An Examination of Resources that Impact the Learning Experience

of Underprepared Community College Students

in a Redesigned Co-Requisite Statistics Course

by

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A Dissertation Submitted to the Faculty of the College of Graduate Studies at

Middle Tennessee State University in Partial Fulfillment of the Requirements for the

Degree of Doctor of Philosophy in Mathematics and Science Education

Middle Tennessee State University

December 2017

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ACKNOWLEDGEMENTS

ABSTRACT

Students entering post-secondary institutions underprepared for their college-level mathematics requirements are often required to enroll in developmental courses. These classes typically do not count towards graduation requirements and result in added time and money for a student's program of study. Furthermore, the literature has found that students just below the threshold of college-ready classification have experienced negative effects related to persistence, which may be explained by the frustration of the additional course work and the stigma some individuals experience when labeled a remedial student. Various reform efforts have been introduced to restructure the curricula and instructional methods to reduce the amount of time needed for underprepared students to satisfy their educational requirements.

This study focused on a co-requisite model, in which underprepared community college students enrolled in a college-level Statistics course along with a weekly support lab to address their academic needs. The underprepared sample was divided into two subgroups, better-prepared (near the college-level placement cut score) and least-prepared. An analysis of covariance was used to conduct two comparisons on the final course average, controlling for high school grade point average: college-ready and better-prepared students, as well as better-prepared and least-prepared students. There was no statistically significant difference in the final course average between the college-ready and better-prepared students, indicating those near the threshold of college-ready classification scored on par with their peers. Alternatively, the better-prepared students scored significantly higher on the final course average than their least-prepared classmates.

In addition, interviews were conducted with six underprepared students to examine their perception of the impact of the course resources on their learning experience. The researcher analyzed the data from a holistic perspective and identified three emerging themes. First, the learning aids available in the online course management system helped students become self-directed learners. Second, the support lab served as a time management mechanism that some participants used to stay ahead of schedule. Third, the classroom instructors provided detailed conceptual explanations that supplemented the lab instructors' emphasis of procedural fluency.

The results of the study offered promising outcomes for better-prepared students who would have traditionally been assigned to a developmental course. Continuing efforts are needed, however, to explore interventions that will best serve the least-prepared students.

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CHAPTER I: INTRODUCTION

The open enrollment nature of community colleges allows students to pursue

higher education opportunities that might not have been available otherwise. Many enter

the community college system, however, underprepared to meet their college-level course

requirements. A report issued by the American College Testing (ACT, 2015) determined

that only 28% of high school graduates met the college readiness benchmarks for

English, Reading, Mathematics, and Science, and just 42% were prepared for college-

level mathematics. As a result, various studies have found that nearly 60% of students

entering two-year colleges are in need of remediation (Attewell, Lavin, Domina, &

Levey, 2006; Complete College America [CCA], 2012), and roughly the same percentage

took at least one remedial mathematics course (National Center for Education Statistics

[NCES], 2012). On average, placement scores require first-time postsecondary students

to take at least two remedial mathematics courses, but they typically only pass one of the

requirements (NCES, 2012). This presents a major obstacle for students in terms of

delaying or even preventing their enrollment in their core-level coursework. Therefore,

traditional stand-alone developmental mathematics courses may not sufficiently address

the needs of the population they intend to serve.

This study examined how underprepared community college students in a co-

requisite Statistics course performed. The co-requisite model allowed underprepared

students to enroll in a college-level section while concurrently receiving support for their

academic needs through participation in a weekly lab. This chapter discusses some of the

forces that have resulted in efforts to reform developmental education, including a

rationale for implementing a co-requisite design. The purpose of the study, the research

questions that were considered, and the theoretical framework used to analyze the qualitative data are then introduced.

Definitions

Throughout this study, the terms developmental education and remedial education are used to refer to the services and courses offered to students who are academically underprepared for postsecondary coursework. Although the term "remedial" sometimes carries a negative connotation (Bailey et al., 2010), with remedial coursework designated for those most underprepared (Boatman & Long, 2010), "remedial" and "developmental" are often used interchangeably in the literature (Bettinger, Boatman, & Long, 2013) and that same convention is used in this study. In addition, gatekeeper courses are defined as the first college-level mathematics course in a student's program of study that earns credit towards their degree completion.

Emphasis on Attending Community Colleges

Adding to the issue of remediating the skills for underprepared students is the increased emphasis placed on community colleges as a vehicle to retrain individuals who may be facing a change in their careers. On July 14, 2009, the White House introduced President Obama's American Graduation Initiative as a means to address the unemployment rate and stabilize the economy, which set a goal to help an additional 5 million Americans earn degrees and certificates at community colleges by the year 2020 (The White House, Office of the Press Secretary, 2009). The President also recognized that students whom the initiative targeted may be in need of academic support: "We'll challenge these schools to find new and better ways to help students catch up on the

basics, like math and science, that are essential to our competitiveness" (The White House, Office of the Press Secretary, 2009, para. 22).

