corequisite delivery model compared to the traditional two-course sequence.

An $\alpha = .05$ probability level was the criterion for significance. The data were input into excel spreadsheets using SPSS for analysis. An eta-squared statistic tested for the ANCOVA effect size. The following guidelines were used to interpret the effect size of the eta-statistic. The finding of .01 or less was a small effect; .06 was a moderate effect

and .14 or greater a large effect (Pallant, 2004). No power statistic was computed due to the large sample size N = 157 with 68 students in the corequisite group and 89 students in the standard group receiving final grades for the classes. According to Stevens (1996) when the N is anticipated to be greater than 100 power is not an issue.

Table 3.1 describes differences in gender between the corequisite group and the standard group. Those students who took the corequisite MAT 105E course are in the "yes" column in the following tables. The control students who completed the standard mathematics course are in the "no" column. As can be seen, approximately two-thirds of the students in the standard math course were female, and three-quarters in the corequsitie course were female. There were twice as many females than males in the study overall.

Table 3.1

Gender by Enrollment in Corequisite Course MAT 105E

Gender		**105E**		**Total**
		No	**Yes**	
Female	Count	61	58	119
	% within 105E	62.9%	76.3%	68.8%
Male	Count	36	18	54
	% within 105E	37.1%	23.7%	31.2%
Total	Count	97	76	173
	% within 105E	100.0%	100.0%	100.0%

Seventy-eight point nine percent of students in the corequisite group were white while the standard group had 72.2 percent (Table 3.2). There were many more white than non-white students in both the groups. The sample has slightly less white students compared to the university population which is 85.3 percent white (Office of Institutional Research, 2016).

Table 3.2

Race by Enrollment in Corequisite Course MAT 105E

Race		**105E**		**Total**
		No	**Yes**	
White	Count	70	60	130
	% within 105E	72.2%	78.9%	75.1%
Non-White	Count	27	16	43
	% within 105E	27.8%	21.1%	24.9%
Total	Count	97	76	173
	% within 105E	100.0%	100.0%	100.0%

Table 3.3 provides data that show that more than half of the students in the pilot group were low-income. The percent of low-income students in the corequsite group was similar to the control group that completed the standard mathematics course.

Table 3.3

Low-Income by Enrollment in Corequisite Course MAT 105E

Low-Income		**105E**		**Total**
		No	**Yes**	
No	Count	43	34	77
	% within 105E	44.3%	44.7%	44.5%
Yes	Count	54	42	96
	% within 105E	55.7%	55.3%	55.5%
Total	Count	97	76	173
	% within 105E	100.0%	100.0%	100.0%

As shown in Table 3.4, almost three-quarters of the corequisite students were not first-generation college students, compared to two-thirds of the students who completed the standard math course.

Table 3.4

First-Generation by Enrollment in Corequisite Course MAT 105E

First Generation		105E		Total
		No	Yes	
No	Count	63	56	119
	% within 105E	64.9%	73.7%	68.8%
Yes	Count	34	20	54
	% within 105E	35.1%	26.3%	31.2%
Total	Count	97	76	173
	% within 105E	100.0%	100.0%	100.0%

Data Collection

In the summer of 2016, the researcher reviewed student transcripts of those students registered for the remedial non-credit bearing math course MAT 095. If the student had a major that required College Algebra, the student was removed from the pool of students who could be randomly selected for the corequisite course as they would not normally take a MAT 105 liberal arts math course.

Initially, the researcher anticipated four classes of 25 students each in the corequisite group and another four classes of 25 students would enroll in the standard mathematics course and serve as the control group. Of the original 89 corequisite group students, 4 students withdrew, 9 students failed without attending, and 8 more students were dropped from the data analysis due to incomplete data. Thus, the final sample of pilot group students completing the corequisite course was 68.

Out of the 111 students in the four control group classes, 7 students withdrew, 7 students failed without attending, and 8 students had incomplete data, and thus were not used in the statistical analysis. The total number of students used for analysis was 89. The actual course score data were collected over one semester during the fall of 2016.

Data Analysis

To run an ANCOVA, all of the following assumptions must be and were met (Pallant, 2004). The use of final course grades provided interval level data. There was a partial random sampling of the pilot corequisite group students, so the assumption of random selection was partially met. There was a limitation because students had the right to join a corequisite course voluntarily, and the control group had the right to select their classes. The analysis used pilot and control group final course scores for comparison, each student's overall course score was used to compile this, thus meeting the requirement of independence of observations.

Assuming that the samples were taken from a normally distributed population, differences in ACT scores between groups created a situation in which the normal distribution of this variable within each group was significantly different. "Fortunately most (statistical) techniques are reasonably robust and tolerant of violations to this assumption. With large sample sizes (e.g., 30 plus), the violation of this assumption of normal distribution should not cause problems" (Pallant, 2004, p. 173).

A one-way Analysis of Covariance (ANCOVA) was run to test for the effect of corequisite course delivery on student course grades. The independent variable was group identity with students enrolled in either the MAT105E corequisite course or the MAT 105 standard course. The dependent variable was the overall course grade. An ANCOVA was

also used to explore differences between group demographic and background variables to examine if covariates predicted the course grade in and of themselves. Covariates used in the study included gender, race, low-income, first-generation college, high school GPA, and math ACT. Use of an ANCOVA further assumes that the covariates were measured without error. While this may be accurate for scores such as high school GPA, math ACT scores, gender, and race there is more possibility of self-report errors in the covariates of low-income and first-generation college identity because of the public stigmas around education level and socioeconomic status that may affect students' reporting.

Limitations

Limitations acknowledged in this study include student self-selection bias, instructor differences, small sample size and duration, and course grades as indicators of success. The potential for self-selection bias cannot be completely ruled out since students decided whether to join the corequisite course after receiving a selection letter. Students were told about the pilot study because of the need for informed consent. Due to voluntary participation, students in the corequisite sections may have already been more motivated, hard-working students willing to take on the challenge of a credit-bearing math course. All students had the opportunity to withdraw from either the corequisite course or standard mathematics course, and some did, as evidenced by the statistics above on participant selection.

Curriculum and resource development was a joint effort by the four instructors to limit variability in classroom instruction. Common powerpoints, handouts, and quizzes further attempted to control for classroom differences. However, the classroom environment is partly due to instructor attitude, energy, and engagement with students;

known as the teacher effect on student achievement (Sanders, Wright, & Horn, 1997). Therefore the teacher effect is a noted limitation in this study because each instructor brings their personality to the class. This is largely mitigated by having each instructor teach sections in both groups. Despite the research on teacher-effect, Darling-Hammond (2000), notes that teacher preparation and certification are strongly correlated to student achievement in math. All four instructors in this study have Master Degrees in mathematics and more than five years of teaching experience.

Another limitation is the small sample size (N = 89 and N = 68) which is sensitive to outliers. One semester of data were collected and analyzed which limits the information on student outcomes such as effectiveness, retention, and graduation. The small class size at a single institution limits the ability to generalize the results. The effects of the corequisite course in this study may not translate to other institutions. Lastly, it is recognized that a study limitation is the use of course grades as gauges of student success. Course grades can vary among instructors based on grading techniques and was controlled for as best as possible using group grading on tests. In group grading each instructor was assigned certain problems to grade on all student tests so that partial credit was comparable across classes.

In spite of these limitations, the results from this study provide educators, administrators, and policymakers with useful information on the effectiveness of the corequisite delivery model for developmental students. Findings will guide practitioners in designing and implementing corequisite courses focused on student achievement. Developmental students will benefit from the opportunity to earn college-credit immediately while remediating deficiencies.

CHAPTER 4

RESULTS

A one-way Analysis of Covariance (ANCOVA) was run to compare the effectiveness of a corequisite credit-bearing college-level mathematics course that included remedial algebra content, MAT 105E, to a standard college-level mathematics course. This study was designed to assess how well developmental students performed in a credit-bearing mathematics course. Students in the standard course were considered college-ready because they had either completed a separate non-credit bearing remedial math course previously or had directly tested into the standard course. The research question asked whether students who received some algebraic remediation as part of a credit-bearing course were able to learn the material concurrently and complete the corequisite course with grades similar to students in the standard course. The results of this study demonstrate that the developmental students in the corequisite course had equivalent academic outcomes compared to students in the standard course.

