THE CO-REQUISITE MODEL: A REGRESSION DISCONTINUITY

A DISSERTATION

SUBMITTED TO THE GRADUATE SCHOOL

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE

DOCTOR OF EDUCATION

BY

BECKY A. MOENING

DR. SERENA SALLOUM – ADVISOR

BALL STATE UNIVERSITY

MUNCIE, INDIANA

DECEMBER, 2016
Approximately 61% of community college students enter college with weak mathematics skills, which requires these students to enroll in a remedial mathematics course before enrolling in a college-level course (Bailey, 2009). Because of this, less than 25% of students requiring mathematics remediation earn the success of a college credential (Completely College America, 2011). The long remedial course sequence costs students time and money without adequately preparing many of these students for a college-level mathematics course. Alternatives to this traditional developmental course sequence have led to the introduction of new instructional models, including the co-requisite model, in an attempt to help more students be successful.

The co-requisite model provides additional academic support while allowing immediate college-level mathematics course access to students. A college-level course is paired with a second mathematics course used as just-in-time remediation to help students fill in the gaps caused by a lack of basic mathematics skills. This instructional model has been implemented in several colleges/universities across the country with positive results. But, do all students benefit from this model?

This study uses demographic subgroups along with course success to analyze the efficacy of the co-requisite model at Franklin Community College. Logistic regression was used to
understand how different subgroups perform. Regression discontinuity showed the impact of the placement test cutoff score on success for students within five points of that cutoff score. After five semesters of implementation of the co-requisite model, pass rates within the gateway mathematics course increased 36.5%. Over 70% of students who required mathematics remediation, who were once lost in the long remedial course sequence, are now passing the college-level mathematics course in their first semester. Students scoring within five points below the cutoff score outperformed those students who scored with five points above the cutoff score. This exemplifies promise for the co-requisite model.
# THE CO-REQUISITE MODEL

## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER 1 INTRODUCTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Statement</td>
<td>10</td>
</tr>
<tr>
<td>Purpose Statement</td>
<td>10</td>
</tr>
<tr>
<td>Research Questions</td>
<td>11</td>
</tr>
<tr>
<td>Significance of Study</td>
<td>11</td>
</tr>
<tr>
<td>Delimitations</td>
<td>12</td>
</tr>
<tr>
<td>Definitions</td>
<td>13</td>
</tr>
<tr>
<td>Summary</td>
<td>15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CHAPTER 2 LITERATURE REVIEW</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual Framework</td>
<td>16</td>
</tr>
<tr>
<td>Why is Change Needed in Remedial Mathematics?</td>
<td>21</td>
</tr>
<tr>
<td>Students Needing Remediation</td>
<td>22</td>
</tr>
<tr>
<td>Age</td>
<td>25</td>
</tr>
<tr>
<td>Gender</td>
<td>26</td>
</tr>
<tr>
<td>Race and Ethnicity</td>
<td>27</td>
</tr>
<tr>
<td>Socio-Economic Status</td>
<td>29</td>
</tr>
<tr>
<td>Success in College-Level Mathematics Courses</td>
<td>31</td>
</tr>
<tr>
<td>How to Change Remedial Mathematics</td>
<td>33</td>
</tr>
<tr>
<td>What is Co-Requisite?</td>
<td>34</td>
</tr>
</tbody>
</table>
CHAPTER 1 INTRODUCTION

Students enter college with the goal of obtaining a college credential: a degree or specialized certificate. In order to achieve the goal of completion, a specific set of courses must be completed and often, at least one of those courses is in the field of mathematics. In the community college setting, many students (61%) arrive with weak academic skills that prevent immediate enrollment in college-level courses (Bailey, 2009). Therefore, these students are placed into remedial (also called developmental\(^1\)) education classes. More than half of community college students place into remedial mathematics and less than a quarter of these students will receive a post-secondary credential (Complete College America, 2011).

Currently, remedial education can be a long and discouraging process. Some college-level mathematics courses require a sequence of up to three developmental courses to be completed before admittance into a college-level mathematics course. Originally, it was thought that these long sequences would give students ample time to learn the skills needed to be successful in the college-level course (Center, 2012). However, previous thinking has been consistently questioned. The long sequences of developmental mathematics have not given students the anticipated benefits of college-level course success but instead have offered additional exit points while costing students more time and money (Edgecombe, 2011).

The disappointment surrounding the outcomes of remedial mathematics has made the improvement of developmental education a priority for many federal, state, and individual organizations (Cullinane & Triesman, 2010; Burdman, 2013). Many community colleges are

---

\(^1\) Remedial education may also be referred to as developmental education (Rutschow & Schneider, 2011; Parker, 2012; Martorell & McFarlin, 2011) and these terms will be used interchangeably throughout this review.
searching for ways to dramatically increase student success in remedial mathematics. For
significant success to occur, the entire system of remedial education must be redesigned, from
organizational structure to course delivery methods (Collins, 2011). Different methodologies
have been recommended, such as supplemental instruction, learning communities, collaborative
learning techniques, and freshman seminars (Boylan, 1999). However, while searching for
alternative methods to improve developmental education, many new instructional models have
been introduced in an attempt to help more students be successful. A few examples include the
self-accelerating emporium model, the co-requisite model, and a modularized delivery (Lass &
Parcell, 2014). The co-requisite model will be discussed in detail throughout this review and
though it may be referred to as paired courses, concurrent enrollment, or co-enrollment, the term
corequisite will be used consistently. The co-requisite model permits students to work on pre-
requisite mathematics skills in the same semester as learning the college-level material
(Tennessee Board of Regents, 2009) and initial results of the co-requisite model indicate overall
improvements in pass rates in gateway mathematics courses (McTiernan & Fulton, 2013).

The framework of the co-requisite model consists of two mathematics courses completed
in the same semester. One of these courses, the gateway course, is a college-level mathematics
course required for the student’s degree or certificate. The other required course is at the level of
developmental mathematics. By taking both courses in the same semester, the student can fulfill
a degree requirement while mastering the basic skills needed for that specific college-level
mathematics course.

Within the co-requisite model, the remedial mathematics course content supports the
college-level course content (Boylan, 1999). The courses are deliberately designed to integrate
supplemental academic support for skills necessary for successful completion of the gateway
course (McTiernan & Fulton, 2013; Cullinane, 2012). The two courses are offered as a unit so the same students are enrolled in each course. This design allows for a cohort structure, which also builds support among students (Edgecombe, 2011).

The co-requisite model is not just a new remedial education technique; it is a redesign of the remedial system while providing support for underprepared students (Vandal, 2014). The current system sees less than 25% of students who place into remedial mathematics earn a post-secondary credential (Complete College America, 2011). This low success rate must be improved and the system that produces these results must be amended.

**Problem Statement**

Pass rates for remedial and gateway mathematics courses within community colleges are low, creating an extra barrier for students while working toward a college credential. Community colleges are implementing new initiatives, such as the co-requisite model, to increase pass rates in these courses. While initial results of the co-requisite model show some success, it is unclear if the model is beneficial to all students. Data has not been analyzed by subgroups and the impact of placement test cutoff scores has not been explored. This study provides this insight into the co-requisite model.

**Purpose Statement**

The purpose of this study is to analyze the relationship between the co-requisite model and student success in the post-secondary mathematics classroom. Two years of data are used to explore differences among student success by subgroups. Regression discontinuity is also included to analyze the impact of the placement test cutoff score on the success of students within five points of that score. The subgroups serve as independent variables and are as
follows: age, gender, race/ethnicity, socio-economic status, and level of academic preparedness. The dependent variable is the result of the college-level mathematics course, pass or fail.

**Research Questions**

The research questions that guide this study are below.

1.) What is the difference in overall student success rates before and after co-requisite implementation?

2.) What is the difference in student success rates, categorized by student demographics, among students enrolled in the co-requisite model?

3.) What is the relationship between student demographics and success in the co-requisite model?

4.) What is the difference in student success for students above the college mathematics placement test cut score compared to students below the cut score?

**Significance of Study**

This study meets a need in the community college setting. Community colleges are in need of an initiative to help increase pass rates in gateway mathematics courses. Mathematics has been a barrier to college credentials as 60% to 70% of students needing mathematics remediation never complete the remedial sequence and thus, never graduate (Bryk & Treisman, 2010). If there is an initiative that will give more students a chance to succeed in mathematics courses, then more students will have an opportunity to earn a college credential. The co-requisite model is an initiative designed to give more students access to gateway mathematics courses, paired with additional academic support. With more students having access to the
gateway course and receiving additional academic support as needed, it is the hope that mathematics pass rates will increase. This study will show the difference in pass rates in gateway mathematics courses, before and after implementation of the co-requisite model. This study will also examine the pass rates among subgroups in terms of age, gender, ethnicity, and Pell grant status. As there is a lack of prior research in success of students by subgroups, this study is an important contribution to this area of research.

**Delimitations**

Multiple delimitations are present within this study. The first is location as Franklin Community College\(^2\) is a community college with multiple campuses. Also, not all students enrolled at Franklin Community College are included in the data set. Only students enrolled in the co-requisite mathematics courses as well as the stand-alone gateway course are included in the study. The gateway mathematics course used in this study is the liberal arts mathematics course required for graduation, not an algebra based course.

Another delimitation is the actual data. All data used for the research into the success of the co-requisite model comes from an archival database. The study was limited to the data available from Franklin Community College’s Center for Institutional Research. Also, the timeframe the co-requisite model has been in use is important to the study. The timeframe of the study begins in the Fall 2011 semester. However, the co-requisite model was not fully implemented until the Fall 2013 semester. The study begins in Fall 2011 to allow two years of baseline data to be collected before the two years of co-requisite data.

---

\(^2\)Franklin Community College is a pseudonym and will be used consistently throughout the review.
Definitions

- *Adult Learning Theory* – This theory indicates that adult learners exhibit different characteristics than student learners (Knowles, 1978).

- *Co-Requisite* – An instructional methodology where a developmental course is paired with a college-level course. The developmental course is designed as a support class to the college-level course (Boylan, 1999). The term co-requisite may also be referred to as: paired courses, concurrent enrollment, or co-enrollment.

- *College-level Course* – Academic course that provides credit toward a college credential (Miller & Morgan, 1997).

- *Cut (cutoff) Score* – The score on an initial placement test to determine appropriate course enrollment (Boylan, 2011).

- *Developmental Education* – Classes taken at a college to bring student skills up to college-level without earning college credit. The term ‘developmental’ is often used interchangeably with ‘remedial’ (Bautsch, 2013).

- *Emporium Model* – The emporium model is a computer-based instruction model with support from tutors and full-time instructors (Lass & Parcell, 2014).

- *Gateway Course* – Credit bearing, high risk to students (high percentage of failing students), and high enrollment courses (Shaffer, 2013).

- *High Needs Students* – High needs students place at least three levels below the college-level course and demonstrate high levels of developmental needs (Cullinane, 2012).

- *Intersectionality* – A tool for studying the ways in which identities (such as age, gender, ethnicity, socio-economic status, etc.) intersect and contribute to unique experiences (Symington, 2004).
• *Just-in-time Remediation* – Academic support given to students on specific concepts at the precise time the help is needed (Jaschik, 2009).

• *Learning Communities* – In a learning community, the classroom not only becomes a place where teaching occurs but also becomes a community in which students learn to learn (Boylan, 1999).

• *Low Needs Students* – Low needs students place just below the cutoff for college-level mathematics as they are lacking only a few skills needed to be successful in the college-level course (Cullinane, 2012).

• *Middle Needs Students* – Middle needs students place approximately two levels below the college-level course and exhibit a need for developmental skills (Cullinane, 2012).

• *Modularized Delivery* – An instructional method where content is broken down into modules and students must master a specific set of modules for a particular program of study (Lass & Parcell, 2014).

• *Remedial Course Sequence* – A sequence of courses increasing in difficulty in one subject area because academic skills are considered to be lower than one level before college-level coursework (Bailey, 2009). Upon completion of the sequence, students are deemed prepared for college-level coursework (Bailey, Jeong, & Cho, 2010).

• *Remedial Education* – Classes taken at a college to bring student skills up to college-level without earning college credit. The term ‘remedial’ is often used interchangeably with ‘developmental’ (Bautsch, 2013).

• *Stand-alone Course* – A course offered without academic support (Vandal, 2015).
Supplemental Instruction – The support provided in Supplemental Instruction (SI) courses consists of small-group sessions in which students who have taken the course previously serve as small-group leaders (Boylan, 1999).

Summary

This chapter introduced the problem of an ineffective remedial mathematics system. Many community college students enter remedial mathematics and yet few are successful at earning a college credential. The traditional method of remediation needs to be renovated in a way that will promote further student success. The co-requisite model is a new instructional delivery method designed with additional academic support in mind. This model is new and colleges are still learning about the design and how it can best be implemented for particular groups of students.

The remaining chapters will provide expanded information and research on the co-requisite model and remedial mathematics education. Chapter 2 will continue to examine the intricacies of the co-requisite model through a review of relevant literature. The methods for the study will follow in Chapter 3 with the results described in Chapter 4. Chapter 5 will provide the conclusion and implications of the study as well as recommendations for future research.
CHAPTER 2 LITERATURE REVIEW

Many community college students enter remedial mathematics and few earn a college credential. The traditional method of mathematics remediation needs to be examined and potentially changed to promote further student success. This literature review begins by showing why higher education needs to change its system of remediation and how that change can be achieved. Next, the focus turns to the students impacted by remedial education, along with how the co-requisite model could potentially influence those students. Then, the relationship of success of students between remedial and college-level mathematics courses will be examined. This transition between the remedial and college-level mathematics courses leads to a discussion on how to change remedial mathematics to better impact the college-level courses.

The co-requisite model will be discussed in depth, particularly considering its impact when implemented with fidelity. While the affordances of the co-requisite model will be discussed, its shortcomings will also be addressed in detail. Finally, the results of early implementation from several locations throughout the nation will be described thoroughly. The instructional models of remedial education will be included and implications for adult learners will be incorporated throughout the review.

Conceptual Framework

Adult learning theory undergirds this study. It is important to understand how adults learn so community colleges can help more students be successful. Many community college students are unsuccessful in remedial mathematics because they lack basic mathematics skills, have low academic confidence, have high mathematics anxiety, or see no relevance to the material being taught (Howard & Whitaker, 2011).
Students may lack basic mathematics skills for a variety of reasons. Non-traditional students may have been away from the academic setting for a significant length of time, making a refresher of mathematical material necessary for future success (Howard & Whitaker, 2011). It is also possible that students lack pre-requisite knowledge because of their struggles in high school mathematics (Mekonnen & Reznichenko, 2008). Students may have never learned the necessary information (Howard & Whitaker, 2011) or possess poor study skills which lead to a lack of basic knowledge (Mekonnen & Reznichenko, 2008).

Students that lack basic mathematical skills are likely to also have low academic confidence and/or high anxiety in the mathematics classroom. Students enrolled in developmental courses know the content is the same as high school material, leading to a lack of confidence (Cox, 2015). Students with difficulties in understanding mathematical concepts often also possess poor practicing skills (Mekonnen & Reznichenko, 2008). These difficulties lead to internal beliefs about mathematical competence. These beliefs plays a large role in influencing success as students believe there is a limit on what is capable of being learned (Howard & Whitaker, 2011).

This limited mathematics competence of students also leads to math anxiety. Students do not want to feel like a failure in the classroom, so they might refrain from asking questions. They would rather not understand a concept than be ridiculed for questioning and appearing less intelligent to their peers (Smith, 1979). From an early age, mathematics is the course where the single, correct answer should be recited as quickly as possible. This often leads to frustration and students are not taught how to work through this frustration, causing more anxiety (Smith, 1979).
Students who lack basic mathematics skills and have low academic confidence and/or high mathematics anxiety may not see relevance in taking a mathematics course which covers a generic variety of skills. Traditionally, mathematics instructors tend to focus on disconnected mathematical practices without emphasis on understanding the deeper contextual material. Students are instructed to memorize facts and rules, then apply these without understanding the methodology behind the facts and rules (Cox, 2015). However, if students are enrolled in a course that covers a specific set of concepts that apply directly to the required college level mathematics class, this course may be better received by students, thereby increasing motivation.

The co-requisite model of instruction attempts to combat these factors by incorporating aspects of adult learning theory. Students who lack basic mathematics skills may not see relevance in taking a mathematics course which covers a generic variety of skills. However, a course which covers specific concepts that tie directly to the required college-level mathematics class may be better received by students. Adult learners want to understand the reasons for learning particular concepts (Kiely, Sandmann, & Truluck, 2014). Adult learners are also motivated to learn material that will have an immediate impact on their life (McDonough, 2013).

Developed by Malcolm Knowles, adult learning theory was developed to identify the characteristics of adult learning. Here, the term ‘adult’ is defined as those whose age, social roles, or self-perception define them as adults (Merriem & Bierema, 2013). It is often assumed that an adult is age 18 or holds the social roles of parenthood, possess a full-time job, or performs the role of family caretaker. People also may simply view themselves as an adult, no matter their age or social role (Merriem & Bierema, 2013). Within adult learning theory, it is important to understand the differences in the life of an adult at the time of learning versus that of a child at
the time of learning and how these changes can affect the learning process (Merriem & Bierema, 2013).

Knowles’ adult learning theory indicates that, along with differences in how adults and children learn, adult learners also exhibit different characteristics than younger learners (Knowles, 1978). These characteristics are most easily seen through the four lens model of adult learning discussed by Kiely, Sandmann, and Truluck (2014): learner, process, educator, and context. Understanding how the adult learner fits within each lens helps to clarify what it means to be an adult learner and how the education system can best serve these students.

The learner lens focuses on the individual adult learner. This is where Knowles popularized the concept of andragogy, or the art of helping adults learn (McDonough, 2013). This lens is also home to Knowles’ model of assumptions of adult learners and how they differentiate from child learners. When compared to children, adults see themselves as more responsible, self-directed, and independent (Kiely, Sandmann, & Truluck, 2014). Children are more dependent on an adult to give direction and demonstrate skills to be learned (McDonough, 2013). Both adults and children have knowledge and experience to draw from and therefore, connect to current learning. However, adults have a more diverse set of experiences to draw from which may make connections in education easier when compared to children (McDonough, 2013; Kiely, Sandmann, & Truluck, 2014).

Adult learners have a readiness to learn based on real-life responsibilities (Kiely, Sandmann, & Truluck, 2014). While children also have real-life activities that impact learning, the responsibilities of adults tend to differ from the responsibilities of children; thus the frame with which adults and children bring to learning varies. These real-life responsibilities and
current life situations often lead the adult learner to possess a stronger need to understand the reasons for learning a particular concept (Kiely, Sandmann, & Truluck, 2014). Adult learners are most motivated to learn material that has a direct and immediate impact on their life (McDonough, 2013).

Motivation is present in both child and adult learners. Adult learners tend to be more intrinsically motivated (Knowles, 1980; Kiely, Sandmann, & Truluck, 2014) as compared to children. However, both children and adults possess intrinsic and extrinsic motivation when it comes to learning (McDonough, 2013). Both child and adult learners possess many of the same characteristics. However, adults have more life experience and more easily make conscious decisions in regards to learning (McDonough, 2013). This wider breadth of experience allows adults to see more connections to the material and may attribute to internal motivation.

Adult and child learners are different in multiple ways. Therefore, it is important to understand the process of how adults learn in comparison to children. Significant life events (divorce, death, childbirth, job change, etc.) can have a substantial impact on the learning process (Kiely, Sandmann, & Truluck, 2014). Adult educators should take into account life events of the adults in the classroom and how those events impact education in order to offer a more positive educational experience. The educational environment also must be considered in the process of educating adults. Adults need a safe and supportive environment where they can be immersed in learning (McDonough, 2013).

Educators need to consider the characteristics of adult learners as well as the backgrounds of each adult learner. Often, educators teach in ways that imitate their experiences, which is not always the best option for teaching adults (Kiely, Sandmann, & Truluck, 2014). Educators
should diversify their teaching methodologies based on the individual learners in the classroom as well as the purposes for learning the particular concepts. Every adult learner has a different set of background knowledge and experiences that guide the learning process. It is up to the educator in the co-requisite classroom to appeal to the individual adult learners and help connect the content to real-life experiences.

**Why is Change Needed in Remedial Mathematics?**

Community colleges face the difficult task of providing a college-level education for students who often enter post-secondary institutions with skills below the college-level requirement (Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009). Remediation at the college level was designed as a basic tool to help underprepared students become college-ready. However, after much research, it appears that subjecting underprepared students to long sequences of classes before enrolling in a college-level mathematics course is not effective (Center, 2012). The data and analyses to support this statement will be discussed throughout the length of the review.