On a statewide level, in 2013 Tennessee governor Bill Haslam launched the Drive to 55 campaign – a goal to have 55% of Tennesseans possess a college degree or technical certificate by 2025. To help achieve this end, the Tennessee Promise initiative went into effect in fall 2015, providing two years of tuition-free community college to graduating high school seniors by covering costs after all other sources of support, including scholarships and Pell Grants, have been exhausted. Politicians in Oregon and Mississippi have proposed similar plans to attract students who may otherwise have deemed college was unaffordable (Fain, 2014). Funding concerns aside, the state of Tennessee has enrolled over 33,000 students using Tennessee Promise since fall 2015, resulting in a 30% increase in first-time freshmen enrollment (Tennessee Higher Education Commission, 2017). Rising enrollments coupled with the skill deficiencies of incoming freshmen could create a strain on the developmental programs designed to get students prepared for their college-level courses.

Performance-Based Funding

According to the organization Jobs for the Future, "Around the country, there is growing interest in revising state higher education funding formulas to drive institutions to do more to improve student outcomes, including retention, transfer, completion, employment, and earnings" (Altstadt, Fingerhut, & Kazis, 2012, p. 18). A 2015 report from the National Conference of State Legislatures (NCSL) indicated that 27 states have transitioned from funding models for two-year colleges that are based on enrollment figures towards measures that reward credits earned, degree completion, and transfer

agreements. An additional five states are in the process of formalizing performance-based funding for their academic institutions. States such as Indiana, Massachusetts, Missouri, Nevada, North Carolina, Ohio, Tennessee, Texas, Utah, and Washington have specific funding metrics tied to the success rates in developmental mathematics or English courses, or the successful completion of a college-level mathematics or English course. Therefore, in order to ensure financial stability, colleges now have a greater responsibility to have strategies in place that support student retention efforts while addressing skill deficiencies.

<p style="text-align:center">Developmental Education as a Roadblock</p>

In theory, developmental courses should prepare students for their gatekeeper courses to offer them the best chance of persisting in their program and ultimately graduating. The reality, however, is often in stark contrast to the desired intentions. Students placed in the lowest level of developmental mathematics, which may entail completing three courses to meet the college-level prerequisites, often do not progress to the point of enrolling in the gatekeeper course for their program of study (Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009). The obstacles faced by remedial students are broader than them simply failing their developmental courses and therefore not earning a degree.

In addition, the sequence itself of developmental courses presents a barrier to degree completion with the time required to complete the courses and the multiple exit points inherent in the sequence. Using a sample from over 57 community colleges on developmental education success rates, Bailey, Jeong, and Cho (2010) found that 67% of the students never completed the developmental sequence. Of that 67%, 29% failed one

of the courses or withdrew; 11% never failed a course, but simply never showed up for the next course in the sequence; and 27% never enrolled in a developmental course despite being placed in one. According to Roksa et al. (2009), pass rates for gatekeeper courses are around 70%, even for those students who are initially placed into a Prealgebra course. For the gatekeeper courses, then, the failure to enroll presents a greater roadblock towards degree completion than students failing the course. Bailey et al. (2010) posited that "the developmental education obstacle course creates barriers to student progress that outweigh the benefits of the additional learning that might accrue to those who enroll in remediation" (p. 261); which may support Complete College America's (CCA, 2012) branding remediation as the "Bridge to Nowhere" (p. 2).

This is not an indictment on developmental education in the sense that it should be abandoned altogether. The evidence presented earlier in the chapter shows that a large percentage of community college students need some form of remediation when entering the post-secondary environment. A redesign of the system in which developmental content is offered, however, could focus on the educational needs of the students while simultaneously addressing the factors that create impediments to persistence and retention.

Redesign Efforts

Course redesign has been characterized as the transformation of large introductory classes using the "power of information technology to simultaneously improve student learning and reduce skyrocketing higher education costs" (Miller, 2010, p. 1). The National Center for Academic Transformation (NCAT), a nonprofit organization founded by Carol Twigg in 1999, has been at the forefront in partnering with colleges and

universities to design, implement, and analyze initiatives that lead to successful changes in educational practices. According to Twigg (2003), redesign efforts typically contain six features: whole-course redesign, active learning, computer-based learning resources, mastery learning, on-demand help, and alternative staffing.