The total number of students in the study included 130 white students and 43 non-white students. Tables 4.1 – 4.8 include students who were in the original sample. This was the combined group of all students who were in the corequisite and standard courses. Within both the corequisite and standard courses, there were approximately twice as many females as males, and approximately three-quarters were white. About half were low-income, and a third were first-generation college students. The covariates of race, gender, low-income, and first-generation were not significantly different between groups and portray a fairly typical developmental student at this public regional Southern University.

Mean Overall College Course Scores and Final Grades

Student Gender

As shown in Table 4.1, females in both groups had slightly higher mean overall scores M = .743 (SD = .138) compared to males M = .719 (SD = .176). In both the corequisite and standard courses the male students were more likely to fail with 22.2 percent of male students earning an F letter grade compared to 13.4 percent of female students (Table 4.2). Passing the course is considered a letter grade of D or higher. Overall 86.6 percent of females earned a letter grade of D or higher versus 77.9 percent of males. In contrast to historical trends, females in this study earned higher mean overall scores in a math class compared to males (Camara, 2003; Kena et al., 2015).

Table 4.1

Mean Overall Score by Gender

Gender	Mean	N	Std. Deviation
Female	.743984	119	.1384838
Male	.719485	54	.1765567
Total	.736337	173	.1513005

Table 4.2

Final Grade by Gender

Final Grade		Gender		Total
		Female	Male	
F	Count	16	12	28
	% within Gender	13.4%	22.2%	16.2%
D	Count	22	5	27
	% within Gender	18.5%	9.3%	15.6%
C	Count	33	13	46
	% within Gender	27.7%	24.1%	26.6%
B	Count	29	17	46
	% within Gender	24.4%	31.5%	26.6%
A	Count	19	7	26
	% within Gender	16.0%	13.0%	15.0%
Total	Count	119	54	173
	% within Gender	100.0%	100.0%	100.0%

Student Race

Research shows that students of color enroll in remediation at higher rates than their white peers (Chen & Simone, 2016; Higher Education for Higher Standards, 2016). According to the ACT (2016), white high school students were over three times more likely to meet math benchmarks compared to African American high school students. These results are in keeping with the literature, which show that non-white students tend to have lower test scores on national assessments (Kena et al., 2015). Minority students are an at-risk population who are more likely to need math remediation (Complete College America, 2016). Once enrolled in remedial math courses only 16 percent of students at four-year institutions in Kentucky will go on to complete the gateway math course.

Tables 4.3 and 4.4 combine students from both the standard and corequisite courses to present data on race. A key result in the data is that the non-white students were more than twice as likely to fail the course compared to white students. Overall, the non-white students earned mean overall course scores M = .684 (SD = .169) and the white students earned M = .753 (SD = .141) (Table 4.3). As reported in Table 4.4, 87.7 percent of the white students had passing letter grades (A, B, C, or D), compared to 72.0 percent of the non-white students. In this study non-white students had a slightly higher enrollment in the standard math course compared to the corequisite course (Table 3.2).

Table 4.3

Mean Overall Score by Race

Race	Mean	N	Std. Deviation
White	.753526	130	.1413406
Non-white	.684370	43	.1694395
Total	.736337	173	.1513005

Table 4.4

Final Grade by Race

Final Grade		Race		Total
		White	Non-White	
F	Count	16	12	28
	% within Race	12.3%	27.9%	16.2%
D	Count	18	9	27
	% within Race	13.8%	20.9%	15.6%
C	Count	37	9	46
	% within Race	28.5%	20.9%	26.6%
B	Count	37	9	46
	% within Race	28.5%	20.9%	26.6%
A	Count	22	4	26
	% within Race	16.9%	9.3%	15.0%
Total	Count	130	43	173
	% within Race	100.0%	100.0%	100.0%

Low-Income Students

Socioeconomic status has been shown to affect course grades (Attewell & Lavin, 2007). Low-income students enroll in remediation at higher rates than their higher income peers (Chen & Simone, 2016; Higher Education for Higher Standards, 2016) and have lower retention and graduation rates (Attewell & Lavin, 2007; Camara, 2003). Research demonstrates that low-income students are an at-risk population.

The data in this study show that low-income students in both courses were almost three times more likely to fail. Students in both the corequisite course and standard course were combined in Tables 4.5 and 4.6. Mean overall course grades were 7 percentage points lower for low-income students (Table 4.5). As shown in Table 4.6, 77.1 percent of the low-income students earned passing grades (A, B, C, and D), compared to 92.3 percent of students that were not low-income. Students who were not low-income were three times more likely to get an A.

Table 4.5

Mean Overall Score by Low-Income

Low-Income	**Mean**	**N**	**Std. Deviation**
No	.778308	77	.1410895
Yes	.702673	96	.1514870
Total	.736337	173	.1513005

Table 4.6

Final Grade by Low-Income

Final Grade		Low-Income		Total
		No	Yes	
F	Count	6	22	28
	% within Low-Income	7.8%	22.9%	16.2%
D	Count	10	17	27
	% within Low-Income	13.0%	17.7%	15.6%
C	Count	20	26	46
	% within Low-Income	26.0%	27.1%	26.6%
B	Count	22	24	46
	% within Low-Income	28.6%	25.0%	26.6%
A	Count	19	7	26
	% within Low-Income	24.7%	7.3%	15.0%
Total	Count	130	43	173
	% within Low-Income	100.0%	100.0%	100.0%

First-Generation College Students

Research shows that being a first-generation college student is a barrier to success (Camara, 2003; Kena et al., 2015). According to Camara (2003), first-generation students are 14 percent less likely to persist in college beyond three years compared to students with parents who had a college degree. In this study combining data from students in both the corequisite and standard courses show that first-generation students had lower mean overall course scores (Table 4.7). First-generation college students scored approximately 4 percentage points lower on the mean course scores than did the students who were not first-generation college students. These results are in line with research that finds first-generation college students demonstrate lower mathematical proficiency (Kena et al., 2015). According to Table 4.8, first-generation students failed at twice the rate of students who had parents with a college degree. Of the first-generation students 75.9 percent passed the course compared to 87.4 percent of students who were not first-generation.

Table 4.7

Mean Overall Score by First-Generation

First-Generation	Mean	N	Std. Deviation
No	.748969	119	.1493093
Yes	.708500	54	.1533254
Total	.736337	173	.1513005

Table 4.8

Final Grade by First-Generation

Final Grade		First-Generation		Total
		No	Yes	
F	Count	15	13	28
	% within First-Generation	12.6%	24.1%	16.2%
D	Count	16	11	27
	% within First-Generation	13.4%	20.4%	15.6%
C	Count	36	10	46
	% within First-Generation	30.3%	18.5%	26.6%
B	Count	32	14	46
	% within First-Generation	26.9%	25.9%	26.6%
A	Count	20	6	26
	% within First-Generation	16.8%	11.1%	15.0%
Total	Count	119	54	173
	% within First-Generation	100.0%	100.0%	100.0%

Correlation of Overall Course Score with High School GPA and Math ACT

High school GPA and mean overall scores had a correlation coefficient of r = .501, $p < .01$ demonstrating that there was a moderately positive association (Table 4.9). Since $p < .01$ the correlation coefficient is significant. Students with higher high school GPAs were associated with the higher course scores as evident in Figure 2.4.

Table 4.9

Correlation of Overall Score with High School GPA

		Overall Score	**High School GPA****
Overall Score	Pearson Correlation	1	.501
	Sig. (2-tailed)		.001
	N	173	167
High School GPA	Pearson Correlation	.501	1
	Sig. (2-tailed)	.000	
	N	167	167

**. Correlation is significant at the 0.01 level (2-tailed).

Note: 6 high school GPAs were not available.

As a statistically significant covariate high school GPA does influence the dependent variable of overall course score. Students in both the corequisite and standard course with high school GPAs lower than 2.50 tended to fail the course, while students with high school GPAs 3.00 or higher earned course scores equivalent to a C or better (Figure 2.4). In both the MAT 105E corequisite course and the MAT 105 standard course students with high school GPAs above 3.49 had the highest mean overall course scores. Students with the highest high school GPAs in the standard course earned mean overall course scores ten points higher than the top students in the corequisite MAT 105E course.