Nationally, more students are encouraged to attend college to earn a post-secondary credential. College completion has become a top priority for both state and federal governments as well as local policy makers and funders (Parker, 2012). While more students are encouraged to attend college, many do not enroll at the college-level. At the community college level, 50% to 70% of enrolled students are required to take at least one remedial mathematics course (Rutschow, Diamond & Serna-Wallender, 2015; Complete College America, 2011; Bailey, 2009). Over half of students need developmental mathematics and therefore it is important to have a program in place to help these students succeed. However, the current remedial system is not fulfilling these needs. Many students who place into remedial education come into college
with more academic challenges than the general student, such as time out of academia or lack of basic skills (Adelman, 2004; Attewell, Lavin, Domina, & Levey, 2006; Doyle, 2012). Therefore, colleges need to provide more services to these students throughout their educational career to promote success (Rutschow & Schneider, 2011). The focus ought to be on the students who need remediation and how the process can work for them, not against them.

Most students who place into developmental mathematics do not complete the required remedial courses for one of two reasons: they did not enroll in the required mathematics course or they did not pass the course in which they did enroll (Roksa, Jenkins & Jaggars, 2009). This may be because students come to college expecting to take college-level courses. When placed into remedial courses, especially when there is more than one remedial course needed, students are more likely to not complete the developmental course sequence (Bailey, 2009). Longer course sequences tend to get the most negative feedback in terms of dismal pass rates. However, the success of students at any level of the remedial course sequence is bleak. Of students who place into remedial mathematics, 60% to 70% do not complete the sequence or simply avoid mathematics altogether and never graduate (Bryk & Treisman, 2010). Something needs to change to help these students find mathematical success in college.

**Students Needing Remediation**

While the focus thus far has been mainly on students who do not enroll or are not successful in developmental mathematics courses, some students are successful. However, that success is hard to celebrate. Only 30% of community college students referred to developmental mathematics will successfully complete their remedial mathematics course sequence (Attewell, Lavin, Domina & Levey, 2006; Complete College America, 2011; Bailey, Jeong & Cho, 2010).
It is discouraging to see such poor success rates for community college students and unfortunately, the disappointment does not stop there. A degree at most community colleges is geared toward completion in two years. However, 20% of all students who are told they need remedial mathematics still have not enrolled in one of those required remedial courses within three years (Bailey, 2009). The obstruction of developmental mathematics is excruciating for students and causes many to never complete their college credential. Of the remedial students who do enroll in the developmental course sequence, only 20% of these students complete the college-level mathematics course within three years (Bailey, Jeong & Cho, 2010). That percentage of success is low, but how low is it?

To illustrate, assume there are 100 students entering a community college. Statistically, 50 to 70 of those students will need remedial mathematics (Rutschow, Diamond & Serna-Wallender, 2015; Complete College America, 2011; Bailey, 2009). Considering a 30% success rate, between 15 and 21 of those students will successfully complete their remedial mathematics course sequence. Therefore, extrapolating from these data, between 35 and 49 out of every 100 students have their chances of college success eliminated due to the barrier of remedial mathematics. With only 20% of remedial students completing the college-level course in the three years following initial enrollment, one can expect only 10 to 14 of those 50 to 70 students will have completed their college-level mathematics course on their way toward earning their credential. The rest of the remedial students, between 46 and 50 of them, still have not passed their college-level course after three years. From the earlier calculations, it is estimated that 15 to 21 of the 50 to 70 will complete the developmental sequence. These numbers are discouraging to many within higher education.
More than half of community college students place into developmental mathematics and yet so few are ever successful. For example, less than a quarter of students who place into remedial mathematics ever receive a post-secondary credential (Complete College America, 2011). According to these data, community colleges are failing nearly 50% of the students who enroll in classes. Something needs to change to give these students a chance to succeed and potentially improve their life with the obtainment of a college credential.

After examining the data, it seems obvious there is a problem with the current state of remedial mathematics. Remedial mathematics is based on a predetermined set of common mathematical concepts and is not effective in overcoming individual student weaknesses (Bailey, 2009). It was created as a one-size-fits-all program and does not take into account individual student needs (Complete College America, 2011). Students needing remediation do not just require academic support in mathematics, but also need basic college success support as well. The present-day remedial mathematics instructional model does not allow for the non-academic support needed for many students to succeed (Center, 2012). Non-academic support could come in the form of study skills, help with time management, and organizational techniques. The low pass rates within developmental mathematics clearly indicate a need for change from the current system. However, the change necessary is not just a redesign of the remedial mathematics curriculum but also of the support system offered to students (Bryk & Treisman, 2010). The new structure of remedial mathematics should not be a one-size-fits-all approach. Every student may require something different based on multiple attributes including age, gender, race or ethnicity, socio-economic status or level of academic need. Each category must be addressed in its own way as it offers its own set of challenges. However, these variables are not mutually exclusive. There is intersectionality among groups, which operates differently across place and time.
(O’Connor, 2001). It is understood that students will fit into multiple categories and may need several different interventions to be successful at the college level. Colleges need a remedial system that will allow for this approach and variability. It is imperative to understand the differences between and among the subgroups, as discussed below.

Age

Community colleges enroll students of all ages. How does age influence the need for remediation and college success? Remedial student success is described as completing a gateway mathematics course within the first two academic years. College success is defined here as passing the college-level mathematics course, and when focusing on age, the lowest success rate belongs to the group of students in their early 20’s (20-24) with a 19.8% success rate. The age group directly out of high school, up to age 19, has a 24.8% pass rate of their gateway mathematics course within the first two academic years. It is the non-traditional college students, age 25 and older, who have the greatest college-level course success rates at 32.3% (Complete College America, 2014). While older students succeed at a higher rate in college-level courses, they do not fare so well in remedial programs. At any level of remediation, older students have lower odds of progressing on to the next class compared to younger students (Bailey, Jeong, & Cho, 2010). There is little research on why older students achieve higher success at the college-level but also struggle within the remedial education programs. However, if an older student is enrolled into the co-requisite model, direct access is given to the college-level mathematics course so the student will not flounder in the long sequence of remedial coursework. Examining students by age is just one way to breakdown the data. Gender is a second way to manipulate the figures.
Gender

When considering the number of students in the community college setting in need of remediation, females hold a slight edge over males. In an extensive study by Colorado community colleges, approximately 66.8% of females enter college needing remediation while a slightly lower 59.5% of males find themselves in remedial classes (The Colorado Department of Higher Education, 2014). A single study showing more females requiring remediation compared to men is not indicative of a gender gap. Though fewer males require remediation, they tend to have lower odds of successfully completing a remedial course and moving on to the subsequent course. Young men are more likely to have low levels of skills, have poor levels of academic achievement, and thus, young men are more likely to leave school early without a credential (Bradley, 2015). Within remedial mathematics, the odds for women to move on to the next class were 1.5 to 1.8 times as high as those for men. This effect was found to be consistent through all levels of remediation (Bailey, Jeong, & Cho, 2010). It appears while women may be more likely to place into remedial mathematics, they are also more likely to work through the material and successfully complete the remedial sequence.

The 7.3 percentage point difference between males and females in remedial mathematics is not consistent with the 12th grade data disaggregated by gender from NAEP (National Assessment of Educational Progress). The latest data prepared by NAEP is from the 2013 school year. Comparing 12th grade students by gender shows nearly equivalent achievement. The average score on the given examination was a 155 for males compared to a 152 for women, yet this difference is not statistically significant. When focusing on those students who scored at or above proficiency, 28% of males and 24% of females scored in this area. Males and females are achieving similarly within mathematics (NAEP, 2013).
The idea of women scoring as high as men, or even out-performing men is seen in other areas besides 12\textsuperscript{th} grade NAEP examinations. Recent studies show more women going into higher education compared to their male counterparts. In 1994, 63\% of female high school graduates went on to college compared to 61\% of male high school graduates. However, in 2012, the female graduates jumped to 71\% attending college while the males remained steady at 61\% (Lopez & Gonzalez-Barrera, 2014). In terms of college completion, between the years 1991 to 2014, women earned more associates degrees than men every year (Bradley, 2015).

These studies disconfirm the stereotype that men are better at mathematics when compared to women. After analyzing multiple years of data and more than one million students, it appears that males and females perform similarly in mathematics (Lindberg, Hyde, Petersen, & Linn, 2010; Stoet & Geary, 2012). Once students are in the mathematics classroom, gender is not indicative of performance. The changes in student success, when examining differences in age and gender, are relatively small when comparing the differences in ethnicity.

**Race and Ethnicity**

The disparity among racial groups when completing gateway mathematics courses is extensive. When focusing on students who begin in remedial mathematics, only 29.2\% of White students complete their college-level mathematics course within the first two academic years. Hispanics are less likely to complete the course compared to Whites, with a success rate of 25.8\%. A larger disparity comes when considering Blacks, completing at just 13.2\% (Complete College America, 2014). This trend tends to be consistent across all levels of mathematics. When students are referred to remedial mathematics two to three levels below college-level, on average, Black students have lower odds than White students of passing on to the next class (Bailey, Jeong, & Cho, 2010).
It is worthy to note that Hispanics and Blacks are more likely to need remediation when compared to their White peers (Bautsch, 2013). However, remediation is a wide-spread need among racial subgroups. When highlighting community colleges, more than 50% of students within each individual ethnic subgroup are in need of remedial coursework. Whites have the lowest percent with 55.3% needing remediation and Blacks have the highest at 86.7% needing remediation. Hispanics (77.8%), Asian (67.6%), and Multiracial (65.3%) are also at a high percentage of students needing remediation (The Colorado Department of Higher Education, 2014). See Table A1 for a full description of the breakdown of remediation by ethnic subgroup.

The number of students needing remediation seems to have a negative correlation to the number of students earning college credentials when considering ethnic subgroups. Blacks have the highest percentage of students in need of remediation and one of the lowest levels of degree attainment at 28%. Only American Indians and Hispanics earn college credentials at a lower percentage, at 23% and 20% respectively. Asians lead the college credential attainment as 59% of students in that ethnic subgroup earn a college credential. Whites are in between the two extremes, with 44% of students earning a college credential (Squires & Boatman, 2014). See Table A1 for a full description of the breakdown of credential attainment by ethnic subgroup.

The breakdown of data by ethnic subgroups in regards to remediation and college credential attainment are very similar to the breakdown of success at the 12th grade level according to data recorded by NAEP. In 2013, the results of a 12th grade examination shows Asian/Pacific Islanders are the top performing with 47% of these students scoring at or above proficiency. Similar to college credential attainment, Whites are next with 33% of students scoring at or above proficiency. Hispanics and Blacks are lowest performing groups, with just 12% and 7%, respectively, scoring at or above proficiency (NAEP, 2013). This shows
consistency in the academic performance of ethnic subgroups from high school through college credential attainment. There are differences among the ethnic subgroups when comparing success rates of students in remedial mathematics to college credential attainment. See Table A2 for a full description of the breakdown of 12th grade achievement by ethnic subgroup. In addition to age, gender, and race or ethnicity, another important factor to investigate when analyzing student success is socio-economic status.

**Socio-Economic Status**

Students classified as having a low socio-economic status are less likely to attend college, persist in college, or graduate from college (Bennett, 2016). Low-income students may receive a federal Pell Grant. A Pell Grant is a federal grant provided by the Department of Education to undergraduate students who show an exceptional level of financial need (Bennett, 2016). Since Pell Grant eligibility is determined by the federal government and applies to all students, this is a consistent measure of differentiating between students with financial need and students without financial need.

In 2011 only 40% of full-time, first year students with Pell Grants graduate within six years as compared to nearly 65% of non-Pell Grant recipients (Vedder, 2011). In just four years, the Pell graduation rates had increased to 51% while the non-Pell rates held steady at approximately 65% (Nichols, 2015). Too many Pell Grant recipients are enrolling at colleges with historically low graduation rates while non-Pell students are more likely to select colleges with higher graduation rates. Students at these select colleges are more likely to obtain a college credential (Nichols, 2015).
However, these differences do not start at the college level; they start at a young age and continue through high school (Walpole, 2003). High school diplomas are considered the norm for students of low socio-economic families while college credentials are expected of students coming from families of higher economic status (Walpole, 2003). Of high school students whose parents are college graduates, 90% will enroll in college compared to just 69% of students whose parents are high school graduates only. The students with parents who have earned college degrees are also more likely to attend a four-year university (Baum & Payea, 2005).

High school students are dependent upon an adult to provide basic needs. The home life of students does impact academic achievement and the highest level of degree attainment of a parental figure is an indicator of home life. The educational background of a parent is often associated with socio-economic status. The educational experience of parents is positively correlated with the success of their children in college. In a 2013 study completed by NAEP, data were disaggregated based on the educational success of the parent(s). Just 9% of students whose parents did not finish high school scored at or above proficiency on the 12th grade proficiency examination. This is compared to students whose parents were college graduates, as 38% scored at or above proficiency. See Table A3 for the full breakdown of student achievement by the education level of the parent(s).

For those students coming from low socio-economic backgrounds, community colleges are often the college choice and not the four-year institutions (Walpole, 2003). Community colleges offer a low cost option (35% of the cost of a public four-year university) with convenient location, which allows students to work, live at home, and take care of their families while attending school. Many community colleges are open admissions so a low high school grade point average is not a detriment to the college application. Lastly, community colleges
provide degrees with a high rate of return for students. Jobs in the health care, computer programming, or trades field can offer excellent pay and benefits when students graduate (Furchtgott-Roth, 2013). Community colleges also offer a variety of classes that may help an undecided student find a career path at a lower tuition cost than exploring courses at a four-year university.

**Success in College-Level Mathematics Courses**

Often, students whose degrees require mathematics are assessed by a placement exam to determine what course to take first. Based on the score thresholds determined by the institution, students are placed into their required mathematics course, either developmental or college-level. To illustrate, in a placement exam with a maximum of 100 points, a score of 30 to 50 might place the student into the lowest developmental course, a score of 50 to 70 might into the intermediate developmental course, and a score of 70 or above indicates the student is college-ready. The number and type of remedial courses on the student’s path may also depend on the level of mathematics course required for the particular degree.

While many schools use cutoff scores to determine mathematics remediation needs, these scores vary from state to state and even from school to school. For example, a score of 50 may place a student into Elementary Algebra at one school and Intermediate Algebra at another school. The placement test itself may also be different from state to state and school to school. The inaccuracy of the placement test makes it difficult to predict student success in a remedial or college-level course (Burdman, 2013). Research shows there is a weak relationship between placement test scores and success in the following remedial or college-level course (Collins, 2011). Because of this, many students whose placement test score places them into remedial
mathematics could potentially succeed in a college-level course rather than spending time in the remedial mathematics sequence (Center, 2012).

Additionally, studies have demonstrated no discernible difference between students who test into remedial mathematics versus the students who score directly into their college-level mathematics course (Doyle, 2012). In other words, the students who place below the cutoff score and into remedial mathematics fare as well as students who place above the cutoff score into college-level mathematics. It is estimated that 50% of students who place into remedial mathematics could earn a C or better in their appropriate college-level mathematics course (Clayton, 2012). Half of community college students requiring remediation are asked to take additional classes and spend more time and money when it is simply not needed.

It is known that students who place into remedial education are less likely to earn a post-secondary credential (Bailey, 2009), so why do colleges continue to require remediation of so many students? The ultimate goal of remedial education is to prepare students for success in college-level courses. However, the only way for students to find success in a college-level course is to have access to the class and experience it first-hand (Cullinane, 2012). More students need to be placed into a college-level course instead of the long remedial course sequence.

Moreover, studies have shown that developmental students are not hurt by attempting courses that are more difficult than where they placed based on the placement test (Bailey, Jaggars, & Scott-Clayton, 2013). Students benefit from being challenged. Because of this challenge, pass rates for college-level courses were similar for students who tested directly into the course compared to students who did not follow their developmental recommendation and
instead enrolled into a college-level course immediately (Roksa, Jenkins & Jaggars, 2009). Therefore, students can have success in a college-level course without completing the long remedial sequence. However, it is difficult to determine which students are more apt to be successful in the college-level course and which students would benefit more from the remedial sequence. Is there a specific student (age, gender, ethnicity, socio-economic status, mathematics placement test score) that leads to a higher probability of success in the college-level mathematics course? More research needs to be done on specific student success and how community colleges can reduce the long developmental course sequence and help students become more successful.

**How to Change Remedial Mathematics***

The current higher education system treats all students needing remedial mathematics as the same and assumes they need the same academic support. However, this is untrue. Students need to be taken out of traditional remedial programs and placed into a program that is customizable and allows for individual needs to be met (Complete College America, 2011). One single approach is not suitable for a developmental course sequence (Bonham & Boylan, 2012). It is important to organize remedial mathematics in such a way that students receive the academic (and non-academic) support they require while at the same time, learn the necessary skills needed for their particular college-level mathematics course. This idea of learning skills exactly when needed fits in with Knowles’ theory of adult learning, as adults learn best when the topic is of immediate value (Knowles, 1984).

Because 50% of students placed into remedial mathematics could be successful in a college-level mathematics course, more students should gain immediate access to college-level courses (Clayton, 2012). The placement scores need to be relaxed and students need to stop
being dictated by that score. College-level courses should be open to more students while incorporating academic support into that college-level course (Bailey, 2009). Students will respond to challenge and with academic support available, will have the same probability of success as they did by being placed into the long remedial course sequence (Adams, 2003; Bahr, 2008). It makes sense to shorten the sequence and allow earlier access to college-level courses for students. Earlier entrance to college-level mathematics courses, coupled with additional academic support, is behind the design of the co-requisite model.

**What is Co-Requisite?**

Co-requisite is more than just a remedial mathematics practice; it is a complete redesign of the remedial mathematics system for academically underprepared students (Vandal, 2014). The co-requisite model allows for students to enroll in a college-level mathematics course while also enrolling in a paired developmental mathematics course in the same semester. Students are exposed to college-level material while also given the academic support needed to help master the college-level topics while attending the developmental course. This is not a one-size-fits-all model (Cullinane, 2012). The developmental course that is paired with the college-level course is designed as a support class (Boylan, 1999). Students are given the skills needed, as needed, on an individual level. With an individualized approach, adult students are permitted to learn through action, learning by doing, and learning through experience, discovery, and exploration (Rogers & Freiberg, 1994). Also worthwhile to note, according to Knowles’ (1984) theory of adult learning, adults need to learn experientially.

Students who take the courses separately (in separate semesters) do not benefit from the relations of the course content or the cohort affect, both of which may lessen their likelihood of success (Edgecombe, 2011). Co-requisite courses are paired in a sense that the same students are
enrolled in both classes, creating a cohort type community. Because of this cohort mentality, the co-requisite course instructors must work together and have close cooperation in order to help students succeed within the two courses (Rauch, 1987). The cohort structure builds another layer of academic support for students that helps lead to success within this model (Edgecombe, 2011).

Success is not only due to the cohort support system, but also the structure of the remedial course. This course is built as a just-in-time remediation for the basic mathematics skills students will need in their college-level course. As students encounter difficulties in a college-level mathematics course, the remedial course is used as an immediate problem-solver. Students receive only the information they need without extra time-wasting material. The course is created simply as support and provides basic needs for students as those needs arise.

The remedial course is used to help students with immediate academic needs. Students come to class and communicate areas of concern, confusion, or frustration from the college-level course. The remedial course instructor uses a variety of teaching methods to address the individual needs of students. Lessons may be re-taught, students may be asked to work in collaborative groups, the instructor may work one-on-one with different students throughout the course, or any number of other methodologies may be put into effect. Each class session may be different as it is guided by the needs of the students.

There are multiple methods proposed for improving the problems of remedial mathematics. Why is now the time to leave traditional remediation in the past and move to a new model? Should the co-requisite model be pursued as a possible solution? There are many considerations that go into this answer, but the answer must reflect student needs. Within the co-requisite model, instructors can develop classroom activities that offer support to student
learning in an environment that encourages students to participate freely without negative ramifications (Novak, 2011). The needs of students needing remediation vary greatly and colleges need a developmental model that will allow for instructors to respond to individual needs on a daily basis (Cullinane, 2012).

**Shorter Sequences**

The current remedial course sequences can require as many as three remedial courses to be completed before a student is permitted to enroll in a college-level course. Research has shown that the longer the required remedial education sequence, the less likely the students will be successful (Vandal, 2014). Not only is this intimidating for students but it provides multiple points for students to exit the system. By cutting down the length of the sequence, possible exit points are eliminated between developmental and college-level courses (Edgecombe, 2011). The co-requisite model eliminates the dreaded long developmental course sequence while incorporating more academic support to students (Vandal, 2014). Students go to college to engage in college-level coursework and the co-requisite model provides that opportunity to students while offering additional support. It is important to eliminate the long sequence and allow students to engage in college-level coursework early in their college careers.

**College-Level Courses**

For the co-requisite model to be successful, the focus must shift away from success in remedial courses and spotlight college-level courses. The goal should be to improve progress in college-level courses that will lead to more students completing a college credential (Center, 2012). Currently, colleges place students into remedial mathematics and offer academic support to help them. Instead, better results may come from placing more students directly into a college-level mathematics course and offering the remedial course as the support. This allows
students to work toward their degrees while still receiving the necessary academic support that is essential to success (Complete College America, 2011). The goal of college is for students to earn credentials, so why are colleges adding extra barriers for students (Boylan, 2011)? The barriers of long remedial sequences can be eliminated by placing students into classes where credits can be earned with individualized support available specifically when needed.