Whole-course redesign allows faculty to collaborate on enacting change that will maintain greater consistency than if individual sections were reformed. Active learning seeks to replace lectures with resources that require students to take responsibility for their learning outcomes. Computer-based learning resources include instructional software that allow students access to course content and can comprise homework assignments, quizzes, practice tests, videos, and study plans that offer repeated practice and feedback. Mastery learning often involves module-based content that students must complete by certain deadlines with minimum scores to demonstrate proficiency. Students have the flexibility to access homework and quizzes outside of class and are frequently given multiple attempts to reach the required benchmarks. On-demand help can come in the form of faculty and peer tutors that may be available in a computer lab to provide individualized assistance, as well as guided examples programmed into the modules that students can access when completing homework or reviewing quizzes. Alternative staffing utilizes undergraduate peer tutors to assist faculty with suitable tasks associated with the redesign, thus providing students with a proper level of intervention when needing help (Twigg, 2003).

Placement Tests and Co-Requisite Models

Students entering college often take a placement test to determine whether they are deemed ready to enroll in their college-level required courses or if they must first

address identified skill deficiencies. Underplacement mistakes of these high-stake tests have brought into question their predictive power in serving as the determining factor for college placement (Scott-Clayton, 2012). In fact, Scott-Clayton and Rodriguez (2012) found that potentially 25% of community college students placed into developmental mathematics courses could have earned at least a B in the relevant college-level course. Furthermore, Roksa et al. (2009) found that 39% of students in the Virginia community college system who were recommended for a developmental mathematics course never even enrolled in the recommended course and only 19% of those placed in the lowest level developmental course ever persisted to the gatekeeper course. Rather than serving its intended purpose of preparing students for their college-level core classes, placing students into developmental courses may ultimately hinder their progress in their academic program.

Complete College America (CCA), a national nonprofit that works with states to increase the number of college degrees earned, has advocated the implementation of co-requisite models to address some of the current issues facing remediation policies. Co-requisite developmental education programs co-enroll students in a remedial and college-level course (CCA, 2013). This allows students to receive the support that they need related to skill deficiencies while simultaneously enrolling in a credit-bearing gateway course that keeps them on track towards graduation. Of importance, CCA (2013) recommended that the academic support provided to students be tailored to specifically meet the needs of the course they were taking. Previously, sequences of developmental courses were a one-size-fits-all approach where students were responsible for all of the same content, regardless of the college-level course that was required for their major.

Since the content in gatekeeper courses differs in the skills that are required to be successful, the co-requisite model targets the relevant skills that will help students progress in their field of study.

Statement of Purpose

Previous studies have produced mixed results on the effectiveness of developmental education programs and have examined a range of outcomes, including persistence, degree completion, and performance in gatekeeper courses. Course redesigns have sought to address some of the limitations that traditional developmental courses presented, but studies examining their effectiveness have often treated students as uniform entities. Co-requisite models, however, consist of underprepared students of varying abilities enrolled in the same gatekeeper course. Therefore, the purpose of the study was to examine how underprepared community college students perform in a redesigned co-requisite Statistics course and the factors that affected their performance in the class.

There were 14 sections of Statistics considered for the study and all students enrolled in the course completed homework and quiz assignments using MyStatLab, a course management system created by the Pearson publishing company. Those classified as underprepared also had to enroll in a support lab that met once a week for two hours. For the purpose of this study, college-ready students were defined by an ACT Math sub-score of at least 19, a COMPASS Algebra score of at least 38, or had previously completed coursework to remediate academic deficiencies. Underprepared students were defined by an ACT Math sub-score below 19 or a COMPASS Algebra score below 38. Furthermore, the underprepared sample was divided into two sub-groups: least-prepared

and better-prepared. Least-prepared students were defined by an ACT Math sub-score below 16 or a COMPASS Algebra below 21; better-prepared students were defined by an ACT Math sub-score from 16 to 18, or a COMPASS Algebra score from 21 to 37.

To control for differences in academic ability, high school grade point average was used as a covariate. Therefore, the following research questions were considered:

1. Using final course averages, how do underprepared community college students in a redesigned co-requisite Statistics course compare to students deemed college-ready?

2. Using final course averages, how do community college students in a redesigned co-requisite Statistics course who are least-prepared compare to students classified as better-prepared?

3. What resources from a redesigned co-requisite Statistics course do underprepared community college students use and perceive to have a positive impact on their course experience?

Concern for Least-Prepared Students

Although there is a need to address the mathematical deficiencies of students entering college, it is also important to consider the results the redesign initiatives produce in relation to student outcomes. Simply comparing students placed into developmental courses with their college-ready peers may not yield meaningful results given the different characteristics between the two groups (Bettinger & Long, 2009), which explains the choice of using high school grade point average to control for differences in this study. Studies that have focused on the impact of remediation for students near the threshold of college-level placement have produced mixed results when

considering persistence rates and degree completion (Bettinger & Long, 2009; Calcagno & Long, 2008) as well as academic credits attempted and potential economic earnings (Martorell & McFarlin, 2011). Boatman and Long (2010) added to the literature by investigating the effects of remediation placement on credits earned, grades in the gatekeeper course, and degree completion for students of varying abilities, including the weakest students who were required to complete a sequence of three developmental courses.