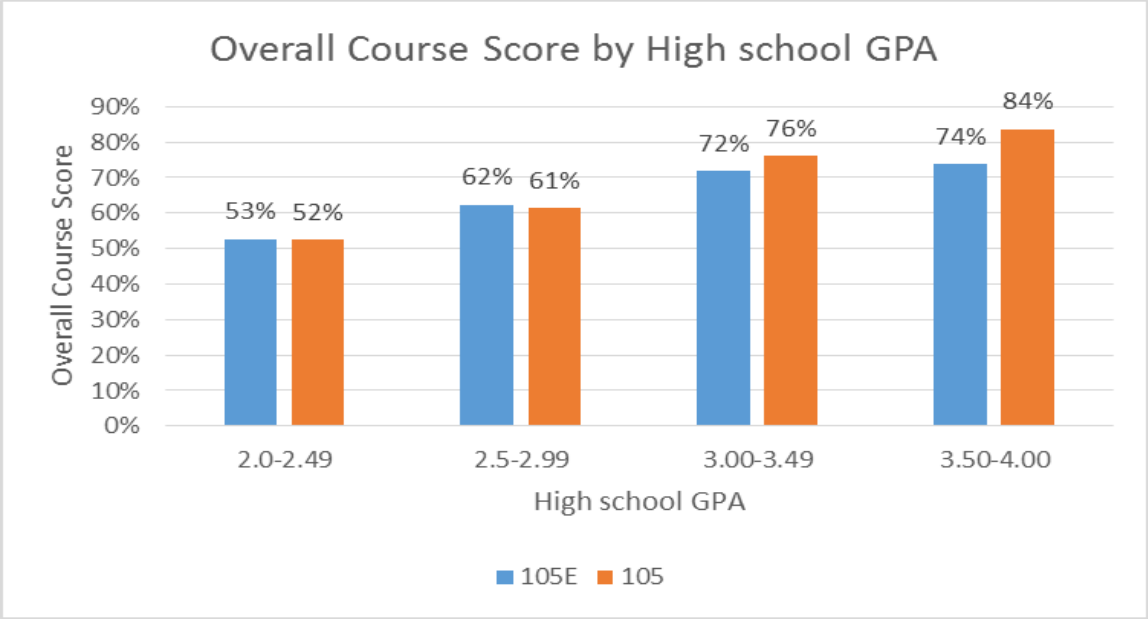

Figure 2.4 Overall course scores by high school GPA for the corequisite MAT 105E students and the standard MAT 105 students

Eighty-five percent of the students in the corequisite course with high school GPAs greater than 3.5 passed the course, while 73 percent of students with a high school GPA below 2.5 passed the course (Figure 2.5). Similarly, the students in the standard course with high school GPAs above 3.5 passed at a rate of 94 percent, which was higher than the 25 percent of students with high school GPAs below 2.5 who passed. Figure 2.5 displays the trend that higher high school GPA is associated with higher pass rates.

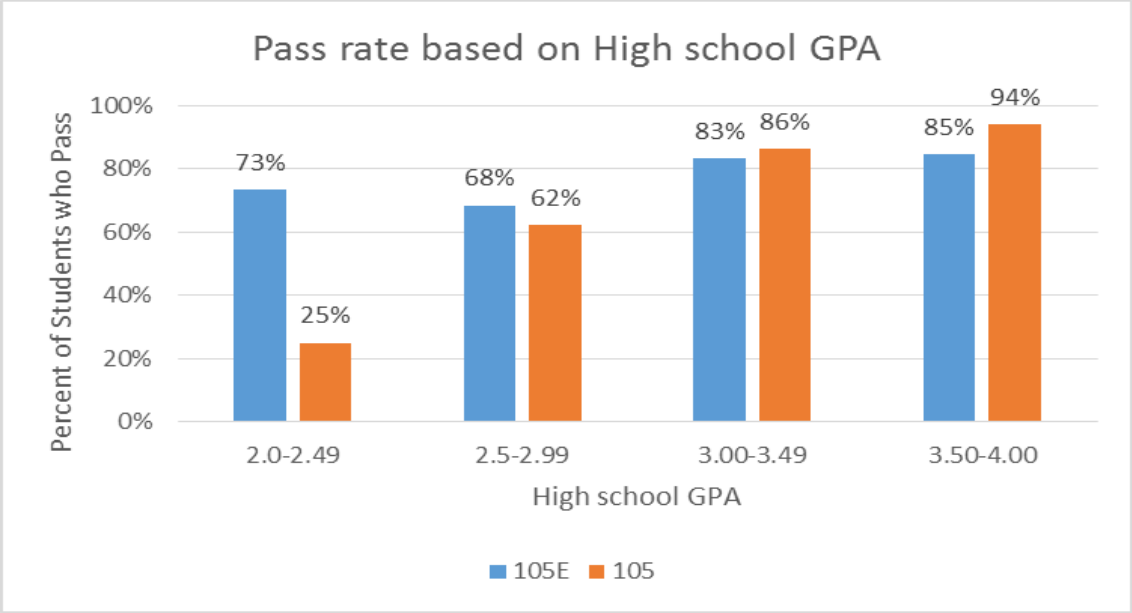

Figure 2.5 Pass rates by high school GPA for the corequisite MAT 105E students and the standard MAT 105 students

The correlation coefficient of r = .521, p < .01 demonstrates a moderately positive correlation between the math ACT score and mean overall scores. (Table 4.10). Higher math ACT scores were associated with higher overall course grades for this sample.

Table 4.10

Correlation of Overall Score with Math ACT

		Overall Score	**Math ACT****
Overall Score	Pearson Correlation	1	.521
	Sig. (2-tailed)		.000
	N	173	160
Math ACT	Pearson Correlation	.521	1
	Sig. (2-tailed)	.000	
	N	160	160

**. Correlation is significant at the 0.01 level (2-tailed).

Students in the sample are identified as developmental math students if they have math ACT subscores below 19. Figure 2.6 displays the overall course scores for students in the corequisite course by math ACT score. Students without math ACT scores were omitted. The positive correlation between math ACT and overall score is seen in the slight score increase from math ACT 16 to 17 to 18. Fourteen percent of the corequisite students had a math ACT score of 15 or below. Interestingly these students had a slightly higher mean overall course score compared to students with math ACT of 16. There is not a clear jump between scores that could provide a cut-off score for students into a corequisite course. Students with math ACT 17 and 18 are considered borderline to the current cut-off score of 19. The results show students with math ACT 18, and possibly 17, had higher passing overall course scores.

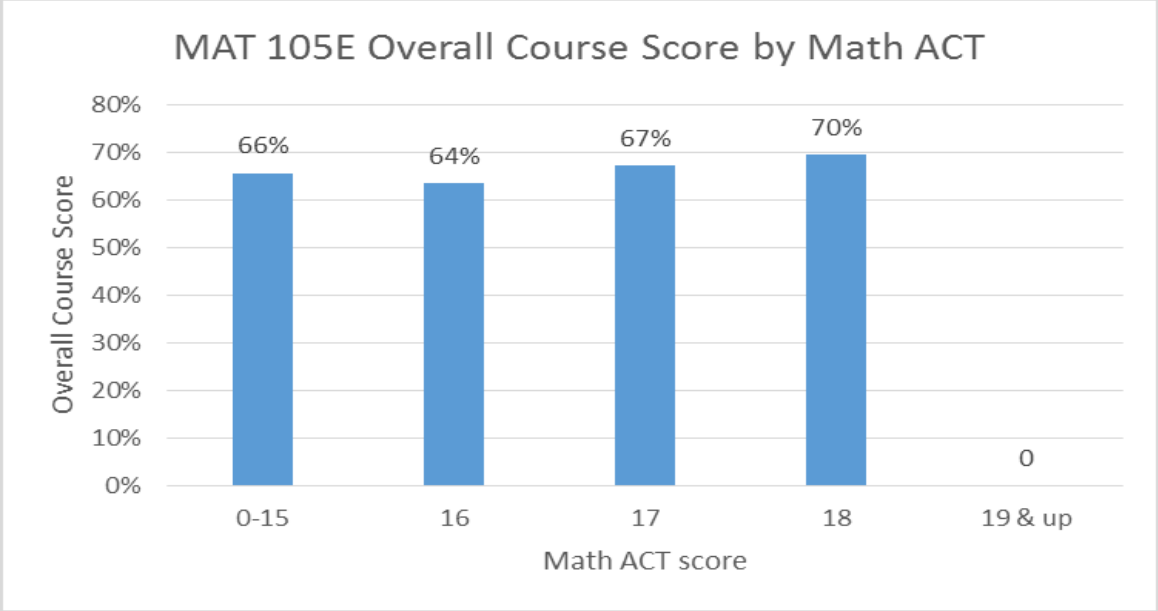

Figure 2.6 Overall course scores by math ACT for the corequisite MAT 105E students

Figure 2.7 shows that 83 percent of borderline students (math ACT score of 18) in the corequisite group passed the math course, compared to 60 percent of standard course students who had math ACT scores of 18 and had completed the prerequisite remedial course. Interestingly, students with math ACT scores of 16 did well in both the corequisite and standard course, with 80 and 92 percent passing respectively. This result calls into question the precision of using ACT scores as the only tool to determine college readiness in math.