**Relevance of Material**

The current state of developmental mathematics is a basic approach. All students in the classroom receive the same information on the same day and are expected to do the same work in the same amount of time. This is not realistic for today’s students. Each student has different life experiences and comes from a different educational background. The prior knowledge of individual students must be taken into account in the classroom. Adult learners have a wide breadth of life experiences which may help to make real life connection to the mathematical concepts within the classroom (McDonough, 2013; Kiely, Sandmann, & Truluck, 2014). The co-requisite model makes the basic mathematics skills relevant because they are used immediately in the college-level coursework (Edgecombe, 2011). Skills are taught to the students who need them on the days the skills are needed. Students see the benefits of the remedial coursework as they are working through both mathematics classes within the co-requisite structure.

Mathematics has traditionally been taught in a lecture type setting. The teacher works through examples and writes notes on the board. Students follow along, copy the notes, work the problems with the teacher, and there may be little engagement (Van de Walle, Karp, & Bay-Williams, 2007). The predominant instructional method of choice for remedial education is this
lecture style approach, which is falling out of favor with the new methodologies available (Levin & Calcagano, 2008).

The co-requisite model, in the remedial portion, encourages students to do more mathematics in a collaborative environment, rather than spending the entire time listening to someone else discuss mathematics (Bonham & Boylan, 2012). The collaborative environment establishes a positive atmosphere for academic modeling while providing a social support system for students. A collaborative atmosphere increases self-esteem and reduces anxiety within students (Laal & Ghodsi, 2012). This encourages student participation and promotes critical thinking skills within the mathematical material and again, makes the material more relevant to the students’ lives.

Cohort System

Student participation is also more easily seen within the cohort system of the co-requisite model. Because students are enrolled in both classes, relationships are built and students spend more time working together. For all students there is great benefit in collaboration and working together throughout the mathematical learning experience (Boylan, 1999; Koski & Levin, 1998). Co-requisite students have the opportunity to live this experience firsthand. These students do not feel alone on the journey and have others to help them work through academic and non-academic issues. Cohorts enrich learning experiences and lead to an improved student experience that is shown by increased academic performance (Pemberton & Akkary, 2010). Therefore, it is beneficial for the remedial students to be enrolled in both mathematics courses together within the same semester. The model shows a positive change in student attitude toward academics as well as an increase in student retention (Koski & Levin, 1998). The cohort experience is positive for students in this model.
Access to Success

In the traditional remedial system, only 20% of students placed into remedial mathematics completed a college-level mathematics course within three years (Bailey, Jeong & Cho, 2010). By eliminating the traditional way of delivering remedial mathematics, the co-requisite model can significantly increase the number of students requiring remediation who complete a college-level mathematics course in one year (Vandal, 2014). Instead of students becoming stuck in the lengthy sequence of remedial mathematics, they satisfy their remedial requirements in the same semester as completing their required college-level mathematics course.

Not only does the co-requisite model increase student access to a college-level course, but it increases success rates in that college-level course. At the beginning stages of implementation, the co-requisite model shows student success rates at levels that are two to three times better than traditional methods of delivery (Jenkins, Speroni, Belfield, Jaggars & Edgecombe, 2010). However, more recent results have seen success rates that are five to six times better than the traditional remedial mathematics delivery models (Vandal, 2015). With these higher levels of student success in the college-level mathematics course, it makes sense to think this will carry over throughout the college experience; and, it does. The co-requisite model has been linked to higher grades and higher completion rates in a college-level mathematics courses as well as increased persistence in enrollment and a greater total credit accumulation for students (Wilcox, del Mas, Stewert, Johnson & Ghere, 1997; Jenkins, et al., 2010; Tennessee Board of Regents, 2009). In this case, the co-requisite model appears to improve student success in more than just the mathematics classroom.
Students Enrolled in the Co-Requisite Model

Remedial mathematics students are generally placed into three categories. Low needs students place just below the cutoff for college-level mathematics as they are lacking only a few skills needed to be successful in the college-level course. This could be an Intermediate Algebra course leading to College Algebra. Middle needs students place approximately two levels below the college-level course and exhibit a need for developmental skills and would potentially start in Elementary Algebra, a course below Intermediate Algebra. High needs students place at least three levels below the college-level course and demonstrate high levels of developmental needs (Cullinane, 2012). These students may be permitted to enroll in Elementary Algebra or they may be asked to remediate on their own and re-test. The amount of remediation required is dependent on where students fall within these categories. Placement into these categories is dependent upon scores on the initial placement exam. There are multiple companies who provide placement exams for colleges, such as the Accuplacer by College Board and the Compass test by ACT. These national exams may be modified to fit specifically for a particular college or to fulfill a specific need.

Low-Need Students

Students who assess close to the cutoff score should be at least as successful by avoiding remediation, as they would be by entering remedial coursework (Cullinane, 2012). These students test close to college-ready and because of the variance in placement tests, may be as prepared for college-level work as students who test slightly above the cutoff line. While these students may be successful going directly into a college-level course, these students generally benefit the most from the co-requisite model (Cullinane, 2012; Bailey, Jaggars & Scott-Clayton,
These students are missing basic skills remedied easily within the support system offered by the co-requisite model of instruction.

**Middle to High Need Students**

Middle to high needs students demand more academic support than their low needs counterparts. The odds of these students being successful in a traditional developmental course sequence are slim (Complete College America, 2011). Only 10% of the high needs students pass a college-level mathematics course in two academic years (Vandal, 2014) and less than 20% of these students ever complete a certificate, degree, or transfer to another school (Cullinane, 2012). These numbers are discouraging and something more needs to be done for these students to find success.

These students with greater academic necessities require targeted programs that accelerate learning (Complete College America, 2011). The co-requisite model fits perfectly as the support is built in and geared toward individual student needs. While the model appears to be an adequate answer to the requirements of high needs students, there is no evidence that shows the co-requisite model is good for high needs students (Cullinane, 2012).

While there is no direct evidence of co-requisite success, there is some indication of positive results for all levels of students. Tennessee has implemented the co-requisite model and they have seen considerably higher success rates for co-requisite students at every initial placement score (Denley, 2015). All levels of students involved within the co-requisite model have helped to increase the success rates. However, there is no suggestion that the rate of success is the same for all levels of students. More research is needed to understand the effects of the co-requisite model on different levels of students.
Shortcomings of the Co-Requisite Model

The cohort affect within the co-requisite model has been previously discussed with benefits outlined. While the cohort model has the same students enrolled in both the college-level course as well as the remedial course, this does not guarantee the remedial and college-level courses will have the same number of total students (Lynxwiler, 1999). It is probable that the college-level course will have some ‘stand-alone’ students. These are students who tested directly into the college-level course or have already completed at least one remedial course and do not require the support of the co-requisite model. This may or may not cause issues for students also required to enroll in the remedial course, but it is something to be aware of when implementing the co-requisite model. There is no evidence that the cohort model is effective in co-requisite implementation in higher education.

Stand-alone students tend to have higher mathematics acumen as they tested higher on the initial placement exam or have already completed some type of remedial mathematics course. This may intimidate the co-requisite students and cause a division among the class. It is important to be aware of the student make-up and work to create a healthy and positive learning atmosphere in the college-level course of the co-requisite model. It is important for all students to feel like they belong in the college-level mathematics class.

Another issue to be aware of is the differences between the two courses. Often times there are two instructors, one for each course. This set-up offers the opportunity for two content area experts to help explain mathematical concepts to students. However, there is also the prospect of dealing with discrepancies in assessment procedures and other basic classroom tendencies (Lynxwiler, 1999). This is why it is vital that the two instructors maintain close cooperation (Rauch, 1987) and participate in frequent communication. Instructors will need to
work together in order to successfully merge content and help students connect material from one class to the other (Lynxwiler, 1999). The college-level instructor should regulate type and frequency of assessments because that is the credit-bearing course students need in order to earn the college credential. Regular meetings can help keep the communication lines open and encourage cooperation between instructors. The differences between the two courses can be taken care of smoothly and lessen the likelihood of a problem if the instructors collaborate frequently. Effective communication between instructors can help lead to positive co-requisite results. The self-design model of collaboration can be effective when the two instructors maintain open dialogue while values and desired outcomes are identified and discussed regularly (Kezar, 2005). Collaboration is an interactive process that can enhance the student learning experience.

**Results of Early Co-Requsite Implementation**

The co-requisite model is in the initial implementation stages as it has only been in effect in higher education for a few years. Currently, four states have enacted remedial reform and implemented the co-requisite model into their new remedial program with at least three more states considering a change within their remedial program (Smith, 2015). Early results of the co-requisite model show improvements in pass rates for both the developmental course as well as the college-level course for all levels of students (McTiernan & Fulton, 2013). The model allows more students to earn college-level mathematics credit in a shorter time period than before implementation.

A community college in Tennessee implemented the co-requisite model with signs of early success. Nearly 650 students across nine campuses were enrolled in the pilot implementation of the co-requisite model within the mathematics curriculum. Enrollment was
not limited to a certain level of student. Any student needing mathematics remediation was eligible to enroll in the newly offered co-requisite model (Denley, 2015).

Within the traditional sequence of developmental mathematics, approximately 12.3% of students who started in remedial mathematics completed the college-level course over several semesters. However, the implementation of the co-requisite model has improved that to 62.5% of students completing the college-level mathematics course in just one semester (Denley, 2015). These students would have otherwise been enrolled in only remedial mathematics without the chance to earn college credit. The increase in student success shows more than a 50 percentage point increase in one year with the implementation of the new instructional model. The initial success provides hope to other colleges implementing the co-requisite model that positive growth may occur with the implementation with the co-requisite model.

Success was not only found in Tennessee. Other states are also seeing success with early implementation of the co-requisite model. Nationally, the developed courses within the co-requisite model have shown to be successful in increasing the performance of students needing remediation (Boylan, 1999). Within the California redesign, the results show that students needing remediation enrolled in the co-requisite model made statistically significant improvements in their mathematics aptitude as documented by standardized tests (Mireles, Taylor & Gerber, 2014). California’s redesign included 16 community colleges and involved a variety of new instructional models, including the co-requisite model. Through spring 2013, the combined instructional approaches, noted as the accelerated model, increased completion rates of students who tested into remediation to 38% where completion rates were 12% with the traditional model (Heyward & Willett, 2014).
Mathematical ability and higher completion rates were not the only improvements seen by students involved in the new model. Involved students were significantly less likely to withdraw from their college-level mathematics course and were significantly more likely to earn higher grades in the college-level mathematics course when compared to the baseline group (stand-alone college-level mathematics students) (Mireles et al., 2014). Also, most colleges want to decrease withdrawal and failures of students and this method of instructional delivery also worked well at reducing these rates (Mireles et al., 2014).

The California accelerated model also fared well for subgroups as completion rates increased within each individual subgroup. With the new accelerated model, 40% of Hispanics completed the college-level mathematics course compared to just 15% of Hispanics completing with the traditional model (Heyward & Willett, 2014). This study focuses primarily on completion rates. It is unknown how the higher completion rates have impacted pass rates within the college-level mathematics course.

Early results of co-requisite implementation at community colleges are inspiring. In one Maryland study implementing an early version of the co-requisite model, 80% of students that had placed into remedial mathematics had completed or were scheduled to complete their college-level mathematics course within two semesters. With the traditional lecture model, only 64% of remedial students were prepared to move on to the college-level mathematics course within two semesters and none of the remedial students had completed the college-level course (Adams, 2003). This college spent multiple semesters working to create paired courses that worked within the curriculum of the college while giving more students a chance for success. In the first full semester of implementation, 65% of co-requisite students successfully completed the college-level mathematics course due to the altered co-requisite model (Adams, 2003). This
is just one percent lower than the students who tested directly into the college level course, as 66% of those students successfully completed the college-level course (Adams, 2003). The co-requisite model gives greater access to the college-level course and allows students the chance of success.

The redesigns of Tennessee and California allowed any student who required remediation to be eligible for the accelerated model. There were no restrictions based on the level of need. Because of the large variety of students involved in the pilot programs, results are mixed when breaking down the data by level of needs of students, particularly, the middle and high needs students of developmental education. Many models (including the Tennessee redesign) are showing dramatic improvements for middle needs students when they are immersed into the co-requisite model (Vandal, 2014). However, it is projected that high needs students will not fare as well. There is no research to show if the co-requisite model will benefit high needs students. High needs students are predicted to require a structured course and at least one semester of strictly remedial work before being introduced to the college-level material (Boylan, 1999). However, the line distinguishing between middle and high needs students is difficult to define. Therefore, it is problematic in determining who may show dramatic improvement by being a part of the co-requisite model and who would benefit most from a more traditional form of remediation education. Research in this area would be helpful.

**Further Research Needed on the Co-Requisite Model**

The co-requisite model has just emerged as an instructional methodology and further research is needed on many aspects of this model. It is not imperative to ask “Does this model work?” but rather “How does this model work?” Which students tend to benefit from the implementation of the co-requisite model? There are only a few studies that show overall student
success. However, little is known about the successes of individual students within subgroups based on: age, gender, ethnicity, socio-economic status, or mathematics placement test score. These subgroups need to be analyzed to conclude which subgroups most benefit from the co-requisite model. It is also imperative to consider students scoring near the placement test cutoff score. Students who score just below the cutoff score receive additional academic support within the co-requisite model. Comparing the success of these students with the students who score just above the cutoff score receiving no additional support provides valuable information about the success of the co-requisite model.

Summary

The current state of remedial mathematics in higher education is broken. Low success rates and long course sequences are discouraging students and creating a barrier to credential attainment. It is important to recognize the existing problems associated with developmental education and moving forward with steps to fix those problems.

Students need early access to college-level courses with appropriate academic support built into the system. Students need to see relevance in the remedial coursework that links to the college-level course. Remedial education needs to be individualized and not set as a one-size-fits-all approach. Every student is different and has diverse needs. Students of different ages, gender, race or ethnicity, and socio-economic status have specific needs and require support from faculty and staff. Academically, these needs can be met through just-in-time remediation as well as a cohort system that constructs an atmosphere of collaboration among students.

The co-requisite model is a design that may increase the percentage of students entering, and completing, college-level mathematics courses. Students will be challenged in the college-
The co-requisite model is built on the premise of support. The co-requisite model is an alternative instructional practice in remedial education. For colleges to increase completion rates, there is a need for innovative remediation programs that result in the collection and use of data (Bautsch, 2013). Franklin community college has implemented this innovative remediation program, the co-requisite model. This statewide college has a large student population enrolled in the co-requisite model that allows for more diverse research to be completed on the different subgroups of students within the co-requisite model. Expanded research on the types of students who are successful within the model will allow colleges nationwide to make future instructional decisions based on best practices leading to student success.
CHAPTER 3 RESEARCH METHODS

The goal of the co-requisite model in the post-secondary mathematics classroom is to increase student access to the gateway mathematics course and subsequently, increase student pass rates. Therefore, I decided to analyze pass rates of students enrolled in the co-requisite model of the gateway mathematics course. While earning a passing grade in the college-level mathematics course is the ultimate goal of the co-requisite model, this is not the highlight of the study. I selected this design to better understand the nuances of the co-requisite model and how it may influence future students.

Students from Franklin Community College historically have had low success rates in remedial mathematics courses as well as within the gateway mathematics course. Throughout the years, many changes have been made to impact the mathematics program with little success. The co-requisite model is the latest redesign of instructional methodology in an attempt to increase success rates within the mathematics curriculum. While this model is new within the Franklin Community College structure, as described in the literature review, it has recently been implemented in other colleges across the country.

Nationally, there is anecdotal evidence that shows success within the co-requisite model in terms of ethnicity. However, there are not systematic studies to describe the effects of the co-requisite model when it comes to analyzing differences of age, gender, socio-economic status (as defined by a student who is eligible to receive the Pell grant), or academic need identified by mathematics placement cut score. Therefore, this is not a replication study, but one to fill a need in the gap of literature, allowing educators to better understand the affordances and constraints of the co-requisite model.
**Purpose Statement**

The purpose of this study is to analyze the relationship between the co-requisite model and student success in the post-secondary mathematics classroom. Two years of data are used to explore differences among student success by subgroups. These subgroups serve as independent variables and are as follows: age, gender, race/ethnicity, socio-economic status, and level of academic preparedness. The dependent variable is the result of the college-level mathematics course, pass or fail.

**Research Questions**

The research questions that guide this study are below.

1.) What is the difference in overall student success rates before and after co-requisite implementation?

2.) What is the difference in student success rates, categorized by student demographics, among students enrolled in the co-requisite model?

3.) What is the relationship between student demographics and success in the co-requisite model?

4.) What is the difference in student success for students above the college mathematics placement test cut score compared to students below the cut score?

Student success is defined as earning a passing grade in the college-level mathematics course. At this college, a passing grade is an A, B, C, or D. This definition of success will be used for all four research questions.
Student demographics, referenced in questions two and three, refer to: age, gender, ethnicity, socio-economic status (defined by Pell grant eligibility), and level of academic need (defined by mathematics placement test score). Question two focuses within each subgroup, testing for significant differences between/among categories within each particular subgroup while question three focuses on the student profile most likely to have success within the co-requisite model of mathematics instruction. Question four emphasizes students who are on either side of the college-determined mathematics placement test cut score. The students who place just above the cut score are placed directly into the college-level mathematics course with no extra academic support. However, the students who score just below the cut score are placed into the co-requisite model of instruction and receive the additional academic support. These two groups are separated by a pre-determined cut score and this question allows for the analysis of success between these two groups of students.

Research Design

This study draws upon quantitative methods due to the primarily numeric data that will be used to analyze differences in pass rates among subgroups (Creswell, 2009). I will use a cohort comparison to analyze pass rates of the gateway mathematics course from before and after implementation of the co-requisite model. I will study the overall pass rates and disaggregate data by ages of students, gender of students, racial identification, and whether or not a student is Pell Grant eligible of the students within the gateway mathematics courses.

The participants are students enrolled in a particular course within a single statewide community college system. All students enrolled in this gateway mathematics course over the time period being evaluated will be included in the research. Students are placed into the course
based on a score earned on a common assessment. This method lacks random assignment as all students who score below the cutoff score are enrolled in the model.

**Context**

Franklin Community College is a two year, open admissions, public institution with fourteen regions around the state. Many of the regions have multiple campuses, all reporting to the same centralized administration team. The highest attainable degree is an associate’s degree and the student to faculty ratio is 19 to 1. Data from the fall semester of 2014 shows a total enrollment of 91,179 undergraduate students with 52% of these students receiving Pell grants. Only 32% of these students are registered as full-time students, meaning, more than two-thirds of Franklin Community College students are part-time. Franklin Community College is a singly accredited statewide community college and the vast amount of students enrolled makes this system exceptional for study.

**Description of the Sample**

The sample will include students enrolled in the gateway mathematics course at Franklin Community College from 2011 to 2015 as well as students enrolled in the co-requisite model from 2013 to 2015. The co-requisite model was implemented in Fall 2013. Therefore, it is important to obtain data from Fall 2011 through Spring 2013 to show a baseline for success in the gateway mathematics course. After implementation in Fall 2013, data will be directly tied to the co-requisite model of instruction. Data will be obtained from two semesters each year (fall and spring), starting in Fall 2011. The summer semester will be excluded due to the low enrollment within the co-requisite model during that time.
Students attending Franklin Community College are primarily female (59%). When studying the ethnic breakdown, 67% of students are White and the next largest group is Black students, at 14%. To see a full table of student breakdown by ethnicity, see Table A4. Data collected on the age of students is not broken down into as many subgroups. According to the data collected from the National Center for Education Statistics, there were only two age groups of students at Franklin Community College (2014), generally classified as traditional students versus non-traditional students. Those age groups were classified as 24 years of age and under (52%) compared to those of 25 years of age and over (48%) respectively.

The breakdown of students into subgroups does not change the overall low success rates of students at Franklin Community College. Of all students enrolled, 3% or less are registered with disability services. Retention rates from first year to second year are less than 50% for both full-time students (45%) and part-time students (38%). Naturally, these low retention rates result in low graduation rates. Of all students who started their college careers at Franklin Community College in 2011, 8% graduated (8% males, 9% females), and 17% transferred to another school. However, when graduation rates are broken down by ethnicity, it does not follow the same proportional breakdown of total student population. Whites have a clear majority (67%) of the student population, and along with Asian students, have the highest percentage of graduates (10%). In contrast, Asians are overrepresented in graduation rates as they make up 2% of the overall student population. See the entire breakdown of graduation rates by ethnicity in Table A4.
**Instruments and Measures**

There are two commanding providers of information that impact every student involved in this study. The first instrument is the Accuplacer test. This is the mathematics placement test taken by all students when they enroll in the college to determine appropriate course placement based on the level of skills possessed by the student. The second measure will be the final grade in the gateway mathematics course. This final grade, pass or fail, in this statewide course will be used to define student success within the co-requisite model.