Students enrolled in a co-requisite model, however, face a different situation in that they are simultaneously completing a gatekeeper course while receiving supplemental assistance for their academic deficiencies. One director of developmental education at a two-year college expressed concern that co-requisite models may not benefit students who are least-prepared if early struggles lead them to withdraw from the course and thereby negatively affect their self-esteem (Mangan, 2015). Unlike the stand-alone developmental courses in which students of similar abilities are enrolled in the course, the co-requisite model presents a more heterogeneous mix as both college-ready and underprepared students complete the same curriculum. Part of the motivation for this study is to understand how the co-requisite model serves the underprepared students, and in particular, those who may face the greatest challenge of being placed in a college-level course.

Theoretical Framework

As a result of the interplay between technology, students, and learning outcomes in a redesigned Statistics course, Activity Theory was the theoretical framework chosen for this study. Initially rooted in the work of Vygotsky (1978) and Leont'ev (1981),

Activity Theory seeks to explain how learning is shaped by the relationships involving a subject (e.g., a student), an object (e.g., a task or activity), and mediating artifacts (e.g., technological tools; Issroff & Scanlon, 2002). Figure 1 provides a representation of the mutual relationships between these three entities.

Engeström (1987) extended the ideas of Leont'ev by developing an activity system representation, which included the community as a social context that influences human actions. Mutual relationships were now established between the subject and the community as well as the object and the community, with mediating factors involved in each case. Figure 2 illustrates the activity system with learning technology as the tool in the transformation process.

In the examples depicted in the two figures, the relationship between subject and object is mediated by tools, which for this study was the learning technology incorporated into the redesigned co-requisite Statistics course. Generally speaking, a tool can be anything used within the activity to help facilitate the desired outcome (Issroff & Scanlon, 2002). The community for this setting was a post-secondary two-year academic institution, with the relationship between subject and community mediated by rules. Rules may be either implicit or explicit norms, as well as social conventions that exist within the community (Issroff & Scanlon, 2002). Finally, the relationship between the object and community is mediated by the division of labor, with the division of labor corresponding to the organization of the community as it relates to the transformation process (Issroff & Scanlon, 2002). There was a division of labor pertaining to the course assignments (object) as the Statistics course and the support lab were taught by different instructors.
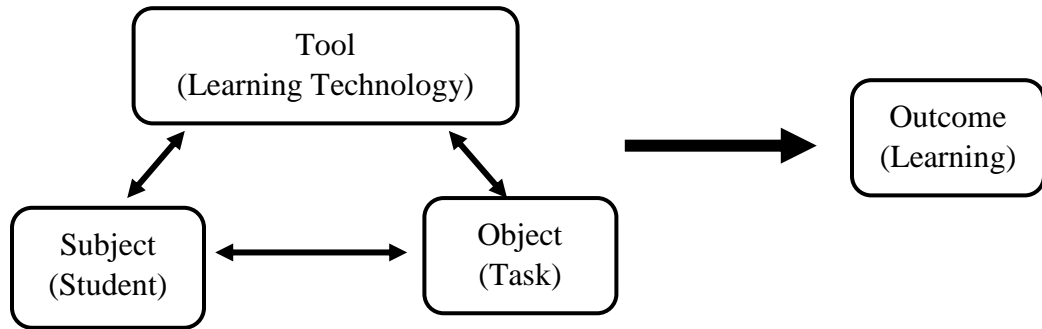
Figure 1. Mediated relationship at the individual level in Activity Theory. Adapted from "Activity Theory as a Potential Framework for Human-Computer Interaction Research," by K. Kuutti, 1996, in B. A. Nardi (Ed.), *Context and Consciousness: Activity Theory and Human-computer Interaction*, p. 28.
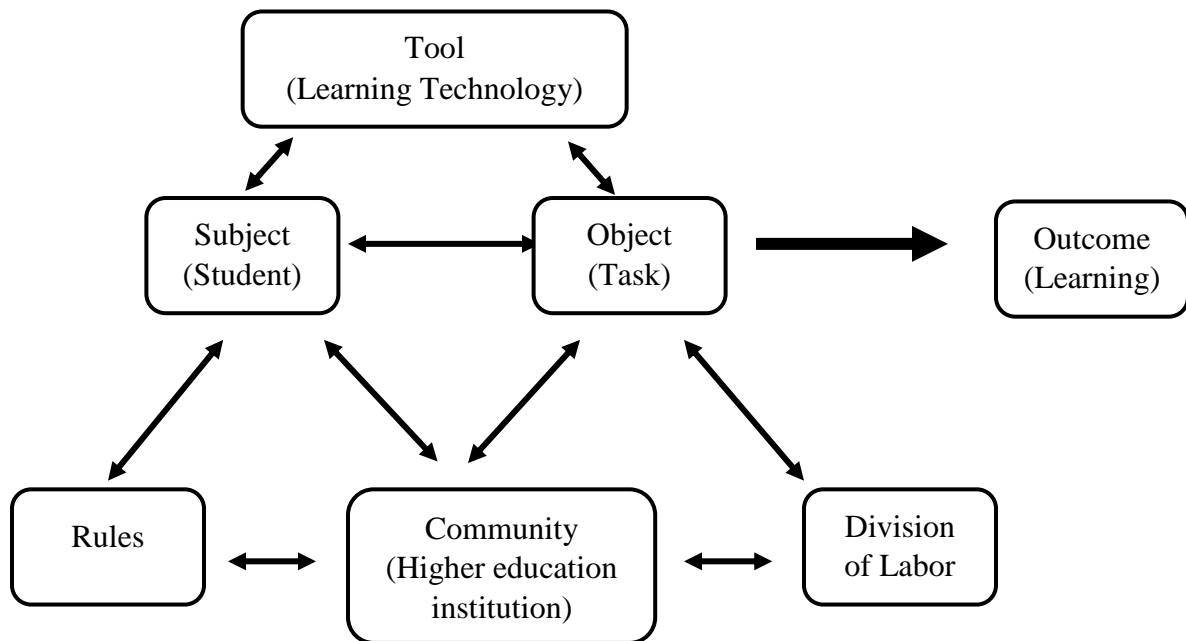
Figure 2. Activity system for using learning technology in higher education. Adapted from "Activity Theory and Higher Education: evaluating learning technologies," by E. Scanlon and K. Issroff, 2005, *Journal of Computer Assisted Learning*, *21*, p. 433.