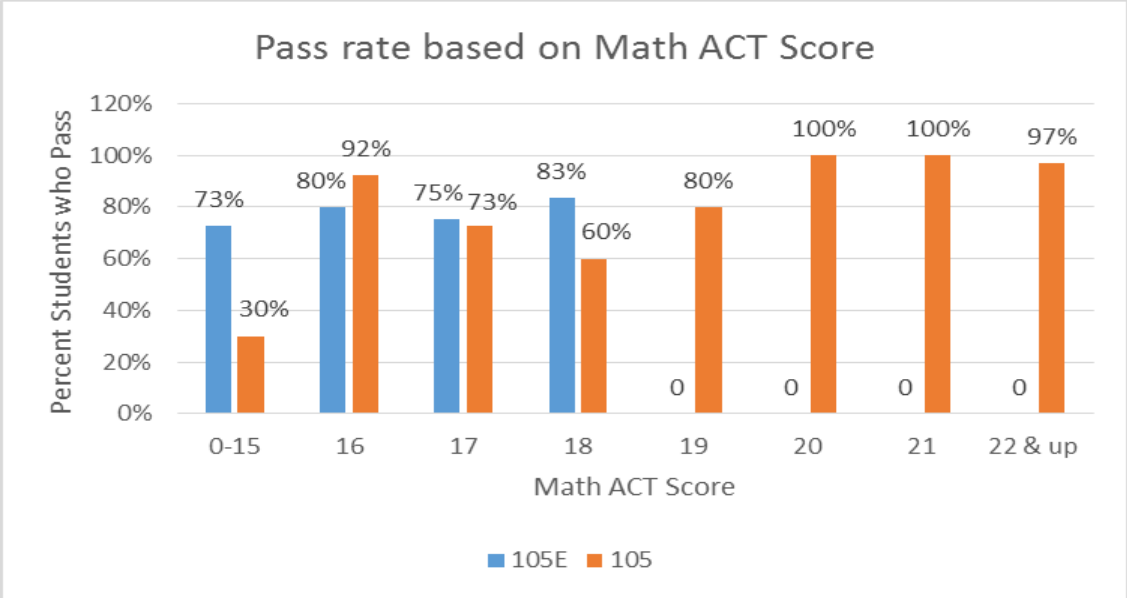

Figure 2.7 Pass rates by math ACT score for the corequisite MAT 105E students and the standard MAT 105 students

Final Grades by Math Course Taken

Students enrolled in the corequisite course more often earned a C or D in the course, and those students who completed the standard course were more likely to earn an A or B (Table 4.11). In fact, based on the data, students in the standard course were six times more likely to earn an A compared to the corequisite students. As shown in Table 4.11, 85.5 percent of the corequisite students earned passing grades (A, B, C, and D),

compared to 82.5 percent of the students in the standard course. A closer look at Table 4.11 shows that the corequisite students passed the course with lower overall grades. Using letter grades the corequisite students earned an overall mean 2.0 GPA (on a 4.0 point scale). The students in the standard course earned an overall mean 2.5 GPA.

Table 4.11

Final Grade by 105E Enrollment

Final Grade		**105E Enrollment**		**Total**
		No	**Yes**	
F	Count	17	11	28
	% within 105E	17.5%	14.5%	16.2%
D	Count	10	17	27
	% within 105E	10.3%	22.4%	15.6%
C	Count	18	28	46
	% within 105E	18.6%	36.8%	26.6%
B	Count	29	17	46
	% within 105E	29.9%	22.4%	26.6%
A	Count	23	3	26
	% within 105E	23.7%	3.9%	15.0%
Total	Count	97	76	173
	% within 105E	100.0%	100.0%	100.0%

ANCOVA on Course Scores by Math Course Taken

The mean overall course score for the 89 students in the standard mathematics course was M = .760 (SD = .168), while the mean overall course score for the 68 students

in the corequisite course was M = .714 (SD = .111). After adjusting for covariates, the estimated marginal mean overall course score for students in the standard course was M = .730 (SE = .013), compared to M = .754 (SE = .015) for the corequisite students.

The observed p-value between those students final overall scores in the corequisite group (MAT 105E) and the students who completed the standard mathematics course (MAT 105) was .258 (>.05), eta squared = .009, so the result is not statistically significant. There was not a significant difference in the overall course scores for students in the corequisite course versus the traditional course, after controlling for covariates.

The covariate of high school GPA was significant and explained 9.4 percent of the variance in test scores. Math ACT scores were also significant and had an even higher impact as they represented 17.7 percent of the variance in test scores. Overall, the model explained 40.4 percent of the variance in course grades. Tables 4.12, 4.13, and 4.14 show the ANCOVA results. Note the N of this data is 157 because 16 students with incomplete data were removed prior to running the ANCOVA.

Table 4.12
Descriptive Statistics
Dependent Variable: Overall Score

105E	**Mean**	**Std. Deviation**	**N**
No	.760231	.1687970	89
Yes	.714949	.1117534	68
Total	.740618	.1481321	157

Table 4.13 provides the adjusted means for the dependent variable for each of the groups. “Adjusted” refers to the fact that the effect of the covariates has been statistically

removed. The estimated marginal means are adjusted by controlling for the covariates. There was a 2.4 percent difference in the overall course percentage scores after controlling for the covariates. These adjusted means indicate that there are no practical differences between the overall scores between the two groups.

Table 4.13

Estimated Marginal Means

105E	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
No	.730[a]	.013	.704	.756
Yes	.754[a]	.015	.724	.785

a. Covariates appearing in the model are evaluated at the following values: Gender = .32; Race = .22; Low-Income = .55; First-Generation = .32; High School GPA = 3.1332; Math ACT = 18.13.

Table 4.14

Tests of Between-Subjects Effects

Source	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared
Corrected Model	1.475[a]	7	.211	16.120	.000	.431
Intercept	.032	1	.032	2.459	.119	.016
Gender	.017	1	.017	1.264	.263	.008
Race	.005	1	.005	.354	.553	.002
Low-Income	.020	1	.020	1.565	.213	.010
First-Generation	.000	1	.000	.018	.895	.000
High School GPA	.202	1	.202	15.446	.000	.094
Math ACT	.418	1	.418	31.979	.000	.177
Enrolled in 105E	.017	1	.017	1.287	.258	.009
Error	1.948	149	.013			
Total	89.540	157				
Corrected Total	3.423	156				

R Squared = .431 (Adjusted R Squared = .404)

Note: High school GPA and math ACT were the only covariates that had statistical significance and did not meet the homogeneity of regression assumption

Levene's test for equality of variances was performed and the results were not significant (F = .012, p = .915), as reported in Table 4.15. The error variance of the dependent variable is equal across groups. The results indicate that the variance for the two groups was relatively equal and the assumption of homogeneity of variance was not violated.

Table 4.15

Levene's Test of Equality of Error Variances[a]

F	**df1**	**df2**	**Sig.**
.012	1	155	.915

a. Design: Intercept + Gender + Race + Low_Income + First_Generation + HS_GPA + ACT_MATH + @105E.

Note: Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

There was no significant difference between course grades between students in the corequisite and standard courses when controlling for the six covariates. Gender, race, low-income, and first-generation college were not significant covariates, while high school GPA and math ACT score were found to be significant. The math ACT score had the largest effect size (partial $\eta^2 = .177$). There was no differences in course grades between the two groups after controlling for the six covariates, $F(1, 149) = 1.28$, $p = .258$. After adjustment for the covariates, the difference between the course grades was not significant (see Table 4.13). The results show the math course students completed did not account for a significant amount of variance in the course grades. The developmental students in the corequisite course had similar course grades to students in the standard

course. The null hypothesis was not rejected since developmental students in the corequisite course earned equal academic outcomes (as measured by course grades) when compared to those students in the standard math course.