**Accuplacer**

Franklin Community College uses the Accuplacer test (owned by College Board) for the mathematics placement test. All students who enroll at Franklin Community College must complete the Accuplacer in order to be placed into the appropriate courses. Currently, students scoring between 30 and 59 on the Accuplacer placement test are advised into the co-requisite model.

Accuplacer is a national placement exam designed by College Board. However, Franklin Community College worked directly with College Board to customize the Accuplacer test which students would use for course placement. The customizable version provides particular questions and is tailored in a way to place students directly into the mathematics courses specific to Franklin Community College. The national version is a more general exam and is not written for placement in a specific course. In Fall 2012, Franklin Community College implemented the generalized national version of the Accuplacer exam while the college worked in tandem with College Board to design the customized edition of the exam.
Mathematics faculty from multiple campuses came together in Spring 2013 to work on an item analysis. College Board guided this work as faculty identified particular mathematics problems that would align with specific mathematics courses offered at Franklin Community College. This work continued into the summer semester where a week-long standards setting took place. Mathematics faculty, College Board, and an independent consulting firm worked together to identify where the cut scores should be and how students would be placed into particular mathematics courses. This standards setting time allowed faculty to complete the customized Accuplacer test multiple times to become comfortable with the branching of questions and gather insight in setting appropriate cut scores. After the standard setting was complete, the independent consulting firm put together a data bank and made recommendations for cut scores within the mathematics program. Franklin Community College used the recommendations put forth by this company. The customized Accuplacer exam was fully implemented in February of 2014. This was not in the beginning of the semester and Fall 2014 was the first full semester the customized Accuplacer was used statewide.

As Franklin Community College begins the second full year of testing, there is a 0.92 reliability with the customized Accuplacer placement test. The validity of the customized test is still in analysis by College Board. Franklin Community College collects and sends data to College Board for analysis each semester. The validity analysis is currently in process with College Board. College Board has received data on the first two semesters (Fall 2014 and Spring 2015). College Board expects the first results of validity testing to be completed in Fall 2016.

**Final Grade in the Gateway Mathematics Course**

The gateway mathematics course is a statewide course that was developed by a committee of 10 mathematics faculty from around the state. These faculty members created a
workbook that is used by every student throughout the state who enrolls in this course. There are also statewide homework sets, projects, and exams. All students are evaluated on the same scale while using the same grading rubrics.

There are 28 lessons in the workbook that correlate to 28 homework sets. There are three projects along with three exams. The original design committee continues to work together to update projects and exams for new semesters. The format of each assessment does not change from semester to semester, the change is an update of the numbers within the problems. Examples of projects and exams can be found in Appendix B.

Success is determined by a student earning a passing grade in this gateway mathematics course. The Franklin Community College grading scale shows the lowest passing percentage at 60%, which is a D.

**Data Collection**

I worked with the Center for Institutional Research at Franklin Community College in order to retrieve archival data. I reviewed data from Franklin Community College students on a statewide scale. I collected data about students who were enrolled in the co-requisite model over the course of multiple semesters. Data included was: age, gender, ethnicity, Pell Grant eligibility status, mathematics placement score, and final gateway mathematics course grade (defined as success) for each student.

Age is a continuous variable while gender and Pell Grant eligibility status will be coded discretely as male and female and eligible versus non-eligible, respectively. With only two variables, these two categorical predictor variables are easily entered into a regression model. Nominal data (gender and eligibility status) can be entered into the regression model by using an
indicator, or dummy, variable. These indicator variables will take on the value 0 or 1 within the regression model. Unlike the bivariate data sets, ethnicity has four levels associated the categorical predictor variable (White/Asian, Black, Hispanic, and Other). Upon analysis of sample size and significance, ethnic groups will be grouped together for regression purposes. Therefore, I will create dichotomous indicator variables in order to analyze each ethnic group, using effect (or dummy) coding. For example, “White” would be coded 1 while “Other” would be coded 0 and “Other” would include all other ethnicities. This would be done multiple times to accommodate all predictor variables for ethnicity. The mathematics placement score is standardized and will be used as a continuous variable while the final grade will be recorded as a dichotomous variable, pass or fail.

The data will be categorized by years and semesters. Data will also be organized by age, gender, race, Pell Grant eligibility status and level of need (based off of placement scores). This is confidential data and therefore, no student names will be used. All students will be coded with a student identification number. Also, because of the nature of this project, all data will be secured within my office. Electronic data will be on a password protected computer. Hard copies of data will be locked in a file cabinet when not in use.

**Data Analysis**

The first research question focuses on the difference in overall success rates of students from before and after implementation. The research associated with this question concentrates on student success over multiple semesters. Two years of pass rates in the gateway mathematics course will be used as baseline data. There are five semesters (two and a half academic years) of pass rates that include co-requisite students. The pass rates before co-requisite implementation will be analyzed in comparison to the pass rates post implantation. This data will allow me to
also use inferential statistics to study the trends over time of pass rates of the gateway mathematics course.

The type of analysis will change for the second research question. Dividing the students into subgroups before analyzing pass rates will require more than a comparison of semesters. First, pass rates of each subgroup will be considered and results will be displayed in tables and graphs. The different subgroups will result in different statistical tests. Age is a continuous variable so the ANOVA test will be used. The other variables (Pell Grant eligibility, ethnicity, and gender) are categorical and therefore will be tested for significance with the chi-square analysis. Both tests are used to determine if there is an association between the independent and dependent variable.

Both chi-square and ANOVA test for statistically significant differences between the means for the independent groups. The third research question goes into more depth than investigating statistically significant differences. Controlling for the categorical predictor variables, age, gender, ethnicity, socio-economic status, and level of academic preparedness, I will use logistic regression to predict the specific student profile with the greatest chance of student success within the co-requisite model. Because I am considering a relationship among multiple independent variables with a nominal dependent variable (pass or fail), logistic regression analysis is appropriate. Logistic regression is suitable as it allows me to understand how the independent variables affect the nominal dependent variable (McDonald, 2014).

It is important to check the data to make sure it can actually be analyzed using logistic regression. There are three assumptions that allow one to check data for appropriate logistic regression testing. The first assumption is that the observations are independent and the second
is the assumption that the independent variables have a linear relationship. The last assumption is that the independent variables do not require a normal distribution (McDonald, 2014). It is anticipated that my data fulfills these three assumptions.

To further examine the relationship between variables, I will use regression discontinuity to compare the success rates in the college-level mathematics course of students who fall within five points on either side of the placement test cut score. The regression discontinuity design is used to understand program effectiveness when participants are placed in a course based on a pre-determined cut score before entering the program. Regression discontinuity differs from logistic regression in that subjects are assigned to particular groups based on a pre-test score. This pre-test must be a continuous measure with a specified cut-off score. Subjects scoring within a particular range on each side of the cut-off score are assigned to a specific group and a comparison among two groups is performed using a pre-test/post-test program (Trochim, 2006). This program follows the quasi-experimental design as a pre-test/post-test is one condition of this research strategy.

**Limitations of the Study**

The gateway mathematics course was developed as a consistent course statewide. However, there is still variability in how the homework, projects, and exams are graded. Even with the presence of a rubric, there is still human error when grading these different course requirements. Human error is also present in that some instructors may eliminate concepts, offer extra credit, or change questions on the homework, projects, or exams.

The demographic data also offers a limitation. The analysis of this archival data permits relationships between variables to be detected. No causal effects can be concluded based off the
information in this study. There is also no information concerning the implementation process or the student experience within the co-requisite model.

**Summary**

The analysis of quantitative data will help to show whether there exists a statistically significant difference in pass rates among subgroups within the gateway mathematics course. Ultimately, I want to know if there is one group that succeeds at a higher rate when compared to the others. Is the co-requisite model better suited for a particular type of student? Or, do all types of students achieve at a similar rate? Is there a specific demographic that fares better within the co-requisite model? How do pass rates differ between students who score just below the placement test cutoff score compared to those score just above the cutoff score? Chapter 4 will discuss the results of these analyses.
CHAPTER 4 RESULTS

This study focuses on the efficacy of the co-requisite model in mathematics at Franklin Community College. Previous studies have shown success within the co-requisite model as a whole while this study will focus on differences in student demographics. The success within the gateway mathematics course serves as the dependent variable within the data analysis. The research focuses on four research questions:

1.) What is the difference in overall student success rates before and after co-requisite implementation?

2.) What is the difference in student success rates, categorized by student demographics, among students enrolled in the co-requisite model?

3.) What is the relationship between student demographics and success in the co-requisite model?

4.) What is the difference in student success for students above the college mathematics placement test cut score compared to students below the cut score?

This chapter will outline the sample used to conduct the study, followed by an analysis of the results pertaining to each research question.

Descriptive Results

The study focuses primarily on the students enrolled in the co-requisite model of mathematics instruction at Franklin Community College. The demographics of students within this instructional methodology differ slightly when compared to the overall student demographics of Franklin Community College, as shown in Table 5. In the 2014 academic year,
the college served over 91,000 students and has averaged just below 2,000 enrolled in the co-requisite model per semester of full implementation.

Table 5

*Comparison of Populations: College Wide (N=91,179) versus Co-Requisite Model (N=9296)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>College Wide</th>
<th>Co-Requisite Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 19 – 24</td>
<td>52%</td>
<td>38%</td>
</tr>
<tr>
<td>Age 25 and older</td>
<td>48%</td>
<td>62%</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>41%</td>
<td>31%</td>
</tr>
<tr>
<td>Female</td>
<td>59%</td>
<td>69%</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White/Asian</td>
<td>69%</td>
<td>63%</td>
</tr>
<tr>
<td>Black</td>
<td>14%</td>
<td>21%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>Other</td>
<td>11%</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Pell Eligibility</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pell Eligible</td>
<td>52%</td>
<td>80%</td>
</tr>
<tr>
<td>Not Pell Eligible</td>
<td>48%</td>
<td>20%</td>
</tr>
</tbody>
</table>

*Note:* The total college population is only for the 2014 academic year while the total co-requisite population is compiled over five semesters of full implementation.

As documented in Table 5, there is a higher percentage of females enrolled in the co-requisite model (69%) and a higher percentage of non-traditional students (62%) when compared to total enrollment at Franklin Community College (59% and 48% respectively). Non-traditional students are those aged 25 and older. While this may seem to be a large disparity, it is not as large as the difference in percentage of Pell eligible students. The co-requisite model of mathematics instruction is made up of 80% of Pell Grant eligible students, while the college itself is just 52% Pell eligible. This is a 28 percentage point difference, the largest of any difference noted in Table 5. Ethnicity shows varied proportions; for example, Whites are less represented in the co-requisite model when compared to college wide, while Blacks have a larger
percentage represented in the co-requisite model. Hispanics and other ethnicities are similar in each group.

Co-requisite students are at a disadvantage when compared to their college peers. The majority of co-requisite students are Pell eligible (80%) and their placement test scores are below college-level. However, as the results will show, with the appropriate level of academic support, these disadvantaged students can perform as well, or better, than their advantaged peers.

The study of the co-requisite model includes the first semester of full implementation, Fall 2013 through the Fall 2015 semester. Table 6 shows the number of students enrolled in the co-requisite model each semester after implementation. Over these five semesters, enrollment in the model nearly doubled (98% increase) while the pass rates rose to 71%, a 36.5% increase from the Fall 2013 semester.

Table 6

*Co-Requisite Students: Fall 2013 – Fall 2015 (n = 9296)*

<table>
<thead>
<tr>
<th>Semester</th>
<th>Number Passed</th>
<th>Number Enrolled</th>
<th>Pass Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 2013</td>
<td>534</td>
<td>1027</td>
<td>52%</td>
</tr>
<tr>
<td>Spring 2014</td>
<td>1219</td>
<td>2218</td>
<td>55%</td>
</tr>
<tr>
<td>Fall 2014</td>
<td>1265</td>
<td>1978</td>
<td>64%</td>
</tr>
<tr>
<td>Spring 2015</td>
<td>1241</td>
<td>2035</td>
<td>61%</td>
</tr>
<tr>
<td>Fall 2015</td>
<td>1446</td>
<td>2038</td>
<td>71%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5705</strong></td>
<td><strong>9296</strong></td>
<td><strong>61.2%</strong></td>
</tr>
</tbody>
</table>
Research Question 1: Difference in Student Success over Time

Two goals of the co-requisite model are to increase student access to the college-level course and increase pass rates. Research question one focuses on this overall student success in the gateway mathematics course. Did the implementation of the co-requisite model appear to result in a difference in student pass rates in the gateway mathematics course? Table 7 shows the total number of students enrolled in the gateway mathematics course each semester along with the pass rates while Figure 1 is a graphical representation of the same data.

Table 7

Gateway Mathematics Pass Rates by Semester

<table>
<thead>
<tr>
<th>Semester</th>
<th>Number Passed</th>
<th>Number Enrolled</th>
<th>Pass Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 2011</td>
<td>4626</td>
<td>7684</td>
<td>60.2%</td>
</tr>
<tr>
<td>Spring 2012</td>
<td>4958</td>
<td>8026</td>
<td>61.8%</td>
</tr>
<tr>
<td>Fall 2012</td>
<td>4567</td>
<td>7202</td>
<td>63.4%</td>
</tr>
<tr>
<td>Spring 2013</td>
<td>4849</td>
<td>7850</td>
<td>61.8%</td>
</tr>
<tr>
<td>Fall 2013</td>
<td>4633</td>
<td>7867</td>
<td>58.9%</td>
</tr>
<tr>
<td>Spring 2014</td>
<td>5216</td>
<td>8387</td>
<td>62.2%</td>
</tr>
<tr>
<td>Fall 2014</td>
<td>5234</td>
<td>8428</td>
<td>62.1%</td>
</tr>
<tr>
<td>Spring 2015</td>
<td>4073</td>
<td>6603</td>
<td>61.7%</td>
</tr>
<tr>
<td>Fall 2015</td>
<td>4793</td>
<td>7217</td>
<td>66.4%</td>
</tr>
<tr>
<td>Total</td>
<td>42949</td>
<td>69264</td>
<td>62.0%</td>
</tr>
</tbody>
</table>
The data displayed in this table highlight interesting developments over time. The Fall 2013 semester is the lowest achieving (58.9%) while this is the first semester of full implementation of the co-requisite model. From Fall 2011 to Fall 2013, there was a 2.2% decrease in pass rates, but from Fall 2013 to Fall 2015, there was a 12.7% increase in pass rates. Overall, from Fall 2011 to Fall 2015 there was a 10.3% increase in pass rates in this gateway mathematics course. It is not fair to say the implementation of the co-requisite model is the cause of this increase, but there could be a correlation between co-requisite implementation and an increase in pass rates.

The co-requisite model affords developmental students the access to the college-level course earlier in their college career where in the traditional mathematics sequence, those students would have been delayed by at least one semester due to enrollment in a strictly developmental mathematics course. Table 8 shows the side-by-side comparison of stand-alone
college-level students to that of the co-requisite students for the five semesters involved in full implementation.

Table 8

*Comparison between Co-Requisite Students and Stand Alone College Level Students*

<table>
<thead>
<tr>
<th>Semester</th>
<th>Stand Alone College Level Students</th>
<th>Co-Requisite Students</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number Passed</td>
<td>Number Enrolled</td>
</tr>
<tr>
<td>Fall 2013</td>
<td>4071</td>
<td>6794</td>
</tr>
<tr>
<td>Spring 2014</td>
<td>4022</td>
<td>6203</td>
</tr>
<tr>
<td>Fall 2014</td>
<td>3997</td>
<td>6501</td>
</tr>
<tr>
<td>Spring 2015</td>
<td>2715</td>
<td>4264</td>
</tr>
<tr>
<td>Fall 2015</td>
<td>3374</td>
<td>5205</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18179</strong></td>
<td><strong>28967</strong></td>
</tr>
</tbody>
</table>

In the first full semester of implementation, Fall 2013, the stand-alone students outnumbered and outperformed their co-requisite counterparts. While stand-alone students still outnumbered the co-requisite students, by Fall 2015 the co-requisite students were passing at a higher rate. In this five-semester timeframe, stand-alone and co-requisite pass rates both increased, but the difference is worth noting. Pass rates for stand-alone students increased by 8.3% while the co-requisite pass rates increased by a much larger 36.5%. The two groups also show an opposite trend in terms of enrollment. Over that same five-semester timeframe, the enrollment of stand-alone students decreased by 23.4% while the co-requisite saw a 107.0% increase in enrollment. Figure 2 below is a side-by-side bar graph displaying the data from Table 8. Just by glancing at the bar graph, it is clear the bars on the right side (co-requisite) show an increase over time while the bars on the left (stand-alone) remain fairly constant.
Data compiled from research question one showed an overall increase in pass rates for students enrolled in the co-requisite model of mathematics instruction.

**Research Question 2: Difference in Student Success by Demographic**

Research question two disaggregates the data by demographics and analyzes the data based on these separate groups: age, gender, ethnicity, and Pell eligibility.

**Age**

The co-requisite model enrolls students of all ages, as shown in Table 9. The majority of students enrolled in the co-requisite model would be considered ‘non-traditional’ as 62% of the co-requisite population is older than 24 years. However, college wide, non-traditional students only make up 48% of the population. These students (excluding those 65 years and older) are
also the highest achieving groups, when comparing within their own age groups, passing at over 60%. The traditional students (under 25 years old) pass at a rate less than 57%.

When analyzing the success of age groups within the co-requisite model, the age group 30 to 39 has the highest portion of passing students. Within the five semesters of full implementation, nearly one out of every four students passing a co-requisite course fell in the age group of 30 to 39. The students aged 65 and older have the smallest percentage of passing students, but also have a sample more than 700 students smaller than the next closest age group, with only 51 students fitting into that category over five semesters.

The last column in Table 9 shows the pass rate within that particular age group. When compared only to other students in their age group, the 40 to 49 year olds pass at the highest rate. The youngest group of students, 19 years and younger, pass just over 50% of the students in that age group; for every student who passes, there is a student in that age group who fails. Figure 3 gives a graphical representation of the pass rate by age group. Students aged 25 to 64 perform better than students younger than 25 or older than 64.

Table 9

Co-Requisite Students by Age Group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Frequency</th>
<th>Percent of Population</th>
<th>Number passed the college level course</th>
<th>Percentage of passing students</th>
<th>Pass Rate within group</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 and Younger</td>
<td>1156</td>
<td>12.4%</td>
<td>600</td>
<td>10.6%</td>
<td>51.9%</td>
</tr>
<tr>
<td>20 – 24</td>
<td>2401</td>
<td>25.8%</td>
<td>1356</td>
<td>23.9%</td>
<td>56.5%</td>
</tr>
<tr>
<td>25 – 29</td>
<td>1519</td>
<td>16.3%</td>
<td>926</td>
<td>16.3%</td>
<td>61.0%</td>
</tr>
<tr>
<td>30 – 39</td>
<td>2099</td>
<td>22.6%</td>
<td>1379</td>
<td>24.3%</td>
<td>66.0%</td>
</tr>
<tr>
<td>40 – 49</td>
<td>1318</td>
<td>14.2%</td>
<td>904</td>
<td>16.0%</td>
<td>68.6%</td>
</tr>
<tr>
<td>50 – 64</td>
<td>752</td>
<td>8.1%</td>
<td>473</td>
<td>8.3%</td>
<td>62.9%</td>
</tr>
<tr>
<td>65 and older</td>
<td>51</td>
<td>0.5%</td>
<td>28</td>
<td>0.5%</td>
<td>54.9%</td>
</tr>
<tr>
<td>Total</td>
<td>9296</td>
<td>99.9%</td>
<td>5666</td>
<td>99.9%</td>
<td>61.0%</td>
</tr>
</tbody>
</table>
Gender

College wide, there are more females (59%) than males (41%). However, enrollment in the co-requisite models has a larger gender gap, 69% female to just 31% males. While females outnumber the males at a ratio of nearly two to one, they outperform males at a ratio closer to three to one, as seen in Table 10. Nearly three-quarters (73.3%) of students who pass the co-requisite mathematics college-level course are females. Focusing within each gender group, just half of males (52.5%) pass while well over half (64.7%) of females pass the course.
Table 10

**Co-Required Students by Gender**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Frequency</th>
<th>Percent of Population</th>
<th>Number passed the college level course</th>
<th>Percentage of passing students</th>
<th>Pass Rate within group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>2865</td>
<td>30.9%</td>
<td>1505</td>
<td>26.7%</td>
<td>52.5%</td>
</tr>
<tr>
<td>Female</td>
<td>6400</td>
<td>69.1%</td>
<td>4139</td>
<td>73.3%</td>
<td>64.7%</td>
</tr>
<tr>
<td>Total</td>
<td>9265*</td>
<td>100%</td>
<td>5644</td>
<td>100%</td>
<td>60.9%</td>
</tr>
</tbody>
</table>

*Note: *31 students did not identify as female or male.