Activity Theory has been used as a theoretical framework in previous studies involving technology-enhanced courses (Barab, Barnett, Yamagata-Lynch, Squire, & Keating, 2002; Scanlon & Issroff, 2005), with its strength coming from the inclusive description that it provides for an activity system (Karasavvidis, 2009). Since MyStatLab was a central component of the redesigned course for this study, Activity Theory provided a suitable lens by which to qualitatively analyze how the technology interacted with other facets of the course to affect the learning experience for the students. The activity system allowed for consideration of not only the interface between the student and the learning software, but also the social context in which those actions were situated.

Significance of Study

Traditional stand-alone developmental mathematics sequence offerings may present obstacles to students ever advancing to their required gatekeeper course (Bailey et al., 2010; Roksa et al., 2009). A co-requisite redesign model offers students the opportunity to complete their college-level requirement while receiving support for their academic deficiencies within the same semester, though for this study, students below a certain placement cutoff score were all grouped together within the same course along with their peers who had been deemed college-ready. Prior studies have examined the effects of remediation in stand-alone courses on academic outcomes, but understanding how the course resources impact a student's performance may shed light on the efficacy of the redesign.

Chapter Summary

Many students entering community colleges are identified as needing to enroll in a remedial or developmental mathematics course. In theory, developmental course work

should provide students with the content they need to prepare them for their college-level requirements. The reality, however, is often in stark contrast. Rather than helping underprepared students improve their academic outcomes, traditional developmental programs may serve as roadblocks to students persisting to their gatekeeper courses (Bailey et al., 2010).

With funding for higher education shifting towards graduation rates and credits earned (NCSL, 2015) and initiatives to increase degree completion (Center for Community College Student Engagement [CCCSE], 2016), it is important to consider methods for redesigning developmental education in order to satisfy these metrics and provide students with the support they need. Co-requisite models offer a promising alternative by placing underprepared students directly into their gatekeeper course, while supplementing that with a required support lab where they can receive individualized attention on the content areas of need. Using an Activity Theory framework (Engeström, 1987), this study examined how elements of a redesigned course shaped the learning experience for underprepared students.

CHAPTER II: REVIEW OF LITERATURE

Because many students arrive at post-secondary institutions underprepared for college-level coursework (Boatman & Long, 2010), developmental education plays an essential role in their academic program requirements. With community colleges facing the responsibility of supplying many of these services, it is important to examine strategies that will successfully remediate students' skill deficiencies and prepare them for their requisite degree courses. This chapter will discuss the complications that are present in sequences of stand-alone developmental courses and some of the factors that have served as catalysts for reform initiatives. Acceleration models are introduced as a possible solution to the problems in developmental education, with a literature review of three approaches: modularization, course restructuring, and mainstreaming. A co-requisite redesign, which is exemplified in the mainstreaming analysis, was the focus of this study.