Summary

The purpose of this study was to examine the effectiveness of the corequisite delivery model for developmental math students. Controlling for six covariates, the results show there is not a significant difference between delivery method and course score. The mean overall course scores were similar for students in the corequisite and standard courses. Male students, non-white students, low-income students, and first-generation students had lower overall course scores in both the corequisite and standard courses. The covariates of math ACT and high school GPA did significantly predict the course grade. Students with higher math ACT scores were associated with the higher course scores. Similarly an increase in high school GPA was associated with an increase in course scores.

The results of this study show that high school GPA and math ACT scores have a predictive value on the dependent variable of overall course scores in a college-level mathematics course. The math ACT score was twice as predictive of overall course scores compared to high school GPA. In this sample, the math ACT score predicted 17 percent of the variability and high school GPA predicted 9 percent of the variability. The correlation between math ACT score and high school GPA with the overall course score highlights the importance of placement procedures.

The ANCOVA found no statistically significant difference in mean overall course scores whether the material was presented in a prerequisite non-credit bearing remedial

algebra course or as integrated content with additional teacher contact time in the corequisite course. Overall the effects of the model were nonsignificant. The results show that there is not a significant difference between the delivery method and the overall course score. The researcher fails to reject the null hypothesis: developmental students who are placed in a corequisite liberal arts math course with embedded remedial content will earn equal academic outcomes (as measured by course grades) when compared to those students who met the prerequisite requirements for the standard liberal arts math course. Despite being considered unprepared for college-level math, students in the corequisite course had comparable results to students considered college-ready.

CHAPTER 5

CONCLUSION AND DISCUSSION

Purpose

This research study sought to assess the effectiveness of a corequisite credit-bearing mathematics course for developmental students. Reform movements nationwide are pushing for developmental students to be placed into credit-bearing courses with additional support instead of the traditional prerequisite non-credit bearing remedial courses. This chapter will include sections on the purpose of this study, the findings, recommendations, and implications for future research.

For more than forty years, developmental education at postsecondary institutions has focused on support services and remedial courses to help students become college-ready. Nationally, close to half of all college students will take a remedial course (Higher Education for Higher Standards, 2016). However, over 60 percent of these developmental students will not graduate within six years. Many studies justify the need for reform, yet few verify the most effective type of reform model. A goal at institutions across the nation is to reform developmental courses to become more effective and improve outcomes. Various reform methods look at different pedagogical strategies to improve student outcomes while reducing time spent in remedial courses. This research was conducted to add to the limited literature on how effective the corequisite method is for a liberal arts math course. The study analyzed the corequisite reform model as a means for improving developmental student outcomes in mathematics.

Interpretation of Findings

The findings of this study did not show a statistically significant difference between the overall course scores of developmental students in a corequisite mathematics course and students in the standard mathematics course, after controlling for student descriptive statistics. The students in the corequisite course had less math preparation than students in the standard course, so it was expected that the corequisite students would be less likely to succeed. The null hypothesis was not rejected since the results demonstrated that the corequisite course with embedded algebraic content was a successful model in helping developmental students earn similar overall course scores to college-ready students. The corequisite model was effective in remediating math deficiencies during a credit-bearing course, which allowed developmental students to earn similar overall course scores. The benefits of a corequisite model compared to the traditional developmental course sequence is that it reduces the number of math courses a student needs, thus saving the student time and money.

An ANCOVA was used to control for any unwanted variance on the dependent variable (course grade), allowing for improved test sensitivity. The variables of gender, race, socioeconomic status, first-generation college student, high school GPA, and math ACT score were covariates because of their influence on math achievement and the difference in frequency between the two groups of math courses. By controlling for the initial group differences based on these six variables the researcher analyzed the relationship between the course delivery and course grade. The four covariates of gender, race, low-income, and first-generation college were not significant. Discussed below are the findings on the two significant covariates; high school GPA and math ACT score.

High School GPA

High school GPA and overall course grade had a correlation coefficient of r = .501 showing that there was a moderately positive association (Table 4.9). These results demonstrate that higher high school GPAs are associated with higher course grades. The literature shows that high school GPA is a moderate predictor of college success (Noble & Sawyer, 2002). As indicated in Figure 2.4, students with higher high school GPAs had higher overall course scores in both the corequisite and standard courses.

Students in the standard course with high school GPAs below 2.5 had a 25 percent pass rate. In comparison 73 percent of students in the corequisite course with high school GPAs below 2.5 passed the course (Figure 2.5). Did the extra contact time in the corequisite course help this subset of corequisite students do better than their counterparts in the standard course? Geisinger (2009) and Winters (2012) provide evidence on the inflation of high school GPAs and the discrepancy in basic skills among students with similar high school GPAs. This could be the case for the students in this study. Students with high school GPAs below 2.5 were almost three times as likely to pass the corequisite course compared to the standard course (Figure 2.5). This could have been due to different levels of basic skills or motivation once in the college course. In contrast McArdle, Paskus, and Boker (2013) found that high school GPA are good predictors of freshman college grades. This conflicting research on the use of high school GPA to place college students highlights the importance of the use of multiple placement measures.

Math ACT

As previously mentioned, math ACT score was another covariate that was statistically significant in the analysis. Similarly, the correlation coefficient of r = .521

demonstrates a moderately positive correlation between the math ACT score and the overall course grade (Table 4.10). In this study, higher math ACT scores were associated with higher overall course grades. In a logistic regression model, Noble and Sawyer (2002) found that ACT Composite scores were effective in predicting first-year college GPAs. Math ACT scores are focused on a single subject providing a uniformity of comparison for success in college math courses, while high school GPA covers a broad range of subjects and account for less variability in math course scores in this study.

Math ACT scores were at least somewhat successful in predicting 17 percent of the variance in success between the college mathematics deliveries compared, thus these scores could be used as part of a placement model that identifies students best able to complete a corequisite mathematics course. The institution in this study uses a math ACT cut-off score of 19 to place students in college-level math. Borderline students discussed in the literature are often considered to be the students within 2 points of the cut-off score (Boatman, 2012). Students with math ACT scores of 16 did well in the corequisite course, with 74 percent passing (Figure 2.7). Based on the results of this study there is some evidence that the math ACT cut-off score for placement into a corequisite liberal arts math course could be lowered to 16. This study also asked how well students with math ACT scores of 15 and lower perform would perform in a corequisite course. As Bailey and Cho (2010) stated, “there is very little known about the effectiveness of (supports for) students who score well below the cutoff scores” (p. 47). This study does provide evidence on student achievement in a corequisite course for students with low math ACT scores.

Students with higher math ACT scores did do well, however students with lower math ACT scores were also successful in completing the course. Interestingly, 73 percent of students (N =18) with math ACT scores 15 and lower passed the corequisite course. However, only 30 percent of students (N = 20) with math ACT scores 15 and lower passed the standard course. These students would have either taken the prerequisite remedial course or passed a different placement test in order to take the standard liberal arts math course. The discrepancy in the pass rate between students with similar math ACT scores is surprising. Students with low math ACT scores performed better taking the corequisite course compared to students who met the prerequisite requirements and took the standard course. The success of the students in the corequisite course could be attributed to the extra three hours a week of required class time.

The success of students with low math ACT scores in the corequisite course calls into question the precision of ACT scores as the lone tool used to determine college readiness in math. The researcher recommends using other placement procedures in combination with math ACT when determining developmental math status. Placement criteria could include math ACT, high school GPA, non-cognitive measures, high school course sequence, and work/life experience. Using multiple measures to determine college readiness would allow institutions to make more informed decisions about the whole student.

Course Grades

The overall findings from the analysis demonstrate the effectiveness of the corequisite model for teaching liberal arts mathematics to developmental students. Although not statistically significant, the corequisite delivery method was effective

because developmental students who did not take the prerequisite course performed similarly to their peers in the control group. The mean overall score for students in the corequisite course was 71.5 percent, compared to 76.0 percent for students in the standard course. When the effects of the covariates are removed the mean overall course score for the corequisite students is slightly higher than for the standard course students. Removing the effects of the demographic and background factors results in an estimated marginal mean overall course score for students in the corequisite course of 75.4 percent compared to 73.0 percent for the students in the standard course. The corequisite model is showing promise as an effective tool for developmental student success in mathematics.