**Ethnicity**

Franklin Community College has eight classified ethnic groups: White, non-Hispanic (White), Black, non-Hispanic (Black), Hispanic, Asian or Pacific Islander (Asian), American Indian or Alaskan Native, Multiracial, Ethnicity Unknown, or Other. Each group has a statistically significant relationship when cross tabulated with success, identified by pass rates. Therefore, grouping ethnicities together does not mask outcomes of the data analysis.

Whites and Asians perform similarly, both at a higher rate than the other ethnicities. Therefore, these two ethnicities were grouped together and used as the comparison group. Blacks and Hispanics are both prominent groups with a large sample size, so were kept separate while American Indian or Alaskan Native, Multiracial, Ethnicity Unknown, and Other were grouped together to form the ‘Other’ category, as shown in Table 11.
Table 11

**Co-Requisite Student by Ethnicity**

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Frequency</th>
<th>Percent of Population</th>
<th>Number passed the college level course</th>
<th>Percentage of passing students</th>
<th>Pass Rate within Ethnic group</th>
</tr>
</thead>
<tbody>
<tr>
<td>White/Asian</td>
<td>5855</td>
<td>63.0%</td>
<td>3767</td>
<td>66.5%</td>
<td>64.3%</td>
</tr>
<tr>
<td>Black</td>
<td>1943</td>
<td>20.9%</td>
<td>981</td>
<td>17.3%</td>
<td>50.5%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>599</td>
<td>6.4%</td>
<td>366</td>
<td>6.5%</td>
<td>61.1%</td>
</tr>
<tr>
<td>Other</td>
<td>899</td>
<td>9.7%</td>
<td>522</td>
<td>9.7%</td>
<td>58.1%</td>
</tr>
<tr>
<td>Total</td>
<td>9296</td>
<td>100%</td>
<td>5666</td>
<td>100%</td>
<td>61.0%</td>
</tr>
</tbody>
</table>

The White/Asian group makes up a majority (63%) of the students within the co-requisite model. This group also represents nearly two/thirds (66.5%) of the students who pass the college-level course within the co-requisite model. This pass rate is nearly consistent when comparing within the ethnic group as just under 65% of the White/Asian students who enroll in the model, pass the college-level course.

The Black students in the co-requisite model do not fare as well. While Blacks make up one-fifth (20.9%) of the population of co-requisite students, they do not pass at the same rate. Of all students passing the gateway mathematics course within the co-requisite model, Blacks are just 17.3% of the group. Only one out of every two Blacks passes the college-level mathematics course. This is the lowest achieving ethnic group as Blacks pass at a rate more than 10% lower (50.5%) than the average (61.0%).

**Pell Grant Eligibility**

Franklin Community College sees slightly more students (52%) as Pell Grant eligible when taking all students into account. However, the vast majority (80.4%) of students in the co-requisite model are Pell Grant eligible, as seen in Table 12. The non-Pell students perform better
within the college-level course as nearly three-fourths (72.5%) of non-Pell students are passing the course compared to just over half (58.1%) of the Pell eligible students.

Table 12

Co-Requisite Students by Socio-Economic Status

<table>
<thead>
<tr>
<th>Pell Grant Eligibility</th>
<th>Frequency</th>
<th>Percent of Population</th>
<th>Number passed the college level course</th>
<th>Percentage of passing students</th>
<th>Pass Rate within group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>7478</td>
<td>80.4%</td>
<td>4348</td>
<td>76.7%</td>
<td>58.1%</td>
</tr>
<tr>
<td>No</td>
<td>1818</td>
<td>19.6%</td>
<td>1318</td>
<td>23.3%</td>
<td>72.5%</td>
</tr>
<tr>
<td>Total</td>
<td>9296</td>
<td>100%</td>
<td>5666</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

When analyzing within subgroups, non-traditional students tend to outperform traditional students and females outperform their male counterparts. The White/Asian group outperforms all other ethnicities and non-Pell eligible students pass at a higher rate than those who are Pell eligible. Research question three takes these nuances and introduces success (passing the gateway mathematics course) as a dependent variable. Does the subgroup analysis hold true when computing logistic regression, and taking other variables into consideration?

**Research Question 3: Relationships between Demographics and Success**

The third research question focuses on the relationship between student success and specific student demographics. Success within the co-requisite model is defined as passing the college-level mathematics course. Therefore, a student will pass (coded 1) or not (coded 0). This is the dependent variable within the logistic regression model.

There are six independent (control) variables. Age and placement test scores are both continuous variables within the model. Male is categorical, with male coded as 1 and else coded as 0. Thirty-one students did not identify a gender and therefore are grouped with the category
coded 0. Ethnicity was split into three groups with White/Asian as the constant group. Blacks, Hispanics, and Other ethnicities were the three groups, each coded as 1. When Blacks were coded as 1, all other ethnicities were coded as 0. This process was replicated for Hispanics and Other ethnicities. Pell eligibility is a dichotomous variable where yes was coded 1 and no was coded 0. The semester of enrollment, described as the cohort variable, used Fall 2015 as the constant group. The other four semesters were coded similarly to ethnicity. For example, when Fall 2013 was coded 1, all other semesters were coded 0. Each semester (Fall 2013, Spring 2014, Fall 2014, and Spring 2015) was coded this way.

Due to the dichotomous dependent variable, logistic regression is the most appropriate model to represent the data. Before running the regression model, each independent variable was run against the dependent variable to check for significance at $p$-value $\leq 0.05$. Age and placements tests are continuous variables and therefore ANOVA was conducted. The null hypothesis, the pass rates are equal, was tested and showed significance. This means we reject the null hypothesis and accept the means for each independent variable are different. The chi-squared test was used for Pell eligibility, ethnicity, gender, and cohorts because these variables are categorical. Each variable showed significance ($p < 0.05$) on its own before being placed into the model. Because the $p$-value was less than 0.05 for each variable, we reject the null hypothesis and accept that the pass rates were different among the groups for each individual variable.

Model building and blocking was used within SPSS (Statistical Package for the Social Sciences) in order to reduce the probability of a Type I error. The regression model was run multiple times while changing when the independent variables were introduced to the model. After multiple attempts, the data showed that age had the largest effect on the odds ratios.
Therefore, the age variable was moved to the last position and became the final variable added to the model. The cohort and ethnicity variables were the greatest affected, so they became the first two variables introduced. The analysis of data, disaggregated by subgroup, shows the highest achieving cohort to be Fall 2015 and the highest achieving ethnic group to be White/Asian, when controlling for other factors. Each of these is the constant for their respective variables. The vast difference in success within these subgroups offers variability and thus makes the cohort and ethnicity variables the first included in the model. This allows analysis to be completed on the effect of other variables on these items. A student’s placement test score, along with whether or not a student was Pell eligible, had a larger effect on the odds ratio when compared to the male variable. Therefore, male was placed in the model after ethnicity but before placement test score and Pell eligibility. The final order for regression was: cohort, ethnicity, gender, placement test score, Pell eligibility, and age. The results from the six block regression analysis can be found in Table 13.
Table 13

**Logistic Regression Building: Co-Requisite Students (n = 9296)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cohort</th>
<th>Ethnicity</th>
<th>Male</th>
<th>Placement Test Score</th>
<th>Pell Eligible</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cohort</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall 2013</td>
<td>-0.881***</td>
<td>-0.867***</td>
<td>-0.794***</td>
<td>-0.790***</td>
<td>-0.746***</td>
<td>-0.779***</td>
</tr>
<tr>
<td>Spring 2014</td>
<td>-0.691***</td>
<td>-0.674***</td>
<td>-0.612***</td>
<td>-0.581***</td>
<td>-0.557***</td>
<td>-0.581***</td>
</tr>
<tr>
<td>Fall 2014</td>
<td>-0.304***</td>
<td>-0.315***</td>
<td>-0.289***</td>
<td>-0.277***</td>
<td>-0.260***</td>
<td>-0.259***</td>
</tr>
<tr>
<td>Spring 2015</td>
<td>-0.448***</td>
<td>-0.454***</td>
<td>-0.446***</td>
<td>-0.448***</td>
<td>-0.454***</td>
<td>-0.447***</td>
</tr>
<tr>
<td><strong>Ethnicity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>-0.553***</td>
<td>-0.532***</td>
<td>-0.488***</td>
<td>-0.424***</td>
<td>-0.475***</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>-0.199*</td>
<td>-0.187*</td>
<td>-0.177†</td>
<td>-0.184*</td>
<td>-0.127</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>-0.261**</td>
<td>-0.239**</td>
<td>-0.232**</td>
<td>-0.204*</td>
<td>-0.165*</td>
<td></td>
</tr>
<tr>
<td><strong>Male</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.420***</td>
<td>-0.444***</td>
<td>-0.501***</td>
<td>-0.507***</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Placement Test</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.096***</td>
<td>0.086***</td>
</tr>
<tr>
<td><strong>Pell Eligible</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.641***</td>
<td>-0.677***</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.022***</td>
<td></td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>0.865</td>
<td>1.019</td>
<td>1.117</td>
<td>1.107</td>
<td>1.621</td>
<td>0.988</td>
</tr>
</tbody>
</table>

*Note:* †p < 0.10, *p < 0.05, **p < 0.01, ***p < 0.001.

The results of analysis shown in Table 13 (coefficients) tell the same story as data shown when analyzing the variables individually. Fall 2015 was the highest performing cohort group. This is the fifth semester of implementation and instructors of the co-requisite model had undergone professional development each semester. It is plausible as more time and development is offered, instructors would be better equipped to teach within the model which may help to increase pass rates. Therefore, it makes sense that each of the other four previous cohort groups has a negative coefficient. This negative coefficient indicates the students within the other cohorts would be predicted to perform more poorly than the group from Fall 2015.
Similarly, the Whites/Asians outperformed all other ethnicities. This is not a surprise as previous research demonstrates that Blacks are least likely to complete a college-level mathematics course while Whites are most likely, and all other ethnicities are in between (Complete College America, 2014). When compared to the White/Asian group, as anticipated, each of the three ethnicities in Table 13 have negative coefficients because they are predicted to perform less than their White/Asian comparison group.

Males are outperformed by females and students who are not Pell eligible outperform those who are. Because male and Pell eligible students are coded 1, the negative coefficients make sense. Both placement tests and age are continuous variables. With age, the data showed the older students tended to outperform the younger, more traditional students. So, a positive coefficient stays consistent with the previously reported data; the older the student, the better chance for success in the college-level course. The positive coefficient for the placement test scores shows that higher placement tests are expected to perform better in the course, a concept that makes sense logically as a higher placement score generally implies better starting mathematical skills.

The outcomes of the logistic regression model (coefficients, $p$-values, and odds ratios) are shown in Table 14. The coefficients come from the final column of Table 13 and can be used to create the model, representing this data.
Table 14

_Logistic Regression: Pass/Fail_

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>p</th>
<th>OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall 2013</td>
<td>-0.779</td>
<td>0.000</td>
<td>0.459</td>
</tr>
<tr>
<td>Spring 2014</td>
<td>-0.581</td>
<td>0.000</td>
<td>0.559</td>
</tr>
<tr>
<td>Fall 2014</td>
<td>-0.259</td>
<td>0.000</td>
<td>0.772</td>
</tr>
<tr>
<td>Spring 2015</td>
<td>-0.447</td>
<td>0.000</td>
<td>0.639</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>-0.475</td>
<td>0.000</td>
<td>0.622</td>
</tr>
<tr>
<td>Hispanic</td>
<td>-0.127</td>
<td>0.172</td>
<td>0.881</td>
</tr>
<tr>
<td>Other</td>
<td>-0.165</td>
<td>0.038</td>
<td>0.848</td>
</tr>
<tr>
<td>Male</td>
<td>-0.507</td>
<td>0.000</td>
<td>0.602</td>
</tr>
<tr>
<td>Placement Test Score</td>
<td>0.112</td>
<td>0.000</td>
<td>1.118</td>
</tr>
<tr>
<td>Pell Eligibility</td>
<td>-0.677</td>
<td>0.000</td>
<td>0.508</td>
</tr>
<tr>
<td>Age</td>
<td>0.022</td>
<td>0.000</td>
<td>1.022</td>
</tr>
<tr>
<td>Constant</td>
<td>0.988</td>
<td>0.000</td>
<td>2.686</td>
</tr>
</tbody>
</table>

*Note. p*-values figured on a two-sided test. OR = odds ratio.

The Hispanic group is the only group to show non-significance. Therefore, within this model, the inclusion of the Hispanic variable does not add to the explanation of student success by ethnicity. Including this variable offers no more insight to success by ethnic groups when compared to the other statistically significant ethnicity variables (Black, \( p = 0.000 \) and Other, \( p = 0.038 \)). However, including this variable does not negatively impact the model, so it remains as the only non-significant independent variable.

The odds ratio (OR) indicates how likely a group is to perform when compared to the constant. An odds ratio greater than one implies as the independent variables increases, the odds of the outcome occurring also increase. Conversely, if the odds ratio is less than one, then as the independent variable increases, the odds of the outcome occurring decrease. From Table 14, both age and placement test scores (both continuous variables) are greater than one. Therefore,
as each of these variables increase, the odds of the outcome occurring increase. As the age of a student increases \((OR = 1.022)\), the odds of that student passing the college level mathematics course also increase. The same reasoning is true of the placement test scores for a student; as the placement test scores increase \((OR = 1.118)\), the odds of a student passing the course also increase. This is the same analysis taken from the positive coefficients. The odds ratios and positive coefficient show consistent findings for the age and placements test scores of a student.

All four cohort semesters listed in Table 14 have odds ratios less than one. Students in each of these semesters are less likely to pass the course when compared to the Fall 2015 semester. Similarly, all three ethnicities have odds ratios less than one. Blacks \((OR = 0.622)\) are the least likely to be successful when compared to the White/Asian comparison group. Both Hispanics and Other ethnicities \((OR = 0.881\) and \(0.848\) respectively) are less likely to be successful than Whites/Asians but have better odds to be successful than Blacks.

Males are considerably less likely \((OR = 0.602)\) to be successful than females and similarly, students who are Pell eligible are substantially less likely \((OR = 0.508)\) to be successful than those students who are not Pell eligible. These analyses suggest the student most likely to be successful follows the demographics of a White/Asian female in the Fall 2015 semester who is not Pell Grant eligible. To go a little further, an older student with a higher placement test score would increase the odds of this student finding success in the co-requisite model of mathematics instruction at Franklin Community College.

**Research Question 4: Success Compared to the Placement Test Cutoff Score**

A regression discontinuity research design focuses on a fixed point and the values that lie on either side of that point. The purpose of this type of design is to assess the strength of a
program that uses the fixed point as a cutoff (Imbens & Lemieux, 2008). How do the subjects perform on either side of this cutoff point? Is there a discernable difference among the outcomes produced by these two sets of students?

In this study, students complete a placement exam and the resulting score places the student into a mathematics course. There is a minimum score needed for a student to place directly into the gateway mathematics course (stand-alone student) without also enrolling in the co-requisite developmental mathematics course (co-requisite student). This minimum score is the fixed point used for this design. Therefore, students who score at this point or higher are placed directly into the gateway mathematics course while those students who score below the cutoff are enrolled in both courses that make up the co-requisite model.

The range of scores for this placement test is 100 and according to Imbens and Lemieux (2008), this design should be implemented by using data within 5% points of the fixed point. Therefore, 5% of 100 yields five points on either side of the fixed point to be included in the regression discontinuity research design. Five points below the cutoff score is coded 0 while five points above the cutoff score is coded 1 within the regression model.

All students who enrolled in the gateway mathematics course from Fall 2013 to Fall 2015 were included in the sample. Table 15 shows the sample sizes of each, where just 202 more students place within five points above the cutoff score (3205) compared to five points below the cutoff score (3003). Even though more students scored above the cutoff, these students did not fare as well in the gateway mathematics course. One-hundred forty-four more co-requisite students, who scored below the cutoff, passed the course (1893) compared to their stand-alone counterparts (1749). The pass rates of the gateway mathematics course for these students are
also present in Table 15. The pass rate for the co-requisite students is 8.4 percentage points higher than those who tested directly into the gateway mathematics course.

As shown in the table, fewer students (48.4%) scored below the cutoff but more of these students (52%) actually passed the college-level mathematics course. In the previous, traditional mathematics sequence, this group of students would not even have access to the college-level mathematics course, let alone be passing the course in this semester.

Table 15

*Sample Size: Students Five Points from Cutoff Scores*

<table>
<thead>
<tr>
<th></th>
<th>Passed Gateway Course</th>
<th>Percent Passing</th>
<th>Total Enrollment</th>
<th>Percent of Enrollment</th>
<th>Pass Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Five Points</td>
<td>1749</td>
<td>48%</td>
<td>3205</td>
<td>51.6%</td>
<td>54.6%</td>
</tr>
<tr>
<td>Above</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Five Points</td>
<td>1893</td>
<td>52%</td>
<td>3003</td>
<td>48.4%</td>
<td>63.0%</td>
</tr>
<tr>
<td>Below</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3642</td>
<td>100%</td>
<td>6208</td>
<td>100%</td>
<td>58.7%</td>
</tr>
</tbody>
</table>

Success is consistently defined as passing the college-level mathematics course. Similar to the previous logistic regression model, the dependent variable indicates if a student was successful in the gateway mathematics course. The independent variables changed slightly, as the cohort variable was removed and the placement test variable now focused on just those students within five points of the cutoff score, coded 1 for above and 0 for below. Within the ethnicity variable, Whites/Asians remained as the comparison group.

When running the logistic regression model with this data, the ‘above’ variable was entered first, followed by ethnicity, gender, Pell eligibility, and age. Table 16 shows the blocking/model building for this regression discontinuity research design.
Table 16

*Logistic Regression Building: Regression Discontinuity*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Above</th>
<th>Ethnicity</th>
<th>Male</th>
<th>Pell Eligible</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above</td>
<td>-0.350***</td>
<td>-0.329***</td>
<td>-0.325***</td>
<td>-0.329***</td>
<td>-0.268***</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>-0.590***</td>
<td>-0.598***</td>
<td>-0.531***</td>
<td>-0.549***</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>-0.284**</td>
<td>-0.272**</td>
<td>-0.267**</td>
<td>-0.177¹</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>-0.427***</td>
<td>-0.426***</td>
<td>-0.400***</td>
<td>-0.300***</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td>-0.229***</td>
<td>-0.265***</td>
<td>-0.240***</td>
</tr>
<tr>
<td>Pell Eligible</td>
<td></td>
<td></td>
<td></td>
<td>-0.363***</td>
<td>-0.460***</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.053***</td>
</tr>
<tr>
<td>Constant</td>
<td>0.534</td>
<td>0.700</td>
<td>0.768</td>
<td>1.031</td>
<td>-0.242</td>
</tr>
</tbody>
</table>

*Note:* ¹p < 0.10, *p < 0.05, **p < 0.01, ***p < 0.001.

There is not a positive coefficient until the final block; age is the only variable with a positive coefficient. The negative coefficients imply the group of students coded 1 are not as likely to be successful when compared to their counterpart. Therefore, a student in the co-requisite model (scoring within five points below the cutoff score), when controlling for demographics, has a better chance of passing the college-level mathematics course than a student who tests directly into the college-level course (scoring within five points above the cutoff score), even when taking other variables into consideration.

The results from this regression model mirror the results of the previous model. Again, Blacks, Hispanics, and Other ethnicities all are less likely to be successful than their White/Asian counterparts with Blacks (-0.549) being the least likely to be successful. Males (-0.240) are less likely to pass compared to their female counterparts and students who are Pell eligible are
significantly less likely (-0.460) to pass when compared to those students who are not Pell eligible. Based on this data, a White/Asian female, non-Pell eligible student who scored below the cutoff has the best chance of passing the gateway mathematics course. Because this particular student scores below the cutoff, this student would be a part of the co-requisite model.

Table 17 provides more analysis in regards to the regression model. Coefficients, \( p \)-values, and odds ratios are given in the table. As expected from the data in Table 16, the only odds ratio over one belongs to age. All other variables have an odds ratio less than one because it is more likely that the descriptor coded as 0 will be successful rather than the descriptor coded as 1. All variables listed in the table are coded as 1 within the regression model.

Table 17

Regression Discontinuity: Logistic Regression

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>( p )</th>
<th>OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above</td>
<td>-0.268</td>
<td>0.000</td>
<td>0.765</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>-0.549</td>
<td>0.000</td>
<td>0.578</td>
</tr>
<tr>
<td>Hispanic</td>
<td>-0.177</td>
<td>0.061</td>
<td>0.837</td>
</tr>
<tr>
<td>Other</td>
<td>-0.300</td>
<td>0.000</td>
<td>0.741</td>
</tr>
<tr>
<td>Male</td>
<td>-0.240</td>
<td>0.000</td>
<td>0.786</td>
</tr>
<tr>
<td>Pell Eligible</td>
<td>-0.460</td>
<td>0.000</td>
<td>0.632</td>
</tr>
<tr>
<td>Age</td>
<td>0.053</td>
<td>0.000</td>
<td>1.055</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.242</td>
<td>0.031</td>
<td>0.785</td>
</tr>
</tbody>
</table>

Note. \( p \)-values figured on a two-sided tests. \( OR \) = odds ratio.