Mission of Community Colleges

The mission of community colleges has traditionally covered a broad spectrum of commitments, including an open-access admissions policy, comprehensive academic programs, and an emphasis on teaching and learning (Vaughan, 2006). After World War II, the Government Issue (GI) Bill led to a rapid increase in the number of students attending college as financial aid packages were made available for tuition and living expenses. Students with marginal academic records, minorities, and lower income groups were now entering the postsecondary landscape in greater numbers, and of all the higher education institutions, community colleges contributed most to providing these educational opportunities (Cohen & Brawer, 2003). As a result, schools that may have

previously focused on vocational training or transfer degrees now had to expand their mission to include developmental education courses in reading, writing, and mathematics (Bailey & Morest, 2003).

Developmental Education Obstacles

A national study conducted by the Community College Research Center at Columbia University found that as many as 60% of incoming students at community colleges must take at least one developmental course (Bailey & Cho, 2010). ACT results or scores from the Computer-Adaptive Placement, Assessment, and Support System (COMPASS) test are often used to identify the skills that students need remediated, and colleges may have a sequence of developmental courses that students must complete before reaching their college-level requirement. When offered in a stand-alone format, these courses are usually each a semester in length, cost the same as a college-level course, and yet the credits do not count towards graduation requirements. As a result, this raises the tuition expenses for a student progressing through a developmental sequence and extends the time that it will take to earn a degree. Furthermore, Bailey, Jeong, and Cho (2010) analyzed a sample of 256,672 first-time degree seeking students who were required to enroll in a sequence of developmental mathematics courses and found that a majority did not complete the sequence (see Table 1).

Table 1

Enrollment and Completion of a Developmental Mathematics Sequence

| Course level | Never | Did not complete sequence | | Completed | |
(below college-level)	enrolled	Never failed / Never withdrew	Failed / withdrew	Sequence	Total
1 level below	37%	2%	17%	45%	59,551
2 levels below	24%	13%	32%	32%	38,153
3+ levels below	17%	23%	44%	17%	43,886
Total	27%	11%	29%	33%	141,590

Note. Adapted from "Referral, enrollment, and completion in developmental education sequences in community colleges," by T. Bailey, D. W. Jeong, and S. W. Cho, 2010, *Economics of Education Review*, *29*, p. 260.

There are three important conclusions that arise from this study. First, a greater percentage of students never enrolled in a developmental course or did not complete the sequence despite never having failed or withdrew (38%) as compared to those who failed or withdrew from a course (29%). This suggests the idea that the sequence itself acts as an obstacle to students reaching their gatekeeper course. The attrition problem created by a sequence of developmental courses can be summarized by the "multiplication principle" (Hern, 2010, p.2), in which a hypothetical scenario assumes pass and persistence rates of 75% throughout the sequence of developmental courses. If 100 students were assigned to a developmental course three levels below the college course, then 75 would pass, and since not all students persist to the next course, 75% of those

who passed would enroll in the next course, meaning 56 students would now continue in the sequence. If the pass and persistence rates remain at 75%, about 13 students will ultimately pass the college-level course. The students who survive the sequence may benefit greatly from the knowledge they have developed (Bahr, 2009), but the issue is that the sequence creates a pipeline with many exit points for students to fall through along the way.

As for the second important conclusion, Bailey et al. (2010) also found that of the sequence completers, nearly two-thirds enrolled in a gatekeeper course and just over three-fourths of those enrolled passed; yet only 20% of those who were referred to mathematics remediation completed a gatekeeper course within three years. So students who made it to the gatekeeper course had a high pass rate, but the inability to enroll in such a course presents a greater barrier than failing the course or withdrawing. Third, only 17% of those who were least prepared, meaning they were placed in a course at least three levels below a college course, successfully completed the sequence. Therefore, the goal of the stand-alone developmental courses to prepare students for their college-level requirement was not meeting its intended purpose for a vast majority of those most in need.

Factors Driving Reform

There are several factors that have contributed to efforts to reform developmental education in recent years. As evidenced in the research by Bailey et al. (2010), developmental education, when offered as a sequence of stand-alone courses, may result in poor outcomes as many students never successfully progress through the entire set of required courses. Students placed in the lowest level of remediation have the lowest

chance of completing the developmental sequence (Bailey et al., 2010; Jaggars & Hodara, 2011; Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009), but Scott-Clayton and Rodriguez (2012) also found discouragement effects among students who fell just below the placement cutoff score for college-level assignment. The authors found that students in this category had higher attrition rates from college, when compared to those who scored just above the cutoff score for college placement. This could be due in part to the frustration that individuals feel at having to take a course they deem unnecessary as well as the stigma some may experience being labeled a remedial student (Scott-Clayton & Rodriguez, 2012). As a result, developmental education may have diversionary consequences or discouragement effects depending on where a student tests into the sequence (Hodara & Jaggars, 2014).