Recommendations

With over 60 percent of developmental students never completing a college degree (CCA, 2012), it is imperative that effective reform models are identified and implemented to support these students. While there is a lack of consensus about how to design the sequence and content of remedial mathematics courses (Center for Community College Student Engagement, 2016; Complete College America, 2012), there is agreement that these developmental students, if admitted, need additional support services. These support offerings include wrap-around services such as counseling, tutoring, advising, and financial aid (Boylan et al., 2017). To enable a greater number of underprepared low-income students to succeed in college there is a need for developmental education and support services (National Center for Education Statistics, 2014). The issue then becomes what support services and courses are most effective in helping developmental students succeed in college.

As it seems likely that the college costs for students will continue to increase (Barry & Dannenberg, 2016), a separate remedial non-credit bearing course only adds to this financial burden. There is a continued push to remove remedial courses and create corequisite courses that include remedial content, not just in mathematics, but across college curricula (Collins, 2010). Refinement is needed to determine the most effective services that support students in overall persistence and retention all the way to graduation. Thus, designing selection criteria that includes math ACT scores of 17 or 18, and some determination of commitment to attend courses and complete homework (assessed through an interview or short questionnaires), would help to place students more likely to succeed in corequisite courses. However, the above does not address the more specific needs of students with very low high school GPAs and math ACT scores. Perhaps required Summer Bridge programming before the actual admittance to the university is the most realistic avenue for these students (Douglas & Attewell, 2014).

Summer Bridge programs at postsecondary institutions are offered to help incoming students become college-ready. Students who successfully complete a full summer session of remediation and courses that help them to learn about the university are more likely to be retained semester-to-semester (Douglas & Attewell, 2014; Tomasko, Ridgway, Waller, & Olesik, 2016). Along with corequisite courses, Summer Bridge could be part of a comprehensive approach to improving the retention and graduation rates of developmental students. In addition to classroom reform models, the research that supports the effectiveness of various models of out of classroom support should also be included in policymaker's legislation around developmental education (Boylan et al., 2017; Goudas, 2015).

Implications for Future Research

A suggestion for future research would be running an ANCOVA using different covariates. Ideally, the chosen covariates should not correlate substantially with one another. It was assumed in this study that high school GPA and math ACT score were not correlated with each other since high school GPA includes a variety of subject areas, while math ACT focuses on math. However, it is possible that high school GPA and math ACT do correlate with each other as well as with the dependent variable of overall course scores. Future research should explore and perhaps remove one of these covariates, as each variable needs to contribute to a reduction in the error variance on its own (Pallant, 2004).

A broader range of research is needed as developmental education reform sweeps the nation. Qualitative research on developmental reform would provide the student or faculty perspective. Interviews and first-person accounts would add depth and understanding to the numerical data on reform models. With the goal of improving the experience and outcome for developmental students, many large-scale quantitative studies miss out on the human experience involved with such drastic changes. With qualitative studies, researchers would gain meaningful information on how certain models, such as the corequisite, are viewed by students and implemented by faculty. For this particular study, the researcher could develop a survey or interview questions to learn about the student experience with the corequisite mathematics course.

The study started with 89 students in the corequisite group and 111 students in the standard group. However, in the corequisite group 4 students withdrew, 9 students failed for non-attendance, and 8 students were dropped from the analysis for incomplete data. In

the standard group 7 students withdrew, 7 students failed for non-attendance, and 8 students were dropped from the analysis for incomplete data. The student data not included in the analysis is a limitation. It was assumed that those students who dropped out of either the corequisite or standard sections were relatively equal in their perceived inability to pass the course. Did the population of students who withdrew or stopped attending have certain characteristics? Did these students have more challenging life circumstances than the students who remained in the class? Future research could center on the retention of these students, not into the next semester, but within the current semester. Future research questions could focus on why students drop out and stop attending class and what interventions and support services would help this vulnerable population.

Due to the relative newness of the corequisite model for developmental education, there are limited longitudinal studies. Tennessee was one of the first states to adopt the corequisite model and thus has the most extensive student data available. Many researchers (Boatman, 2012; Boylan et al., 2017; Denley, 2016) have used these data to report on the effectiveness of the corequisite delivery model for developmental students. As more institutions across the nation begin to implement the corequisite model, it is important to monitor student success over time regarding retention and graduation. I regret not including more semesters' worth of data in the analysis that could have provided more information on student retention semester to semester. Longitudinal studies should follow students after the corequisite course to see if retention and graduation rates of developmental students are improved. The ANCOVA was a fair way to test the delivery model, but a further look at grade distributions long-term would

provide valuable data. Such data could include how students who complete corequisite mathematics courses perform in higher level mathematics courses. Future research could determine how well-prepared corequisite students are for advanced math courses.

In this study, there were three hours of additional remedial content and student-teacher contact per week. The students were required to stay an extra hour after each class, and this appears to have helped them develop algebraic skills. It is unknown if making this extra time voluntary or at a different time would have been as helpful, as some of the students had difficulties with transportation, childcare, and other issues that made having the class be two hours back-to-back the most practical approach. During this time, the assigned course teachers used interactive group work and other methodologies that engaged the students, which seemed more effective in keeping the students focused and participating. Exploration of support services such as the amount of contact with course advisors, cohorts for courses, financial support, and social events was beyond the scope of this study but warrants further investigation.

As can be seen from Tables 2.1 and 2.2, more white female students opted to take the experimental corequisite course with the embedded algebraic content for college credit. Bandura's (1993) theory of self-efficacy states that the student who chooses this believes they can "do it." As some research supports the importance of self-efficacy on mathematics achievement (Pajares & Miller, 1995), this variable could be explored more using a brief self-efficacy questionnaire before students choosing the corequisite versus the remedial non-credit bearing prerequisite course. Of course, it was also possible that these students were more aware that even a "D" grade constituted a passing grade. Knowing a D grade would earn college credit, regardless of the knowledge gained, may

have affected the effort level of some students. Students enrolled in the corequisite course earned more C or D grades while students who completed the standard course were more likely to earn an A or B. In fact, students in the standard course were six times more likely to earn an A compared to students in the corequisite course. This is not surprising since standard course students entered the course more prepared.

Further research could also examine the dropout rates. In this study close to 6 percent of students in the total sample withdrew and 8 percent failed for nonattendance. Qualitative research could focus on why students stop attending classes; is it more challenging life circumstances? What factors cause student attrition in individual classes? Do students perceive the subject as too difficult? Parsing down the data between the two groups shows that 6 percent of students in the standard course failed for nonattendance while 10 percent of students in the corequisite course. What caused the higher dropout rate in the corequisite course? Future research on factors that cause students to dropout would provide valuable insight that could be used to help students persist.

Conclusion

Over the last decade, there has been a push by educational organizations, state policymakers, and college administrators to redesign or eliminate remedial courses. Due to the low graduation rates of underprepared students, many stakeholders are questioning the effectiveness of developmental education (Bahr, 2013; Bailey, 2009). Until high school graduates meet college readiness standards, the need for remediation will persist. An area of reform in developmental education is redesigning the delivery method of remedial courses. This study provides a systematic evaluation of a corequisite developmental math model while limiting extraneous factors. This study contributes to the research on the effectiveness of corequisite delivery models for all developmental math students, not just the borderline students. A control group (standard course students) was used in order to have reliable baseline data to compare the corequisite student results with.

The literature review examined the effectiveness of developmental education. The ongoing debate has resulted in redesign efforts across the nation as universities respond to low remedial student pass rates coupled with financial pressures linked to state performance funding. There is a shortage of sound research on the various developmental reform models currently being implemented. The corequisite delivery model has shown early success in some states, including Tennessee, West Virginia, and Indiana. Corequisite courses involve placing developmental students directly into credit-bearing college-level math courses with extra support.

Findings from this study were not statistically significant, but did provide some insight. Using an ANCOVA, the researcher failed to reject the null hypothesis that a

corequisite liberal arts math course was effective in passing developmental students at the same rate as students in the standard math course. The delivery method did not result in different overall course grades. Thus after controlling for six covariates, the mean overall scores between the students in the corequisite and standard courses were very similar.