Because the variable labeled as ‘above’ is coded as 1 and has an odds ratio less than 1, those students who score within five points below the cutoff score (and are enrolled in the co-requisite model) are more likely to be successful in this course than the students who score within five points above the cutoff score.
Summary

The empirical data analyzed within these four research questions show a correlation between student success and the co-requisite model for some groups of students at Franklin Community College. Within the five semesters of implementation, student success has increased at a faster rate for co-requisite students than for students who tested directly into the college-level course. Older, female, White/Asian, and non-Pell eligible students have the greatest chance of success in the co-requisite model. This is shown when comparing within subgroups and within the logistic regression model. If students score just below the cutoff score, they have a higher chance of success in the college-level class than those who score just above the cutoff score. For some groups, students who test into the co-requisite model are succeeding at a higher rate than those who enroll directly into the college-level course. While this is exploratory over just five semesters, the co-requisite model has data to show there is potential for student success.
CHAPTER 5: CONCLUSIONS

Successful completion of a mathematics course is often required to earn a credential in higher education. Yet, more than half of community college students enter the college classroom lacking foundational mathematics skills, thus requiring remediation. Over their higher education careers, due to these weak mathematics skills, a quarter of these students will never earn a college credential (Rutschow, Diamond & Serna-Wallender, 2015; Complete College America, 2011). These students may spend up to three semesters in a developmental mathematics sequence costing time and money while leading to multiple exit points for students (Vandal, 2014). Gateway mathematics course pass rates and graduation rates are low and a change needs to occur to increase mathematics proficiency, which may in turn, raise graduate rates.

Students in a long developmental sequence are more likely to discontinue their education due to the extra barriers on their education path (Boylan, 2011). Studies have shown that half of remedial mathematics students could be successful in the college-level course if given access to a more rigorous curriculum rather than placed into a developmental sequence (Clayton, 2012). Therefore, a new instructional methodology, the co-requisite model, has been introduced (Vandal, 2014). This model gives developmental level students access to the college-level mathematics content with additional academic support, all in the same semester.

The co-requisite model includes two mathematics courses completed in the same semester. One of these courses is the college-level credit-bearing course while the other is classified as a developmental course, serving as academic support to those students, giving just-in-time remediation. The students enrolled in the developmental course learn the necessary pre-requisite mathematics skills needed to be successful in the college-level course at the same time the skills are needed in the college-level course. This method is successful because adult
learners prefer to see a connection at the time they are learning the remedial mathematics material (Kiely, Sandmann, & Truluck, 2014; McDonough, 2013). The concepts presented in the developmental portion of the model tie directly to the concepts taught in the college-level course. This shows relevance to the material while helping the students find success.

National early research shows the efficacy of the co-requisite model for students who otherwise may have been trapped in the long developmental mathematics sequence. The initial results show a majority of students enrolled in the co-requisite model having success in the college-level class (McTiernan & Fulton, 2013). However, to date, no detailed analysis of the co-requisite model has been completed with data broken down by subgroups or studied using a regression discontinuity model. These studies have been completed with the traditional model of remedial instruction, but not with the co-requisite model. In this particular study, Franklin Community College data has been disaggregated by subgroups: age, gender, ethnicity, Pell eligibility status, placement test score, and cohort (semester of enrollment). The nuances of these subgroups were explored and used in different capacities to analyze the effectiveness of the co-requisite model since implementation on campus in the Fall 2013 semester. This study compared students within subgroups as well as across subgroups. These subgroups were included in a logistic regression model to study the effects of each controlled variable on the others. A regression discontinuity design was also used to study the impact of the placement test score on student success. These regression models show consistency in the subgroups recording the greatest successes within the co-requisite model.

Trends were analyzed within subgroups before the variables were included in a logistic regression model. Student success was examined while controlling for each of these variables, taking note of the impact of each variable on student success within the co-requisite model at
Franklin Community College. The models were repeated, adding variables in different orders to inspect the differences within the regression model. These tests gave way to an examination on different student subgroups and a comparison on which groups perform better within the co-requisite model. Is the co-requisite model geared toward success for a particular type of student, or is it suited for all students? The following research questions were used to help respond to this overarching question.

**Research Questions**

1.) What is the difference in overall student success rates before and after co-requisite implementation?

2.) What is the difference in student success rates, categorized by student demographics, among students enrolled in the co-requisite model?

3.) What is the relationship between student demographics and success in the co-requisite model?

4.) What is the difference in student success for students above the college mathematics placement test cut score compared to students below the cut score?

**Results**

The results of this study are similar to past literature in the areas of age, gender, ethnicity, Pell Grant eligibility, and placement test scores. Each independent variable was analyzed individually as well as in comparison to each additional variable within logistic regression. This regression model was used to show the effects of each independent variable on the dependent variable, success in the college-level mathematics course.
Age

Data analyses from Franklin Community College suggested that traditional students (age 24 and younger) were the lowest performing age group within the co-requisite model while students between the ages of 30 and 49 perform much higher than all other age groups. Allowing non-traditional students (age 25 and older) direct access to the college-level course is beneficial to those students who would otherwise spend at least one semester in a strictly developmental mathematics course.

Historically, in college-level mathematics courses, non-traditional students tend to succeed at a higher rate than traditional students (Complete College America, 2014). However, when non-traditional students find themselves in a developmental sequence, they tend not to perform as well as than their traditional peers (Bailey, Jeong, & Cho, 2010). Non-traditional students tend to struggle when at least one semester of developmental education is required before enrollment in the college-level mathematics course.

The analyses presented in this dissertation illustrate that at Franklin Community College, non-traditional students outperform traditional students within the co-requisite model. These students are no longer sitting in a developmental mathematics course for multiple semesters before enrolling in the college-level course. The co-requisite model allows the non-traditional students direct access to a college-level course with the support of the developmental piece. However, traditional students make up 38% of the co-requisite population and nearly one out of two fails the college-level course. This is a large population with lackluster success rates. These young students tend to enter college with a lack of academic preparedness for college-level material. They still have the high school mindset that classes can be passed without completion
of homework or other class activities (Cherif, Adams, Movahedzadeh, Martyn, & Dunning, 2014).

Gender

Franklin Community College is a typical community college when considering enrollment by gender. Nationally, enrollment at community colleges is predominately female (57%). Franklin Community College is similar, as 59% of enrolled students are female. While enrollment is similar to other community colleges, within this study there is an even larger gender gap. Females outnumber males in both enrollment and in pass rates within the co-requisite model. Women enroll in the co-requisite model at more than twice the rate (69% to 31%) and pass at nearly three times the rate of males (72% to 28%), while one out of every two males fail. In general, females are both more likely to need remediation (66.8% of females compared to 59.5% of males) (Colorado Department of Higher Education, 2014) and are more likely to enroll in college (71% of females compared to 61% of males) (Lopez & Gonzalez-Barrera, 2014). While the trend of enrollment at Franklin Community College is consistent with that of colleges across the country, once students are in the classroom, the trend is fragmented. Results at Franklin Community College are inconsistent with previous literature that states males and females perform similarly once in the mathematics classroom (e.g. Lindberg, Hyde, Petersen, & Linn, 2010; Stoet & Geary, 2012).

Some of the patterns at Franklin Community College might be explained by recent policy changes. Prior to co-requisite implementation, Franklin Community College had two mathematics paths: STEM (Science, Technology, Engineering, and Mathematics) and non-STEM. The implementation of the co-requisite model occurred in the same semester as a third mathematics pathway was created. This pathway, the “Tech” pathway, includes programs such
as Machine Tool Technology and Manufacturing, Production, and Operations. The Tech pathway includes programs primarily completed by males, as males tend to learn more by a hands-on approach and sometimes struggle in a traditional classroom setting (Williams, 2015). Those programs used to fall under the non-STEM pathway, which is the liberal arts mathematics course included in the co-requisite model. Therefore, the number of males in the non-STEM pathway has decreased due to the creation of the Tech pathway. This does not offer insight as to the difference in success rates between males and females, but it does offer insight into the large enrollment difference by gender within the college-level course of the non-STEM mathematics course.

**Ethnicity**

Within the co-requisite model at Franklin Community College, there is a substantial gap in gateway mathematics success rates when disaggregated by ethnic subgroups. Whites and Asians are a majority of the co-requisite students (63%) but also achieve at the highest rate as 64.3% of these students pass the college-level course. On the other side, one out of two Black students fail the college-level mathematics course, by far the lowest achieving ethnic group. While Blacks make up just 14% of the Franklin Community College population, they represent over 20% of the co-requisite population. This follows the literature, as Whites and Asians tend to outperform all other ethnic subgroups while Blacks tend to be the lowest achieving group (Complete College America, 2014). In general, 86.7% of Black students enrolled at community colleges require some type of mathematics remediation (The Colorado Department of Higher Education, 2014). The 2013 data of high school seniors show just seven percent of Black students testing proficient in mathematics (NAEP, 2013). Therefore, Black students are struggling in mathematics at the high school level which translates to a higher need for
remediation at the college level. A lack of basic mathematics skills perpetuates the poor success rates of Black students.

The outcomes of the co-requisite model tend to follow national achievement trends when comparing ethnicities. At Franklin Community College the percentage of Black students enrolled in the co-requisite model is 6.9 percentage points higher than the percentage enrolled college wide. Black students do need more remediation when compared to the other ethnic subgroups. The poor success rates within the co-requisite model for Black students (one out of two Black students fail the college-level course) continues the trend for poor performance in mathematics courses for Black students. The co-requisite model does not appear to be meeting the needs of the Black students.

**Pell Eligibility**

The Franklin Community College student population is split nearly in half between Pell eligible and non-Pell eligible students. However, the co-requisite population is much different as there is a four to one Pell to non-Pell ratio within the co-requisite model. At Franklin Community College, the co-requisite model helped nearly half of the co-requisite enrolled Pell eligible students pass a gateway mathematics course that had been a barrier to graduation in the past. Students who formerly were placed into a developmental sequence up to three courses long are now passing the college-level course within the first semester. The access to the college-level course along with additional academic support is helping Pell eligible students find success in the mathematics classroom while eliminating a former barrier to graduation.

The first full academic year of co-requisite implementation was 2013-2014 and there was an increase of 2189 (13%) in college credentials earned at Franklin Community College. The
following year (2014-2015) saw an increase of 670 earned credentials (3.5%). These rates are college-wide and information split between Pell and non-Pell was not available. While there is no evidence the co-requisite model is directly impacting graduation rates, there does appear to be a positive correlation between students succeeding in the co-requisite model and a rise in graduation rates.

Literature shows students from a low socio-economic background are less likely to attend college, persist through coursework, or graduate (Bennett, 2016). Nationally, Pell eligible students tend to graduate at a rate around 14 percentage points lower than non-Pell eligible students (Nichols, 2015). While there is no evidence suggesting the co-requisite model has increased graduation rates for Pell-eligible students, Franklin Community College is awarding more credentials since the implementation of the co-requisite model.

**Placement Test Cutoff Scores**

It is difficult to find an appropriate placement test cutoff score that accurately predicts student success in a mathematics course at any level (Collins, 2011; Burdman, 2013). Franklin Community College has gone through months of testing and analyses to determine placement test cutoff scores to place students into an academically appropriate mathematics course. Students who test below college ready are placed into a developmental course, while those who place above the cutoff score go into college-level courses. The co-requisite model allows those students who test below college-ready to enroll in both the developmental course and college-level course simultaneously. However, it is difficult to determine if this cutoff score is beneficial for students.
Students requiring remediation can be successful in the college-level course in the first semester when given additional academic support, as demonstrated by the co-requisite model of instruction. Students enrolled in the co-requisite model receive seven contact hours of mathematics instruction each week while students enrolled in only the college-level course receive just four contact hours of mathematics instruction. The increase in academic support could play a role in the positive outcomes for students enrolled in the co-requisite model.

However, it is suspected that half of students who score below the cutoff score could be successful in a stand-alone college course (without additional academic support) as students benefit from being challenged (Clayton, 2012). Students needing remediation are not hurt by being placed directly into a college-level course despite their performance on the placement test (Bailey, Jaggars, & Scott-Clayton, 2013). Bailey, Jaggars, and Scott-Clayton (2013) used regression discontinuity to study student success around a specific cutoff score. Students scoring within five points of this cutoff score showed no difference between the two groups. Multiple other studies implementing regression discontinuity report students who score below the cutoff were not shown to perform as well as those who scored above (Calcagno & Long, 2008; Matrorell & McFarlin, 2011; Scott-Clayton & Rodriquez, 2012). Note, these studies included data taken from the traditional method of remediation. Students who tested below were placed into a remedial mathematics course and spent at least one semester in the developmental sequence before enrolling in the college-level course.

While my study employed the same statistical method, it showed different results for the regression discontinuity model. This may be due to the alternate instructional model, as students who scored below the cutoff were placed into the co-requisite model and were immediately enrolled in the college-level course. Literature shows students in the traditional method of
developmental mathematics instruction who score just below the cutoff do not fare as well as those who score just above. However, within the co-requisite model, students who score below the cutoff score outperform those students who score above. These co-requisite students are receiving three extra hours of academic support, all directly related to the college-level mathematics course. It is likely that this extra time, dedicated solely to the college-level concepts and skills, is a benefit to these students. The new instructional method leads to different, and encouraging, results.

**Implications**

The analysis of five semesters of full implementation data give insight into the potential benefits and difficulties of the co-requisite model of instruction at Franklin Community College. The overall pass rates within the college-level mathematics course increased, but not all students succeed at the same rate. To understand the potential reasons behind the differences in pass rates, the significance of the placement test scores may need examination. Also, the implementation procedures of the course, along with instructor fidelity, should be observed.

**Practice**

The co-requisite model shows success through the first five semesters of implementation. However, when disaggregating data by subgroups, not all students succeed at the same rates. Females outperform males and Whites/Asians outperform other ethnicities. Within the co-requisite model, the number of Pell eligible students severely outnumbers non-Pell eligible students, however, the non-Pell students succeed at a higher rate than their Pell eligible counterparts. How can the model be modified to help a wider variety of students succeed? The examples, as well as the homework problems and exam questions, used in the statewide course
should be re-examined for bias. Modifying the examples, along with homework and exam questions, may be a way to reach the interests of more students.

After five full semesters, instructors continue to be immersed into the model and learn the nuances of teaching within this two-course system. Professional development has been, and will continue to be offered to instructors of both co-requisite courses. However, the focus of this professional development may need to change. Instead of focusing on teaching styles, the professional development should emphasize meeting the needs of particular students. Research shows active learning has the greatest impact on teacher performance (Varela, 2012). Therefore, examples should be demonstrated and instructors should have the opportunity to practice instructional strategies for different types of learners and classroom situations.

Though the current study did not explicitly review co-requisite implementation, professional development should not be a one-size-fits-all approach (Varela, 2012). Instructors around the state should become familiar with the demographics of students within their particular region and learn the distinctions of those subgroups. Professional development should be geared toward teaching different types of students. Involve the instructors in the professional developmental process and allow instructors the time to demonstrate their best practices. Classroom data should also be shared. The type of students who were successful with specific forms of interventions should be discussed. Instructors are actively engaged in the co-requisite implementation and should work together to strengthen instructional methodologies based on this data. Successful interventions for particular groups of students should be shared, demonstrated, and practiced by other instructors. Professional development days where instructors sit and listen without being actively engaged are not useful (Varela, 2012).
Instructors should be aware of the patterns of success within the co-requisite model as it may offer new insights into student success. However, these are only patterns and instructors must still be willing and able to alter lesson plans to fit the needs of their students. Instructors with a skill set suitable for meeting the needs of multiple types of students could continue to improve success within the co-requisite model.

Policy

Placement test cutoff scores are determined through a long sequence of data analyses. However, the overall inaccuracies of cutoff scores do not necessarily predict how students will fare in the appropriately placed mathematics course (Burdman, 2013). The regression discontinuity model shows students who score within five points below the cutoff score and enroll in the co-requisite model outperform those students who score within five points above the cutoff score and enroll in the stand-alone college-level course. Students close to the cutoff score benefit the most from the co-requisite model of instruction (Cullinane, 2012; Bailey, Jaggars, & Scott-Clayton, 2013).

The results of the regression discontinuity model give pause to the accuracies of the placement test cutoff scores. Some students placing in the developmental mathematics course outperform students who tested directly into the college-level course. However, it is unclear as to the effect of the actual placement score on student success within the co-requisite model. It cannot be assumed that all students whose placement test score falls below the cutoff will be successful within the co-requisite model. However, early data suggest it is a successful model. The model could help students who score above the cutoff score be successful who may otherwise have difficulty. Local policy makers might consider making the co-requisite model an option for all students, not just those who score below the placement test cutoff score. The co-
requisite model should be required for students who score below the cutoff score and be optional for those who test above the cutoff score. A student who feels anxiety, or who would simply like additional mathematics support, should be permitted to enroll in the co-requisite model.

Unfortunately, financial aid will not cover the cost of a course not required for the student. Therefore, if a student scores above the cutoff and is placed directly into the college-level course, financial aid is not an option to cover the cost of the academic support course within the co-requisite model.

**Application of Adult Learning Theory**

Adults learn differently than children. Adults want to see relevance in the material they are learning. They want to immediately use the concepts learned to have an impact in their lives (Kiely, Sandmann, Truluck, 2014; McDonough, 2013). The co-requisite model fits well for adult learners because the material learned in the developmental course is immediately relevant within the college-level course. In the past traditional models of instruction, students would spend at least one semester in a developmental math course where a plethora of mathematics information is learned with no immediate impact seen by students. It could be one or more semesters before these students use the skills learned in that developmental mathematics course. The co-requisite model does not waste time on unneeded material. This model gives students what they need at the time they need it.

Adult learners see themselves as more responsible, self-directed, and independent (Kiely, Sandmann, & Truluck, 2014). However, many adult students in the co-requisite model do need the extra support and to be guided and helped through the college-level mathematics course. It is important for instructors to keep in mind that adult learners are most motivated by information directly impactful on their lives/courses (McDonough, 2013).
The co-requisite model embodies the characteristics of adult learning theory. The success of the adult students enrolled in the co-requisite model shows the importance of instructors being cognizant of these characteristics. While it is important to understand how this theory relates to adult students, it is also worth noting how it relates to the adult instructors. The life experiences of a seasoned instructor may influence the classroom atmosphere, and create a more learner-friendly environment. On the contrary, a new instructor may have less experience to draw from, thus creating a more static classroom. Effects of adult learning theory should be analyzed based on the experience level of the instructor and how this experience impacts the educational experience of the student.

**Recommendations for Future Research**

The early success of the co-requisite model is promising within the mathematics department at Franklin Community College, as well as other colleges around the country. However, not all students are succeeding at the same rate. Therefore, there are improvements to be made within the model to increase success for all students.

**Achievement Gap**

While showing positive results, the co-requisite model is not equally successful for all subgroups of students. Perhaps the instructional methodologies incorporated into the co-requisite course are helpful to only certain groups of students. Therefore, it is important to understand the type of instruction used in the co-requisite classroom. The type of instruction used should coordinate with the types of learners in the classroom. There are many different learning styles and it is vital for instructors to meet the needs of the various types of learners in their particular classroom. Past research shows that males perform better in a hands-on
educational environment. Therefore, if hands-on activities are not included in the current curriculum, perhaps that is a change that may be incorporated within the course.

The type of instruction used currently in the classroom can be used to promote future changes within the implementation of the course. Professional development can be used to bring instructors together to share best practices on instructional methodologies for different types of student learners within the co-requisite model. Instructors have first-hand knowledge on the successful classroom strategies and should be a part of the professional development planning and execution (Varela, 2012). This will help instructors gain awareness of learning patterns of the different student groups and how to best meet the needs of the learners in the classroom. Instructors who work to alter their teaching to reach different types of learners will better serve all students.

Placement Test Cutoff Scores

Placement test scores are not good predictors of college-level success (Collins, 2011). The regression discontinuity model showed students enrolled in the co-requisite model who scored within five points below the cutoff score outperformed those students who were in the college-level course, scoring within five points above the cutoff score. Therefore, it is worth considering the group of students who score just above the cutoff score, as they may benefit from the additional academic support of the co-requisite model. Would raising the cutoff score benefit these students? That question is not an easy one to answer.

The reasons for the failings of the students scoring just above the cutoff score needs to be investigated. Additional academic support offered in the co-requisite model may not be helpful to the students if there are outside influences working negatively on their mathematical aptitude.
Also, by raising the cutoff score, more students would be placed into remedial mathematics. Many students already have fear/anger toward mathematics and placing these students into developmental courses may increase these negative feelings (Howard & Whitaker, 2011; Cox, 2015; Mekonnen & Reznichenko, 2008). The impact of the placement on mental stability must also be accounted for before increasing the cutoff score. The early success of the co-requisite model is not enough to make a change to the cutoff score to increase the number of students enrolling in the model. However, a change to the cutoff score is worth investigating. If a change to the cutoff score is not optimal, a suitable option may be to offer optional enrollment in the support course for students testing above the cutoff score. Students who desire additional academic support may be more likely to succeed within the co-requisite model and therefore within the college-level course.