External issues, such as policy mandates or financial concerns, also serve as a catalyst for reform. Over a dozen states have restricted or denied funding for developmental education at four-year institutions (Jacobs, 2012), meaning the onus for addressing the needs of the underprepared population is becoming even more heavily emphasized at community colleges. Coupled with this initiative is the fact that 27 states have funding models in place at two-year colleges that include performance-based indicators such as course completion rates, time it takes to complete a degree, number of degrees awarded, transfer rates, or the number of low-income or minority graduates (NCSL, 2015). Historically, community colleges were funded based on their enrollment numbers, but the trend towards performance-based funding now places a greater importance on institutions getting their students successfully through their coursework and towards degree completion. With the aforementioned struggles that developmental

education students face and the responsibility for remediation being directed away from four-year institutions, two-year colleges must consider alternative curricular strategies that simultaneously benefit the underprepared students and ensure the school's financial stability.

Acceleration Models

Acceleration models for developmental education represent a possible solution that academic institutions can adopt to target the remediation skills for underprepared students while considering their retention within their program of study. Edgecombe (2011) defined acceleration models as the restructuring of curricula and teaching methods that reduce the time required for students to complete their educational requirements. Acceleration has the potential to advance students' progress to college-level courses for two reasons. First, it attends to the problems with the developmental sequence structure by reducing potential exit points, thereby increasing the chances that students will advance in their studies; and second, it allows students who may have been underplaced by diagnostic assessments to move quicker through unnecessary content (Hodara & Jaggars, 2014).

With the increased availability of computers, a common feature among acceleration models is the use of electronic technology to support student learning. Standards developed by the American Mathematical Association of Two-Year Colleges (AMATYC, 2006) called for faculty to implement technology that would promote students' conceptual understanding and skill development. Computer-assisted instruction (CAI) is a widely used strategy to supplement direct instruction, where students can access software to help develop content mastery through continuous assessment (Epper &

Baker, 2009). The following section will discuss some of the literature on acceleration models that have used technology in an effort to improve the outcomes for developmental education students. Different descriptors are used for the various reform strategies, but three primary models to accelerate developmental education are discussed: Modularization, Course Restructuring, and Mainstreaming with Supplemental Support.

Modularization

Modularization models seek to separate traditional semester-long developmental education courses into distinct learning modules that target specific concepts and skills (Nodine, Dadgar, Venezia, & Bracco, 2013). Diagnostic tests are used to determine the particular competencies required for each student, thereby providing them with an individualized plan to address only those skills deemed in need of remediation. While some modular courses may be instructor-led, others use educational software products such as MyMathLab, ALEKS, Cognitive Tutor, and StatTutor to supplement in-class instruction or as the principal tool for delivering content and developing skills (Rutschow & Schneider, 2011). When courses are self-paced, students may work independently to demonstrate mastery of content by achieving benchmark scores on assessments, and then progress to more advanced modules (Epper & Baker, 2009). Therefore, this model has a goal of targeting the skills that students need to prepare them for their college courses and the self-paced format allows students to receive individualized instruction which may reduce the time needed to remediate those skills.

Tennessee redesign. Beginning in 2006, the Tennessee Board of Regents (TBR), the sixth largest higher education system in the country with over 200,000 students enrolled in six universities, 13 community colleges, and 27 technology centers (Hargett,

2011), partnered with the National Center for Academic Transformation (NCAT) to redesign how its developmental mathematics courses would be offered. Its goals were to implement effective assessment instruments that raised completion rates for students as well as decreased the amount of time that they spent taking developmental coursework (NCAT, 2009). Before the redesign, there was a sequence of three stand-alone semester-long courses – basic remedial, basic developmental, and intermediate developmental (Twigg, 2009), – in which students enrolled based on the results of a placement test. For students placed in the lowest level course, this could add over a year to their program of study before being eligible to take their college-level mathematics requirement.

Boatman and Long (2010) used a regression discontinuity design to examine causal effects of a student's placement in the developmental sequence on persistence, degree completion, and the total number of college credits completed. Although no significant differences were found related to persistence, they determined that students enrolled in developmental mathematics courses ultimately completed fewer college-level credits than their peers who enrolled in the next highest-level course. The greatest negative effects for degree completion were found among the students who were enrolled in the highest level developmental course when compared with students placed in a college-level course. Alternatively, those who were least prepared exhibited much smaller negative effects as a result of their developmental assignment. As a result, Boatman and Long (2010) concluded that developmental education affects different students in different ways, but recommended that strategies be considered that allow students to satisfy their remedial requirements without being discouraged from taking additional classes.