This study found that the corequisite model for a liberal arts math course was an effective tool in helping developmental students pass a credit-bearing course with similar course scores to students in a standard liberal arts math course. The developmental students in the corequisite course were able to pass a credit-bearing math class their first semester without taking the traditional prerequisite remedial course. Therefore the corequisite course was able to reduce the math sequence and cost for developmental students by providing success in college-level mathematics.

The covariates of high school GPA and math ACT scores were significantly correlated with the overall mathematics course scores. Math ACT score predicted 17 percent of the variability and high school GPA predicted 9 percent of the variability in the model. The correlation of both math ACT score and high school GPA with the overall course score highlights the importance of placement procedures.

It is an exciting and challenging time to be a developmental educator. Colleges and universities should focus on proven strategies that support developmental students to graduation. With the goal of improving remedial courses and supports for developmental students the corequisite delivery model shows promise and provides favorable evidence. Nevertheless, remedial course redesign is only a piece of the puzzle needed to help students complete college. This study found one implementation of a corequisite liberal arts math course to be effective for developmental students. However, corequisite courses

need to be in tandem with other support services and multiple placement measures. The findings of this study should be interpreted with that in mind.

APPENDIX

Student Informational Letter

Dear STUDENT'S NAME,

My name is Katie Fair, and I am the Developmental Math Coordinator at EKU. This fall we will be offering a MAT 105E course for developmental students that allows you to take a credit-bearing math course. You have been selected for the opportunity to participate in the credit-bearing MAT 105E math course in the fall 2016 semester, instead of the developmental course MAT 095 for which you are currently registered.

To participate, you will need to respond to this email by June 18th.

It has been verified based on your selected major that the MAT 105E course will satisfy your major requirements for math. The corequisite MAT 105E liberal arts mathematics course will be at the same time as the MAT 095 course, so **your schedule will not change**. The purpose of the corequisite course is to place you in a credit-bearing course that satisfies your general education math credit in one semester while helping you develop your basic math skills.

The course will cover the material from MAT 095 while teaching the MAT 105 content. You will be expected to devote time outside of class to homework and studying. With hard work, this course could be an excellent opportunity for you to skip MAT 095.

Here are some facts about this opportunity:

1) Your schedule will stay the same; you will go to MAT 105E instead of MAT 095.

2) You can earn general education math credit your first semester, which saves you money on paying for the developmental MAT 095 course followed by the general education math course.

3) If you pass the class, you will earn general education math credit.

4) If you fail the course with a grade of 50-60%, you will have the option of repeating MAT 105E or taking MAT 095 the next semester. Students with overall grades below 50% will be placed into MAT 095 the next semester.

Please respond to katherine.fair@eku.edu by July 18th if you would like to participate in the corequisite MAT 105 this coming fall semester. Also please feel free to contact me at if you have any questions about this opportunity. If I do not receive a response from you, I will assume you do not want to participate, and you will stay in your current MAT 095 course.

STUDENT'S NAME, we are excited to work with you this fall and help you reach your goals!

REFERENCES

Academic Outcome Goals. (May, 2017). Academic outcome goals: Definition and philosophy of academic outcomes [PDF file]. Retrieved from https://ww2.harford.edu/IR/assess_pdf/ACADEMIC%20OUTCOME%20GOALS.pdf

ACT. (2016). The condition of college and career readiness 2016. Iowa City, IA: Author.

Astin, A. W. (1984). Student involvement: A developmental theory for higher education. *Journal of college student personnel*, *25*(4), 297-308.

Attewell, P., & Lavin, D. (2007). Passing the torch: Does higher education for the disadvantaged pay off across the generations. New York, NY: Russell Sage Foundation.

Attewell, P., Lavin, D., Domina, T., & Levey, T., (2006). New evidence on college remediation. *Journal of Higher Education 77(5)* 886-924.

Bahr, P. R. (2012). Deconstructing Remediation in Community Colleges: Exploring Associations between Course-Taking Patterns, Course Outcomes, and Attrition from the Remedial Math and Remedial Writing Sequences. *Research in Higher Education, 53(6),* 661-693.

Bahr, P. R. (2008). Does mathematics remediation work? A comparative analysis of academic attainment among community college students. *Research in Higher Education*, *49*(5), 420-450.

Bailey, T. (2009). Challenge and opportunity: Rethinking the role and function of developmental education in community college. *New Directions for Community Colleges*, *2009*(145), 11–30. http://doi.org/10.1002/cc.352

Bailey, T., Smith Jaggars, S., & Jenkins, D. (2015). *Redesigning America's community colleges: A clearer path to student success.* Cambridge, MA: Harvard University Press.

Bailey, T., Smith Jaggars, S., & Scott-Clayton, J. (2013). COMMENTARY: Characterizing the Effectiveness of Developmental Education: A Response to Recent Criticism. *Journal of Developmental Education*, *36*(3), 18.

Bailey, T., Jeong, D. W., & Cho, S.-W. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. *Economics of Education Review*, *29*(2), 255–270. http://doi.org/10.1016/j.econedurev.2009.09.002

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist*, 28, 117-148.

Barry, M. N., & Dannenberg, M. (2016). *Out of pocket: The high cost of inadequate high schools and high school student achievement on college affordability.* Education Reform Now. Retrieved from https://edreformnow.org/app/uploads/2016/04/EdReformNow-O-O-P-Embargoed-Final.pdf.

Barnett, E., & Hughes, K. (2010). *Issue brief: Community college and high school partnerships* (Policy brief). Retrieved from Community College Research Center website: http://ccrc.tc.columbia.edu/media/k2/ attachments/community-college-and-high-school-partnership.pdf

Bettinger, E. P., & Long, B. T. (2009). Addressing the Needs of Underprepared Students in Higher Education Does College Remediation Work? *Journal of Human Resources*, *44*(3), 736–771. http://doi.org/10.3368/jhr.44.3.736

Boatman, A., & Long, B. T. (2010). Does remediation work for all students? How the effects of postsecondary remedial and developmental courses vary by level of academic preparation. A ncpr working paper. National Center for Postsecondary Research. Retrieved from http://eric.ed.gov/?id=ED512610

Boatman, A. (2012). Evaluating institutional efforts to streamline postsecondary remediation: The causal effects of the Tennessee developmental-course redesign initiative on early student academic success. Harvard University.

Boylan, H. R. (1990, July). *Developmental education 101*. Paper presented at the Kellogg Institute for the training and certification of developmental educators, Boone, NC.

Boylan, H. R. (2009). Targeted Intervention for Developmental Education Students (T.I.D.E.S.). *Journal of Developmental Education*, *32*(3), 14–23.

Boylan, H. R. (2011). Improving Success in Developmental Mathematics: An Interview with Paul Nolting. *Journal of Developmental Education*, *34*(3), 20–27.

Boylan, H. R., & Bonham, B. S. (2007). 30 Years of Developmental Education: A Retrospective. *Journal of Developmental Education*, *30*(3), 2–4.

Boylan, H. R., Bonham, B. S., & Rodriguez, L. M. (2000). What are remedial courses and do they work: Results of national and local studies. *Learning Assistance Review*, *5*(1), 5–14.

Boylan, H. R., Calderwood, B. J., & Bonham, B. S. (2017). College Completion: Focus on the Finish Line. *National Center for Developmental Education*.

Calcagno, J. C., & Long, B. T. (2008). The impact of postsecondary remediation using a regression discontinuity approach: Addressing endogenous sorting and noncompliance. New York, NY: National Center for Postsecondary Research, Teachers College, Columbia University: National Bureau of Economic Research.

Camara, W. J. (2003). College Persistence, Graduation, and Remediation. Research Notes. RS-09. *College Entrance Examination Board*.

Chen, X. (2016). Remedial Coursetaking at US Public 2-and 4-Year Institutions: Scope, Experiences, and Outcomes. Statistical Analysis Report. NCES 2016-405. *National Center for Education Statistics*.

Chickering, A., & Reisser, L. (1993). The seven vectors: An overview. *Education and identity*, 43-52.

Cho, S., Kopko, E., Jenkins, D., & Smith Jaggars, S., (2012). New evidence of success for community college remedial English students: Tracking the outcomes of students in the accelerated learning program (ALP) (CCRC Working Paper Number 53). New York, NY: Community College Research Center, Teachers College, Columbia University.