**Graduation Rates**

Colleges are asked to increase the number of graduates each year (Parker, 2012). This is a trying task for community colleges where more than half of incoming students require some mathematics remediation and less than a quarter of these students will complete a college credential (Rutschow, Diamond & Serna-Wallender, 2015; Complete College America, 2011). The barrier of remedial mathematics must be examined and transformed to help more students achieve higher education success. The current instructional model of remedial mathematics provides a long sequence of courses that provide multiple exit points for students, resulting in poor retention rates (Edgecombe, 2011). The implementation of the co-requisite model has changed the instructional model and given hope to remedial students.

In just five semesters of full implementation, the college-level mathematics course associated with the co-requisite model has an average pass rate of 61.2%. These students are
passing the college-level course, thereby receiving college credit in the mathematics course. In the old, traditional model of instruction, these students would spend at least one semester in a purely developmental mathematics course before being permitted to enroll in the college-level course. This model costs students additional time and money, all while not earning credits toward graduation. The new co-requisite model results in higher pass rates at Franklin Community College and this follows national trends.

Nationally, the co-requisite model has been linked to higher grades and higher completion rates in the college-level mathematics course as well as increased persistence in enrollment and a greater total credit accumulation for students (Wilcox, del Mas, Stewert, Johnson, Ghere, 1997; Jenkins et al., 2010; Tennessee Board of Regents, 2009). While it is known that the co-requisite model is having a positive impact on pass rates within the college-level mathematics course at Franklin Community College, it is unknown if this is having a positive effect on graduation rates. A comparison of graduation rates of students who started in traditional remedial mathematics prior to co-requisite implementation compared to those students who completed the co-requisite model would be a beneficial study. Five semesters of data show the co-requisite model is helping more students achieve success in the college-level mathematics classroom. It will be important to find out how this translates to more students successfully completing a college credential as the model continues to evolve. Eighty percent of co-requisite students are Pell-eligible and a college credential could have a significant financial impact on the lives of these students. That college credential could be the first step to a new job or better life for these disadvantaged students.
Summary

The co-requisite model has increased student pass rates in the gateway mathematics course at Franklin Community College over the five semesters of full implementation. All subgroups have seen some success while the older, White/Asian female who is non-Pell eligible show the greatest chance at success, on average. In the Fall 2015 semester, more than 70% of co-requisite mathematics students at Franklin Community College passed the gateway mathematics course; this illustrates promise for the co-requisite model.

But the promise of the co-requisite model may stretch further than just increased pass rates in a gateway mathematics course. In the past, mathematics has been a barrier to graduation for many students who begin in remedial courses (Bryk & Treisman, 2010; Bailey, 2009). However, the co-requisite model provides new opportunities for mathematical success for these disadvantaged students. Students enrolled in the co-requisite model are disadvantaged because they have lower mathematic ability (shown by placement test score) and are low income (80% are Pell eligible). However, within the co-requisite model at Franklin Community College, 58% of Pell eligible students are passing the college-level mathematics course. In the traditional method of mathematics remediation, this group of students would spend at least one semester in a remedial course before enrolling in the college-level course. Now, these students are completing the college-level course in the first semester.

Students in need of mathematics remediation are gaining access to the college-level course in the first semester and succeeding in the course. The regression discontinuity model shows these disadvantaged students are outperforming their college-level peers, when comparing students just above the cutoff score to just below the cutoff score. The co-requisite model is reducing the barrier to graduation for disadvantaged students. The co-requisite model may be a
means to mitigating this achievement gap while helping disadvantaged students earn a college credential.
REFERENCES


Cullinane, J. (2012). Developmental education structures designed for the readiness continuum: Clarifying the co-requisite model. *The Charles A. Dana Center at The University of Texas at Austin, 1.*

Cullinane, J. (2012). Developmental education structures designed for the readiness continuum: Aligning the co-requisite model and student needs. *The Charles A. Dana Center at The University of Texas at Austin, 2.*


Miller, M. & Morgan, S. (1997). What is college-level course work?.

National Center for Education Statistics. Retrieved from
http://nces.ed.gov/collegenavigator/?q=Ivy+Tech+Community+College&s=all&id=150987.

http://www.nationsreportcard.gov/reading_math_g12_2013/#/.

https://edtrust.org/resource/pellgradrates/.


APPENDIX A

Table A1

Percent of Students Requiring Remediation

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Percent Requiring Remediation</th>
<th>Percent Earning a College Credential</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>55.3%</td>
<td>44%</td>
</tr>
<tr>
<td>Multi-Racial</td>
<td>65.3%</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>67.6%</td>
<td>59%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>77.8%</td>
<td>20%</td>
</tr>
<tr>
<td>Black</td>
<td>86.7%</td>
<td>28%</td>
</tr>
<tr>
<td>Native American</td>
<td></td>
<td>23%</td>
</tr>
</tbody>
</table>


Table A2

12th Grade Achievement, by Ethnicity

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Average Examination Score</th>
<th>Percent Scoring At or Above Proficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asian/Pacific Islander</td>
<td>172</td>
<td>47%</td>
</tr>
<tr>
<td>White</td>
<td>162</td>
<td>33%</td>
</tr>
<tr>
<td>Multi-Racial</td>
<td>156</td>
<td>26%</td>
</tr>
<tr>
<td>American Indian</td>
<td>142</td>
<td>12%</td>
</tr>
<tr>
<td>Alaskan Native</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>141</td>
<td>12%</td>
</tr>
<tr>
<td>Black</td>
<td>132</td>
<td>7%</td>
</tr>
</tbody>
</table>

Note. Data retrieved from National Assessment of Educational Progress, 2013

Table A3

Student Achievement by Parental Educational Attainment

<table>
<thead>
<tr>
<th>Highest Level of Parental Education</th>
<th>Average Student Score on 12th grade Examination</th>
<th>Percent of Students who Scored At or Above Proficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did Not Finish High School</td>
<td>137</td>
<td>9%</td>
</tr>
<tr>
<td>High School Graduate</td>
<td>139</td>
<td>12%</td>
</tr>
<tr>
<td>Some Education Post-High School</td>
<td>152</td>
<td>20%</td>
</tr>
<tr>
<td>College Graduate</td>
<td>164</td>
<td>38%</td>
</tr>
</tbody>
</table>

Note. Data retrieved from NAEP, 2013.
Table A4

*Student Data by Ethnicity*

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Percent of Student Population</th>
<th>Percent Graduates</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>67%</td>
<td>10%</td>
</tr>
<tr>
<td>Black</td>
<td>14%</td>
<td>2%</td>
</tr>
<tr>
<td>Unknown</td>
<td>9%</td>
<td>7%</td>
</tr>
<tr>
<td>Hispanic/Latino</td>
<td>6%</td>
<td>9%</td>
</tr>
<tr>
<td>Asian</td>
<td>2%</td>
<td>10%</td>
</tr>
<tr>
<td>Multi-Racial</td>
<td>2%</td>
<td>3%</td>
</tr>
</tbody>
</table>
APPENDIX B

Exam 1
Name:_____________________________

1-7 Multiple choice – select the best option.
1.) Which choice best represents the ratio 20 to 24 as a fraction in lowest terms? 2 points
   a.) \( \frac{10}{12} \)   b.) \( \frac{5}{6} \)   c.) \( \frac{20}{24} \)   d.) \( \frac{6}{5} \)

2.) What is the correct name of the number, 53,000,000,000? 2 points
   a.) Fifty-three million b.) Fifty-three billion c.) Fifty-three trillion d.) Five point three billion

3.) The World Bank estimates China’s GDP as 10.36 trillion dollars. Which of the following correctly represents this in Scientific Notation? 2 points
   a.) \( 10.36 \times 10^{12} \)   b.) \( 10.36 \times 10^9 \)   c.) \( 1.036 \times 10^{10} \)   d.) \( 1.036 \times 10^{13} \)

4.) A hair measures .000025 of a meter. Which of the following correctly represents this in Scientific Notation? 2 points
   a.) \( 2.5 \times 10^6 \)   b.) \( 2.5 \times 10^5 \)   c.) \( 2.5 \times 10^{-5} \)   d.) \( 2.5 \times 10^{-6} \)

5.) Historically, the elderly tend to vote more in elections than younger people. If you were to make a bar chart of voters ages from youngest to oldest, the data would be: 2 points
   a.) Skewed Left   b.) Skewed Right   c.) Symmetrical

6.) If 4.7% of the 6,540,000 Indiana residents were listed as Foreign-born in 2013. Which of the following represents how many people in Indiana are Foreign-born? 4 points
   a.) 3,073,800   b.) 1,391,489   c.) 30,738,000   d.) 307,380

7.) A school has the following starting salaries, with the percent of employees who are expected to be hired at the listed salary.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjunct</td>
<td>$18,000</td>
<td>75%</td>
</tr>
<tr>
<td>Faculty</td>
<td>$50,000</td>
<td>22%</td>
</tr>
<tr>
<td>Admins</td>
<td>$225,000</td>
<td>3%</td>
</tr>
</tbody>
</table>

Which of the following best represents an average starting salary at the school? 4 points
   a.) $50,000   b.) $97,667   c.) $31,250   d.) $18,000

8.) The amount of personal debt in the U.S. is estimated 16.95 trillion dollars. The current U.S.
population is about 322 million people.

i. Write each number in scientific notation. 2 points

ii. Use scientific notation to calculate the current debt per capita. 4 points

iii. Write a sentence explaining the meaning of the value you found in part ii. 2 points

9.) 223.6 is 43% of what number? 4 point

10.) Theresa paid $396 in taxes on a gross income of $1,650. What percent of her gross pay is being taken out in taxes? 4 points

11.) What is 180% of 72? 4 points

<table>
<thead>
<tr>
<th>Indiana 2010 data</th>
<th>All</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
</tr>
<tr>
<td>All ages</td>
<td>6,483,802</td>
<td>100</td>
<td>3,190,071</td>
</tr>
<tr>
<td>Under 15 years</td>
<td>1,331,067</td>
<td>21%</td>
<td>680,620</td>
</tr>
<tr>
<td>15 to 64</td>
<td>4,311,627</td>
<td>66%</td>
<td>2,151,519</td>
</tr>
<tr>
<td>65 and older</td>
<td>841,108</td>
<td>13%</td>
<td>357,932</td>
</tr>
</tbody>
</table>

12.)

i. Calculate the ratio of Males 65 years and over to Females 65 years and over. 2 points

ii. Is this a part-to-part or a part-to-whole ratio? 1 points

iii. Use your answer from part i. in a sentence. 3 points

13.)

i. Use the data in the ‘All’ column at the left of the table above to calculate the ChildDependency Ratio for this population. 2 points

ii. Write a few sentences using your value from part i. Explain what the value represents and why it might be important. 4 points
14.) Write a few sentences about trends that you see in this graph. How do the countries compare? 4 points

Old Age Dependency Ratio per 100

<table>
<thead>
<tr>
<th>Country</th>
<th>2015</th>
<th>2040 predictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

15.) The average cost of a new home in 1960 is $16,500 what would a comparable cost be in 2010, if the price kept up with inflation since 1960. 4 points

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual CPI</th>
<th>CPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>218.056</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>172.200</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>130.700</td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>82.400</td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>38.800</td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>30.200</td>
<td></td>
</tr>
</tbody>
</table>

16.) Based on the information from the table on the left, has Ivy Tech’s tuition increased more or less than the rate of inflation since 2010? Provide at least 2 calculations to support your answer. State your findings in complete and meaningful sentences. 6 points

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual CPI</th>
<th>Tuition</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>236.736</td>
<td>$126.15</td>
</tr>
<tr>
<td>2013</td>
<td>232.957</td>
<td>$116.15</td>
</tr>
<tr>
<td>2012</td>
<td>229.594</td>
<td>$111.15</td>
</tr>
<tr>
<td>2011</td>
<td>224.939</td>
<td>$107.80</td>
</tr>
<tr>
<td>2010</td>
<td>218.086</td>
<td>$104.55</td>
</tr>
</tbody>
</table>

17.) Solve the proportion for x. 2 points

\[ \frac{x}{35} = \frac{12}{21} \]
<table>
<thead>
<tr>
<th>Country</th>
<th>Homicide Deaths</th>
<th>Population In Millions</th>
<th>Homicide Deaths Per Capita</th>
<th>Homicide Deaths Per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>196</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>14,574</td>
<td>144</td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>11,286</td>
<td>1390</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>12,253</td>
<td>320</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

World Health Organization data

18.) i. Find and write the homicide deaths per capita for the countries in the table as decimals rounded to seven places. 2 points

ii. Find and write the homicide deaths per 100,000 for the countries in the table. 2 points

iii. Which country has the worst death rate per capita? 2 points

iv. Explain the meaning of the homicide death rate per 100,000 for the United States by using it in a sentence. 2 points

19.) If France has a population of 65 million and a homicide death rate proportional to that of Belgium, how many homicide deaths would you expect in France (round answer to the nearest whole number)? 4 points

20.) Professor Ivy’s students have the following scores on her Exam.

   87  77  57  87  91  69  45  92  52  48  98

   a.) What is the mean score? 4 points

   b.) What is the median score? 4 points

   c.) What is the mode of their scores? 2 points

21.) How would you respond to your classmate, if they said “This teacher doesn’t know what she is talking about, she says I am in 75th percentile for the class, but I got a 91% on this test not a 75%”? 4 points
22.) An “A” is considered 4.0, a “B” is 3.0, a “C” is 2.0, a “D” is 1.0, and an “F” is 0. A student received the following grades, what is their grade point average for that semester? 4 points

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sociology</td>
<td>3.0</td>
<td>F</td>
</tr>
<tr>
<td>Spanish</td>
<td>4.0</td>
<td>A</td>
</tr>
<tr>
<td>Science</td>
<td>4.0</td>
<td>C</td>
</tr>
<tr>
<td>New Student Seminar</td>
<td>1.0</td>
<td>D</td>
</tr>
</tbody>
</table>

23.) Professor Ivy uses the **weights** by category listed in the table to calculate her grades:

<table>
<thead>
<tr>
<th>Weight of Area</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Labs</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Quiz</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td>Exams</td>
<td>45%</td>
<td></td>
</tr>
</tbody>
</table>

**Your friend has the following averages:**
- Homework: 92
- Labs: 88
- Quizzes: 82
- Exams: 68

a.) Calculate his weighted grade for the class. 4 points

b.) Will your friend be able to improve his letter grade in the class by improving his homework score only? Explain why or why not. 2 points
Exam 2

Conversions should be given to you on a separate sheet. Name:______________________

1-6 Choose the best answer.

1) 14,000,000 Milligrams is how many Hectograms? 3 points
   a) 14        b) 1.4        c) 14,000        d) 140

2) Taking a shower uses 65.2 Liters of water. Choose the value that best represents this in gallons. 3 points
   a) 17.3 gallons        b) 15.4 gallons        c) 276.4 gallons        d) 69.1 gallons

3) Indiana is 94,326 square kilometers in size. Choose the value that best approximates this to the nearest 100 square miles. 3 points
   a) 36,400 mi²        b) 244,500 mi²        c) 58,600 mi²        d) 3,400 mi²

4) Your friend in the Italy tells you that it is 19°C today. What is that temperature in Fahrenheit? See your conversion sheet for the formula. 3 points
   a) 40.6°F        b) 66.2°F        c) 28.33°F        d) 91.8°F

5) A television uses 250 watts of electricity and local emissions from electricity produce 1.37 pounds of CO₂ per kWh. How much CO₂ is produced by using the television for 8 hours? 3 points
   a) 342.5 lb        b) 2,740 lb        c) 0.3425 lb        d) 2.74 lb

6) According to medical data, the ages at which patients have their first knee replacement surgery follows a normal distribution. The average age for a first knee replacement is 50 years of age, with a standard deviation of 9 years. Therefore, doctors can expect the middle 95% of their knee replacement surgery patients to be between what ages? 3 points
   a) 41 – 59        b) 32 – 68        c) 23 – 77        d) 45 – 55.1

7) Your friend’s child is prescribed Penicillin with dosage instructions of 15 mg per kg per day to be given 3 times per day. If the child weighs 82 pounds, what is the dose that the child should receive, rounded to the nearest milligram? 5 points

8) The SR-71 can travel at 3,530 kilometers per hour. How fast is this in meters per second? (round the final answer to the nearest whole number) 5 points
9) Your friend goes to a meeting and has to drive 250 miles. Her car averages 28 mpg. 4 points
   a.) How many gallons of gas will be needed to drive to the destination? (round the final answer to the nearest hundredth)
   b.) How much CO2 will be produced by driving to the destination? (round the final answer to the nearest whole number)

10) Doctors recommend walking 10,000 steps per day. If an average person’s steps are 2.5 feet per step, how many kilometers would the average person walk in a week if they took 10,000 steps per day? (round the final answer to the nearest whole number) 6 points

11) Professor Ivy wants to buy a box of cereal and has two choices: a rectangular box that is 1 foot tall, 6 inches long and 2.5 inches wide; or a rectangular box that is 28 centimeters tall, 20 centimeters long and 5 centimeters wide. Which box has the larger volume? Show work that justifies your answer. 6 points
12) This table has data on students eligible for free or reduced fee lunch *From: http://datacenter.kidscount.org/*

<table>
<thead>
<tr>
<th>Location</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indiana</td>
<td>512,000</td>
<td>49.1</td>
</tr>
<tr>
<td>Missouri</td>
<td>432,000</td>
<td>49.9</td>
</tr>
<tr>
<td>Kentucky</td>
<td>395,500</td>
<td>57.0</td>
</tr>
<tr>
<td>North Dakota</td>
<td>34,000</td>
<td>31.2</td>
</tr>
<tr>
<td>Michigan</td>
<td>738,000</td>
<td>48.6</td>
</tr>
<tr>
<td>Tennessee</td>
<td>430,500</td>
<td>44.2</td>
</tr>
</tbody>
</table>

a.) **Label** each vertical axis and give each graph a **title**. 2 points

b.) Why is the bar for North Dakota a different height in the two graphs? 2 points

c.) Give an example of a real-life situation where one of the graphs below might be preferable over the other. 2 points
Problems on this page may require the use of a z-score table.

13) Sally plans to buy a used Pontiac as soon as she gets her driver’s license. She has been researching the cost of used Pontiacs posted on Craigslist for the last year. According to her research, there is a normal distribution for the cost. The average cost is $4,500, with a standard deviation of $250.

a) Fill in the values for $\mu - 3\sigma$, $\mu - 2\sigma$, $\mu - \sigma$, $\mu$, $\mu + \sigma$, $\mu + 2\sigma$, $\mu + 3\sigma$ for the normal curve for the cost: 2 points

b) Quantify, how likely is it for her to be able to purchase the car she wants for $4,000 or less? Explain your reasoning. 4 points

c) Sally doesn’t want to miss out on getting the car she wants. How much money would you recommend that she have saved if she wants to make sure she will be able to purchase the car? Use the information you found in part a, to come up with a reasonable value. Explain how you arrive at this value and quantify why you believe it is a sufficient amount. 4 points

14) 13 year old boy’s heights have a mean of 61 inches with a standard deviation of 1.5 inches.

b) If Toby measures 63 inches in height, what would the z-score for his height be? 2 points

b) What percentage of 13 year old boys would be taller than he? 4 points

15) The assessment center finds that it had the following wait times during finals week. What is the probability that a student pulled at random from this group waited at least 7 minutes? 4 points

<table>
<thead>
<tr>
<th>Minutes waited</th>
<th>Number of students</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td></td>
</tr>
</tbody>
</table>
**16-19 use the table provided:** The technology department does a study of the types of laptops students and faculty own. The table below shows the results.

<table>
<thead>
<tr>
<th></th>
<th>Faculty</th>
<th>Student</th>
<th>Total type of laptop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows P. C.</td>
<td>62</td>
<td>48</td>
<td>110</td>
</tr>
<tr>
<td>MAC</td>
<td>28</td>
<td>80</td>
<td>108</td>
</tr>
<tr>
<td>Chromebook</td>
<td>20</td>
<td>12</td>
<td>32</td>
</tr>
<tr>
<td><strong>Total type of respondent</strong></td>
<td><strong>110</strong></td>
<td><strong>140</strong></td>
<td><strong>250</strong></td>
</tr>
</tbody>
</table>

16) What is the probability that a person chosen at random from the study was a student? 3 points

17) What is the probability that a person chosen at random from the study owns a Windows P.C. or is a student? 3 points

18) What is the probability that a person chosen at random from the study has a Chromebook and is a student? 3 points

If a person chosen at random from the study is a faculty member, what is the probability they own a MAC? 3 points
19) Professor Erudite has determined that 2% of students have *amity faction syndrome*. The school purchases a test that can detect *amity faction syndrome* with 90% accuracy and tests the first 1000 students to enroll for fall.