Complete College America. (2012). *Remediation: Higher education's bridge to nowhere.* Indianapolis, IN: Author. Retrieved from http:www.completecollege.org/docs/CCA-Remediation-final.pdf

Complete College America. (2015, June 23). The results are in. Corequisite remediation works [Web log post]. Retrieved from http://completecollege.org/the-results-are-in-corequisite-remediation-works/

Complete College America. (April 2016). *Co-requisite remediation: Spanning the completion divide*. Retrieved from http://completecollege.org/spanningthedivide/

Complete College America website. Visited 2/18/2016. Retrieved from http://completecollege.org/about-cca/

Center for Community College Student Engagement. (2016). *Expectations meet reality: The underprepared student and community colleges.* Retrieved from http://www.ccsse.org/nr2016/

Collins, M. L. (2010). Bridging the evidence gap in developmental education. *Journal of Developmental Education, 34(1),* 2-8.

Denley, T. (2016). Co-requisite remediation pilot study - Fall 2014 and Spring 2015 and full implementation Fall 2015. *Tennessee Board of Regents Office of the Vice Chancellor for Academic Affairs.*

Diaz, C. R. (2010). Transitions in developmental education: An interview with Rosemary Karr. *Journal of Developmental Education, 34*(1), 20-25.

Douglas, D., & Attewell, P. (2014). The bridge and the troll underneath: Summer bridge programs and degree completion. *American Journal of Education, 121*(1), 87-109.

Edgecombe, N., Jaggars, S. S., Baker, E. D., & Bailey, T. (2013). Acceleration through a Holistic Support Model: An Implementation and Outcomes Analysis of FastStart@ CCD. *Community College Research Center, Columbia University*.

Goudas, A. M., & Boylan, H. R. (2012). Addressing flawed research in developmental education. *Journal of Developmental Education, 36*(1), 2–13.

Goudas, A. (2015). What reforms really work? Differences between claims and conclusions in recent research. *NADE Conference PowerPoint presentation*. Greenville, SC.

Gula, T., Hoessler, C., & Maciejewski, W. (2015). Seeking mathematics success for college students: a randomized field trial of an adapted approach. *International Journal of Mathematical Education in Science & Technology*, *46*(8), 1130–1148. http://doi.org/10.1080/0020739X.2015.1029026

Darling-Hammond, L. (2000). Teacher quality and student achievement. *Education policy analysis archives*, *8*, 1.

Higher Education for Higher Standards. (December 2016). *Alignment policy brief: Precollege interventions help increase college readiness, reduce remediation.* Retrieved from: http://higheredforhigherstandards.org/scalingsails/

Kena, G., Musu-Gillette, L., Robinson, J., Wang, X., Rathbun, A., Zhang, J., Wilkinson-Flicker, S., Barmer, A., and Dunlop Velez, E. (2015). The Condition of education 2015 (NCES 2015-144). U.S. Department of Education, National Center for Education Statistics. Washington, DC. Retrieved [date] from http://nces.ed.gov/pubsearch.

Kentucky Association for Developmental Education. (2015, April 10). *Executive board meeting minutes.* Retrieved from www.the-kade.net/wp-content/uploads/2015/09/KADE-Spring-15-minutes.docx.

Kentucky Council on Postsecondary Education. (2017). *2016-2020 Strategic Agenda: Stronger by degrees.* Retrieved from http://test.cpe.ky.gov/ourwork/strongerbydegrees.html

Kentucky Developmental Education Task Force. (2007). *Securing Kentucky's future: A plan for improving college readiness and success.* Council on Postsecondary Education. Frankfort, KY.

Kentucky's Guiding Principles for Developmental Education and Postsecondary Intervention Programming. June 2015. Council on Postsecondary Education. Retrieved from: http://www.cpe.ky.gov/NR/rdonlyres/B8CA09C0-6AE7-41F4-B6C5-EC5F6A315B3B/0/DevelopmentalEducationandInterventionProgrammingGuidingPrinciplesFinal.pdf

Levin, H. M., & Garcia, E. (2013). Benefit-Cost Analysis of Accelerated Study in Associate Programs (ASAP) of the City University of New York (CUNY). *New York: Teachers College, Columbia University*.

Martorell, P., & McFarlin, I., Jr. (2011). Help or hindrance? The effects of college remediation on academic and labor market outcomes. *Review of Economics and Statistics*, *93*(2), 436–454. http://doi.org/http://www.mitpressjournals.org/loi/rest

McArdle, J.J., Paskus, T.S. & Boker, S.M. (2013). A multilevel multivariate analysis of academic performances in college based on NCAA student-athletes. *Multivariate Behavioral Research*, *48*(1), 57-95.

NADE National Association for Developmental Education. (2017, October 18). Retrieved from https://thenade.org/Mission-Vision-and-Goals

National Center for Education Statistics. (2014). Percentage of degree-granting postsecondary institutions with first-year undergraduates offering remedial services, by control and level of institution: 1989-90 through 2013-14. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

Noble, J., & Sawyer, R. (2002). Predicting different levels of academic success in college using high school GPA and ACT composite score. ACT Research Report Series.

Office of Institutional Research. (2016). Eastern Kentucky University. *Factbook.*

Pallant, J. (2004). SPSS Survival Manual: A step by step guide to data analysis using SPSS for Windows (Versions 10 and 11). Chicago Ill.: Open University Press.

Pajares, F., & Miller, M. D. (1995). Mathematics self-efficacy and mathematics performances: The need for specificity of assessment. *Journal of counseling psychology*, 42(2), 190.

Saddlemire, G. (1978). *Reflections on the developmental education movement.* American College Personnel Association Convention, Detroit, MI.

Sanders, W. L., Wright, S. P., & Horn, S. P. (1997). Teacher and classroom context effects on student achievement: Implications for teacher evaluation. *Journal of personnel evaluation in education, 11*(1), 57-67.

Saxxon, D. P., & Morante, E. (2014). Effective Student Assessment and Placement: Challenges and Recommendations - ProQuest. *Journal of Developmental Education*, *37*(3). Retrieved from http://search.proquest.com/openview/28a2f8bc1f4246eadb9130a61a5acc47/1?pq-origsite=gscholar

Scott-Clayton, J., & Rodriguez, O. (2012). *Development, discouragement, or diversion? New evidence on the effects of college remediation* (No. w18328). National Bureau of Economic Research.

Stevens, J. (1996). Applied multivariate statistics for the social sciences (3rd edition). Mahway, New Jersey: Lawrence Erlbaum.

Tomasko, D. L., Ridgway, J. S., Waller, R. J., & Olesik, S. V. (2016). Association of summer bridge program outcomes with STEM retention of targeted demographic groups. *Journal of College Science Teaching*, *45*(4), 90-99.

Winters, C. A., & Gurney, G. S. (2012). Academic Preparation of Specially-Admitted STUDENT-ATHLETES: A Question of Basic Skills. *College and University*, *88*(2), 2.

Zientek, L. R., Ozel, Z. E. Y, Fong, C. J. & Griffin, M. (2013). Student Success in developmental mathematics courses. *Community College Journal of Research and Practice*, 17, 990-1010.

VITA

Katherine E. Fair

Education

2015–Present
Eastern Kentucky University, College of Education
Doctorate in Educational Leadership & Policy Studies

2006–2008
Michigan State University, College of Natural Science
Master of Science in Industrial Mathematics
Certificate in Business and Communications

2002–2006
Michigan State University, College of Education
Secondary Education Teaching Certificate

2001–2005
Michigan State University, College of Natural Science
Honors College
Bachelor of Science in Mathematics
Earth Science Minor

Professional Experience

2012–Present
Mathematics Lecturer/ Developmental Coordinator
Eastern Kentucky University, Richmond, KY

2011–2012
Adjunct Mathematics Professor
Bluegrass Community and Technical College, Lexington, KY

2009–2010
High School Mathematics Teacher *Lafayette High School, Lexington, KY*

2006–2008
Graduate Teaching Assistant *Michigan State University, East Lansing, MI*

2005–2006
Teacher Education Internship Program *Haslett High School, Haslett, MI*

Presentations

2016 National Association for Developmental Education Conference

Professional Memberships

- Council on Postsecondary Education—Developmental Math Professional Learning Community
- National Council of Teachers of Mathematics (NCTM)
- National Association for Developmental Education (NADE)
- Kentucky Association for Developmental Education (KADE)