Fill out this table for the 1000 students. *4 points*

<table>
<thead>
<tr>
<th></th>
<th>Test Shows Positive</th>
<th>Test shows Negative</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>has syndrome</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does Not Have</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>syndrome</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>1000</td>
</tr>
</tbody>
</table>

a) If you receive a **positive** test, what are the chances you **don’t** have *amity faction syndrome*? *2 points*

i) What is it called when you receive a positive test result for a disease you don’t have? *1 point*

b) If you receive a **negative** test, what are the chances you **do** have *amity faction syndrome*? *2 points*

i) What is called when you receive a negative test result for a disease you do have? *1 points*

21) The following is an excerpt from [www.harrisinteractive.com](http://www.harrisinteractive.com):

When it comes to the World Series, a repeat is not expected to be in the works as almost one in five baseball followers (17%) say the San Francisco Giants will win the Fall Classic this October, followed by the New York Yankees (13%), the Detroit Tigers (9%), the Oakland Athletics (8%), and the Los Angeles Dodgers (7%). Less than one in ten baseball followers (6%) say the Boston Red Sox will win again.

These are some of the results of The Harris Poll® of 763 adults who follow Major League Baseball, surveyed online between June 4 and 16, 2014.

a) What is the population represented here? *1 points*

b) What is the **sample size**? *1 points*

c) Calculate the **95% margin of error** approximation for this poll. *2 points*

d) What is the **95% confidence interval** for the percent of Americans that say the San Francisco Giants will with the Fall Classic this October? *2 points*

e) Express your answer to part d in a **meaningful sentence**. *2 points*
Show work for full credit! 1 – 15 Choose the best answer. There were 40,600 suicide deaths in the U.S. in 2012. The population was 312.8 million. Which of the following best represents the deaths per capita in Scientific Notation? 2 points

a.) $1.298 \times 10^{-4}$  
b.) $7.704 \times 10^{-3}$  
c.) $7.704 \times 10^{3}$  
d.) $1.298 \times 10^{4}$

2.) A sheet of paper has an area of 93.5 in$^2$. Which of the following best represents its area in square centimeters?

Recall 1 in = 2.54 cm or 1 cm ≈ 0.394 in  2 points

a.) 1,532.2  
b.) 36.81  
c.) 14.50  
d.) 603.2

3.) Suppose you bought a house in 2006 for $120,000. Use the table above to calculate the 2013 value adjusted for inflation. 2 points

a.) $120,419$  
b.) $232,957$  
c.) $103,847$  
d.) $138,665$

4.) Professor Ivy records the following scores on her final: 43, 48, 48, 52, 67, 72, 80, 88, 92. What is the median score for the final? 2 points

a.) 67  
b.) 65.6  
c.) 48  
d.) 69.5

5.) A salesman drives 250 miles for a job. His vehicle averages 24 mpg fuel efficiency. If gasoline produces 19.8 pounds of CO$_2$ per gallon of emissions, how much CO$_2$ is produced by his trip? 2 points

a.) 118,800  
b.) 206.25  
c.) 1.9008  
d.) 118.8

6.) An “A” is worth 4.0, a “B” is 3.0, a “C” is 2.0, a “D” is 1.0, and an “F” is 0. A student received the following grades, which of the following is their grade point average for that semester? 2 points

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>History</td>
<td>3.0</td>
<td>B</td>
</tr>
<tr>
<td>French</td>
<td>5.0</td>
<td>C</td>
</tr>
<tr>
<td>Science</td>
<td>3.0</td>
<td>D</td>
</tr>
<tr>
<td>New Student Seminar</td>
<td>1.0</td>
<td>A</td>
</tr>
</tbody>
</table>

a.) 2.50  
b.) 3.00  
c.) 2.167  
d.) 2.60
7.) Women’s dress sizes follow a Normal Distribution with a Mean of 10 and a Standard Deviation of 1.5. If a store owner wants to stock dresses that fit the middle 99.7% of women, what sizes should she order? 2 points
   a.) sizes 5.5-14.5    b.) sizes 5 – 9    c.) sizes 8.5-11.5    d.) sizes 7-13

8.) Professor Ivy’s students have a Mean grade of 70 and a Standard Deviation of 5, if Johnny has an 82 in the class, what would the z-score for Johnny’s grade be? 2 points
   a.) 68     b.) 0.854     c.) 2.4     d.) -2.4

<table>
<thead>
<tr>
<th></th>
<th>Blue eyes</th>
<th>Brown eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light hair</td>
<td>425</td>
<td>675</td>
</tr>
<tr>
<td>Dark hair</td>
<td>350</td>
<td>525</td>
</tr>
<tr>
<td></td>
<td><strong>775</strong></td>
<td><strong>1200</strong></td>
</tr>
</tbody>
</table>

9.) What percent of the community has either blue eyes or dark hair?
   a.) 48.6%     b.) 65.8%     c.) 17.7%     d.) Cannot be determined

10.) A poll asked 3,000 college students if they like math, 42% responded yes. Find the margin of error associated with this poll and choose the best statement below. 2 points
   a.) Exactly 42% of all college students like math.
   b.) We are 95% certain that between 41.982% and 42.018% of college students like math.
   c.) We are 95% certain that between 40.2% and 43.8% of college students like math.
   d.) There is no way to determine the margin of error with this information.

11.) Which of the following would give the balance for a $500 deposit in an account with an APR of 3.0% that compounds interest daily that is invested for 5 years? 2 points
   a.) $500 \times 0.03 \times 5$
   b.) $500 \times (1 + 0.03)^5$
   c.) $500 \times (1 + \frac{0.03}{12})^{5 \times 12}$
   d.) $500 \times (1 + \frac{0.03}{365})^{5 \times 365}$

12.) Indiana’s poverty rate for 2013 was 14.1%, down 10.2% from 2012. Which of the following can you conclude? 2 points
   a.) In 2012 the rate was 24.3%
   b.) In 2014 the rate should be 38.2%
   c.) In 2012 the rate was 15.5%
   d.) In 2012 the rate was 15.7%
13.) Your friend is currently paying $475 in rent monthly and wants to know how large of a 30 year mortgage she could afford with a $475 monthly payment, if she qualifies for a 3.5% APR. What could you type into Excel to calculate this value? 2 points

a.) =PV(.035/12, 30*12, 475)
b.) =FV(.035/12, 30*12, 475)
c.) =PMT(.035/12, 30*12, 475)
d.) =475(1.035)^{30*12}

14.) A mechanic charges $55 for an engine check and $25 per hour for his services. Which of the following is a model of his charges. 2 points

a.) y = 3.2x + 55  b.) y = 55^{3.2x}  c.) y = 55x + 25  d.) y = 25x + 55
15.) A $450 smartphone depreciates 8% each year. Which of the following models the value of the phone after t years? 2 points

a.) \( A = -0.08t + 450 \)  

b.) \( A = 450(0.08)^t \)  
c.) \( A = 450(0.92)^t \)  
d.) \( A = 450(0.92)^t \)

16.) You finance a $500 washing machine completely on credit, you will just pay the minimum payment each month for the next three months. The APR is 18.99% and the minimum payment each month is 4% of the balance. Determine the finance charge, new balance, and minimum payment required for each of the next two months, and the starting balance for month 3 in the table below: 6 points

17.) Using the formula:

\[
Balance = Principal \left(1 + \frac{\text{interest rate}}{\# \text{times comp each year}}\right)^{((\# \text{times comp each year}) \times \text{(number of years)})}
\]

Find the balance after 12 years on a $2,500 deposit earning 3.0% interest compounded quarterly. 4 points

18.) If your county’s population is growing at 2.5% per year, how long will it take for the population to double? 2 points

Recall the functions

\[
= \text{PMT(monthly interest rate, number of deposits, amount of loan)}
\]

\[
= \text{PV(monthly interest rate, number of deposits, payment amount)}
\]

\[
= \text{FV(monthly interest rate, number of deposits, payment amount)}
\]

19.) Your friend is investing in a 401(k) that promises 2% growth. He plans on investing $250 each month for 40 years.

a.) What could you type into Excel to calculate the balance in the account after 40 years? 2 points

b.) If the function from part a is entered correctly, Excel returns a value of $183,608.91 for balance in the 401(k) after 40 years.
i. How much did your friend make in deposits over the 40 years? 1 points
ii. How much interest is earned in the account after 40 years? 1 points

20.) This table lists the Median income for each county. 6 points

<table>
<thead>
<tr>
<th>County Name</th>
<th>2001</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boone County</td>
<td>$71,342</td>
<td>$63,717</td>
</tr>
<tr>
<td>Wayne County</td>
<td>$47,231</td>
<td>$36,559</td>
</tr>
</tbody>
</table>

a.) Find the Absolute Change in the Median Income for **Boone County** from 2001 to 2011.
b.) Find the Relative Change in the Median Income for **Boone County** from 2001 to 2011.
c.) Write a sentence using the Relative Change you found in part b to explain the meaning of the value.

21.) Using the **2011** column, compare the 2 counties Median incomes to each other. Write a few sentences that compare **Boone** and **Wayne County’s 2011** Median Incomes by using absolute and relative terms. 4 points

22.) Economists predict that Americans will spend $1,180 on Summer Vacation in 2015, this is up 3% from 2014. What did Americans spend in 2014? 4 points

23.) A computer originally priced at $249 is marked down 20%. What will the sales price be? 4 points

24.) A sales company offers to pay door-to-door salespeople $25 a day plus $1.25 for every magazine they sell.
   a. Set up a Linear Model representing the daily pay for this job. 4 points
   b. How many sales would you have to make in a day to make $80? 2 points

25.) Ivy Tech Tuition was $1,986 in 2000 and $3,090 in 2010. Suppose the change in tuition costs could be modeled linearly.
   a. Find the slope you would use in a linear model of tuition costs versus years. 2 points
   b. Interpret the meaning of your slope value by writing a sentence explaining its meaning. 2 points
   c. Setup a linear model for Ivy Tech’s tuition. 2 points
   d. Use your linear model to predict the tuition in 2016. 2 points
26.) This graph shows the real data points for Distance Education Enrollment for Ivy Tech from 2000-2011. A trend line has also been created with the equation and $R^2$ value shown in the box on the graph.

![Graph showing Distance Education Enrollment 2000-2011]

\[ y = 1301.5x - 1404.3 \]
\[ R^2 = 0.8839 \]

a.) Use the **trend line** equation to estimate the enrollment for 2005. **2 points**

b.) How does this value compare with the **actual value** for 2005? **2 points**

c.) Find and interpret the linear correlation coefficient, $r$. **2 points**

d.) Interpret the meaning of the **slope** of the **trend line**. **2 points**

e.) Should we use this model to predict enrollment for 2020? Why or Why not? **2 points**

27.) An oil spill’s area can be modeled with the exponential equation $A = 100(1.2)^t$ where $t$ is time in days and $A$ is the area in square miles.

a.) What will the area of the spill be after 10 days? **2 points**

b.) When the area of the spill reaches 1,000 square miles, it will be an ecological disaster. After about how many days will the spill have an area of 1,000 square miles? **2 points**

28.) A college student ingests 300 mg of caffeine at 6:00 am. He metabolizes the caffeine at 25% per hour. About how much caffeine is still in his system by 9:00 am? **4 points**

29.) This table shows the number of reported cases of a disease in a country.

<table>
<thead>
<tr>
<th>Week</th>
<th>Size</th>
<th>Absolute</th>
<th>Relative</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12,000</td>
<td>XXXXXXXXXX</td>
<td>XXXXXXXXXX</td>
</tr>
<tr>
<td>1</td>
<td>16,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>21,870</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>29,525</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>39,858</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
a.) Find the Absolute and Relative changes for weeks 1-4 2 points
b.) Write an equation that would model this data. 2 points
Project 1: Excel Grade Book Project

Understanding how weighted averages work will be a very important topic for you in this course, since your grades are determined in this way. In this project, you will create an Excel spreadsheet that can calculate a math 123 student’s final grade for the course. You will then write a reflection paper answering several questions regarding your project.

In this project you are required to do the following:

1. Create an Excel spreadsheet that will be capable of calculating a student’s final grade in this course. Keep in mind that weighting is involved in determining the final grade. Please refer to your math 123 syllabus for specific grading information and use this in your calculations.

Since it is early in the semester, you will only be using the sample student data provided on the following page to test your spreadsheet.

It is recommended that your Excel spreadsheet contain the following:

- Your name, course name and project name.
- The scores provided on the next page
- Averages for each category being graded
- A legend which lists the categories used to weight the grade and their assigned weight in the overall course grade
- A labeled cell with the Final course grade that uses a formula to calculate the weighted average grade for the course. **This cell SHOULD NOT use Excel’s built-in ‘SUMPRODUCT’ function, come up with your own formula for this cell. If a score is changed in your spreadsheet, your final calculation should recalculate.**
- In addition to correctly calculating the final grade, your spreadsheet should be well-organized, with clear labels

2. Write a typed reflection paper (minimum one page). It must include the following information:
   a. Explain how Excel can be used to calculate weighted average grades.
   b. What is the predicted score based on the data provided? What letter grade is this?
   c. What would the student need to get on the last exam to bring the weighted average up to the next letter grade higher?
   d. What would the predicted final score be (based on the original sample student data provided) if the student missed the last 2 homework assignments AND did not turn in the last project?
   e. How would you respond if a student made the following statement at the end of the semester?, “My final grade is a 58% and I only need 2 more points to get a “D”, can’t I have some extra credit on the homework so I can pass the course?”
f. Professor Ivy calculates her grades as points out of total points for quizzes and homework: Example HW1= 89/90, HW2= 56/72, HW3= 25/25, Q1= 56/72 and Q2= 25/30. Since each grade is out of a different point value, Professor Ivy does not want to turn these grades into percentages. How would you have to modify (if any) your spreadsheet to calculate a student’s final grade in Professor Ivy’s class?

g. Reflect on your experience creating this spreadsheet - What have you learned from doing this project?

h. What did you notice about Excel spreadsheets and how can this help you determine your future grade in this course?

i. How might you use Excel in the future?

In addition to addressing the statements above, your paper should:

- Have a logical organization.
- Be able to be understood by an audience of your peers (i.e. don’t assume that you are writing this to your instructor, make sure anyone could understand your statements.)
- Provide support for your statements. E.g. explain how values were found.
- Give specific values (i.e quantify statements).

3. **Electronicly submit your Excel spreadsheet and reflection paper via the Gradebook Project link in Blackboard.**

Use the following sample student data set to compute a final grade for this course using an Excel spreadsheet. Assume all scores are out of 100 and that all grades have been recorded for this student.

<table>
<thead>
<tr>
<th>Homework</th>
<th>Quizzes</th>
<th>Projects</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>65</td>
<td>60</td>
<td>68</td>
<td>72</td>
<td>68</td>
</tr>
<tr>
<td>59</td>
<td>75</td>
<td>54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>80</td>
<td>82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>65</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>90</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>88</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Project 2: Statistics Project

Adult Heights

In this project you will be using a list of adult heights in an Excel file provided to you (posted in Blackboard) to calculate various statistical values such as: mean, median, mode, maximum, minimum, range and standard deviation. You will be putting this data into a frequency distribution table and creating a histogram graph from the data. You will be asked to describe your observations.

Each student will also gather data on the heights of at least 5 adults. **Note whether each person is male or female.** You will then use your adult heights in calculations of z-scores to compare your data to the approximately “normal distribution” of data provided to you in the Excel file.

**In this project you are required to do the following:**

4. Put your name on the provided Excel spreadsheet.

5. Convert your heights to inches using an Excel formula (Do NOT use a calculator!)

6. Find the following statistics for each Excel tab (Male, Female, All). (**Note:** You must enter the appropriate formula into the appropriate cells to make your calculations.):
   - Mean, median, mode, minimum, maximum, range, the 25th Percentile, 90th Percentile, and Standard deviation

7. Create a frequency distribution table for the provided data. The male and female frequency distributions are optional (bonus), but the “All” data frequency distribution is required. (**Remember that the intervals used must be consistent in the table. It would be best to make intervals at least 2 inches wide and no more than 4 inches wide.**)

8. Construct a bar graph or histogram from your frequency distribution tables using the data from your “All” column and place it in an open space in the spreadsheet. Male and female frequency distributions are optional (bonus).
   a. Give your graph a title.
   b. Label the x and y axes.

9. Find the z-scores of your data items. Use the given male data statistics to find z-scores of your male data, and use the given female data statistics to find z-scores of your female data. What do your z-scores mean? (**Hint:** Use percentiles from the z-score table in the book to describe where the heights you gathered compare to the rest of the (male or female) data.)
10. **Bonus Question**: According to the 68-95-99.7 Rule, 68% of the data should be found with 1 standard deviation of the mean, and 95% of the data should be found within 2 standard deviations of the mean. Verify these facts by showing calculations needed and using explanations where needed.

11. Write a **reflection paper** about your experience with this data project. Include the following items:
   - A comparison of the data by gender. Remember to use different calculated stats to compare men to women.
   - A description of where your five data items fall with respect to the male or female data sets (See instructions for #6 above for details here.)
   - A comparison of the mean and median of each data set (Male, Female and All). Is each data set skewed right or left? What does that mean?
   - A comparison of your class data with the following data from the United States and what does it mean.
     - Mean height for men is 70 inches and women 65 inches.
   - Explain the advantage of making the frequency table and bar graph or histogram over leaving the data in the original form

Your spreadsheet and reflection paper must be submitted in Blackboard.
Project 3: Financial Project

As an Ivy Tech student, you are making an investment in your education. This project will look at how that investment will pay off if you graduate and get a job in your desired field.

The National Center for Education Statistics reports the median annual income for a high school graduate is $30,000. (http://nces.ed.gov/fastfacts/display.asp?id=77) This is the value that you will be comparing your expected salary and lifestyle to in the following areas:

1.) **Income Comparison:** Research your expected income after you graduate college. Assume you obtain whatever level of education needed to enter your desired area of employment and that you will have a salary equivalent to the annual Median salary found at: http://www.bls.gov/oes/current/oes_in.htm#27-0000 *You will need to click on your desired career in order to see the Annual Median wage.
   - Your presentation should explain what your desired area of employment is and what the median annual salary for that position is.
   - Your presentation should contain at least one statement comparing your expected salary with that of the median income of a high school graduate.

2.) **Housing Comparison:** Current 30 year mortgage rates are at 4.25% and a good rule of thumb is to spend no more than 36% of your gross income on house payments. Use Excel to determine the largest value of a house that could be bought using a 30-year mortgage at 4.25% with payments that are 36% of gross monthly income for someone with only a high school diploma and then do the same calculation using your expected salary.
   - Your paper should contain at least one statement comparing the value of the house that a high school graduate can afford and that you expect to be able to afford.
   - You do not have to turn in the Excel sheet for this, but should explain in your paper what Excel function was used for these calculations.

3.) **Retirement Comparison:** 401 k investments are expected to earn a 2.99% annual return. Assume that 5% of gross monthly income is to be set aside for 401 k investment. Use Excel to determine the balance on such a 401 k after 40 years of investment for the high school graduate and for your expected income. Also use Excel to determine how many years it would take for the high school graduate and for your expected investment to reach $150,000.
   - Your paper should contain at least one statement comparing the value of the 401 k investment of the high school graduate and for your expected salary.
   - Your paper should contain at least one statement comparing the time it would take for the 401 k investment of the high school graduate and for your expected salary to reach $150,000.
You do not have to turn in the Excel sheet for this, but should explain in your paper what Excel function was used for these calculations.

4.) **Raises:** The high school graduate’s income is not expected to increase over the next five years, but assume that your field will guarantee you a 2% raise on your annual salary each year for the next five years. Determine what your new annual salary will be in five years. How will this increase in income affect your housing and 401 k plans?

- Your paper should contain at least one statement comparing the initial salary with the salary after 5 years of raises.
- Your paper should explain how you determined the increased salary.
- Your paper should address how your mortgage and 401 k values would change with the increased salary.

In addition to addressing the statements above, your paper should:

- Have a logical organization.
- Be able to be understood by an audience of your peers
- Provide support for your statements. E.g. explain how values were found.
- Give specific values (i.e. quantify statements).
- Contain a variety of comparison statements, including use of relative change sentences.

**Project Checklist:**

- Explanation of career choice
- Comparison of your expected salary vs. a hs graduate.
- Comparison of house you could afford with expected salary vs. hs grad.
- Explanation of how house value was determined.
- Comparison of 401k value you would expect vs. hs grad.
- Explanation of how the 401k value is determined.
- Comparison of length of time it would take to achieve $150,000 in retirement funds for your expected income vs. hs grad.
- Explanation of how the time to reach $150,000 is determined.
- Comparison of starting salary to salary after 5 years of raises.
- Explanation of how increased salary is determined.
- Discussion of how the increased salary might affect mortgage and 401k values. Including specific quantities.
- Presentation should be elegant and coherent with a logical organization.