The TBR course redesign initiative sought to use modularization as a means to reduce the time required to become college-ready and improve student outcomes related to learning and retention. Two of the schools that participated in the project were Cleveland State Community College (CSCC) and Jackson State Community College (JSCC).

CSCC results. In its traditional lecture format, CSCC's developmental courses of Basic Math, Elementary Algebra, and Intermediate Algebra had a Drop-Failure-Withdrawal (DFW) rate of 45% (Wyrick, 2009). As part of its redesign, the school adopted the emporium model (Twigg, 2003) by having students meet one hour each week in class and two hours in a large computer lab, allowing students to complete assignments online while instructors offered individualized assistance. The content for each developmental course was organized into modules with all homework and testing completed online using MyMathLab. If students completed all of the modules for one course, then they could immediately register for the next course in the sequence and begin work within the same semester.

Descriptive summaries appeared to show positive outcomes for the redesign. For Elementary Algebra, students earning a C or better (completion rate) increased from 50% prior to the redesign to 68% after the redesign; and for Intermediate Algebra the completion rate rose from 57% to 74% (Wyrick, 2009). Basic Math showed an initial increase in the completion rate from 50% before the redesign to 65% after the first semester of implementation, but then returned to the 50% success mark in the subsequent semester (Wyrick, 2009). This may coincide with some of the findings by Boatman and Long (2010), indicating that interventions may vary in their efficacy based on the

students' level of preparation. In terms of reducing the amount of time spent remediating academic deficiencies, the continuous enrollment component allowed 50 students to complete at least two developmental courses in one semester and two students finished the entire sequence within one semester. This contributed to the number of students enrolling in a college-level course increasing by 42% after the redesign was established (Wyrick, 2009). Furthermore, Boatman (2012) found that the redesigned courses resulted in more college-level credits being earned after two years, indicating that students are both completing their developmental requirements and persisting in their programs of study.

JSCC results. Similar to CSCC, traditional developmental courses at JSCC had a failure rate of nearly 44% (Bassett, 2009). The college also employed an emporium model (Twigg, 2003) for their redesign, but they condensed three developmental courses into one course comprised of 12 modules: modules 1-3 replaced Basic Math, modules 4-7 replaced Elementary Algebra, and modules 8-12 replaced Intermediate Algebra. Students took a pretest at the beginning of the semester to identify the skills and concepts that they would be required to master, meaning students only had to complete those modules associated with the areas in need of development. All course content was administered in MyMathLab and students met in a computer lab where they could receive individualized tutoring, faculty-led discussion groups, and access to video lectures.

During fall 2008, the first semester of implementation, 11 traditional sections (220 students) of developmental mathematics and 13 redesigned sections (356 students) were offered. In the traditional sections, 41% of the students passed with a C or higher, whereas 54% of the students in the redesigned sections earned at least a C (Bassett,

2009). The grade in the redesigned sections was the average of the modules completed. Elementary Algebra showed the greatest gains in pass rates, with 32% of traditional students earning a C or higher, compared with 66% in the redesigned sections. Intermediate Algebra, however, had a pass rate of 48% among the traditional population and only 44% in the redesign. In terms of completing the developmental requirements, by spring 2009, 42% of students in the redesign satisfied all of their required modules and were ready to enroll in a college-level course; historically, on average only 18% of students in the traditional sequence successfully advanced all the way through Intermediate Algebra to allow them access to a college-level course (Bassett, 2009). Some of these gains can be explained by the fact that students only had to master the modules deemed necessary by the pretest, which during the 2008 academic year resulted in 74% of the students having to complete fewer than the maximum 12 modules (Bassett, 2009). With regard to persistence in college-level classes, though, Boatman (2012) found no statistically significant difference between traditional developmental students and those who experienced the redesign.

Modularized courses offer a self-paced structure to developmental education that ideally allows students to receive customized instruction for their learning needs. Redesigns that only require mastery of content diagnosed as deficient also presents an opportunity for students to accelerate through their developmental requirements and proceed to their gatekeeper course. The self-paced nature of the modules, however, may not be suitable for students who struggle with time management skills (Nodine et al., 2013). Nodine and colleagues also contend that modularization may take away some of the contextualization of the curriculum, resulting in an emphasis on procedural fluency at

the expense of conceptual understanding. Ultimately, it is important to ensure that students exit their developmental courses sufficiently prepared to succeed in their college coursework.

Course Restructuring

Another acceleration model, known as course restructuring, looks to reduce the time needed to complete developmental mathematics requirements by modifying the curriculum or reorganizing instructional time (Edgecombe, 2011). Two examples of course restructuring include compressed courses and curricular redesign. These strategies aim to minimize redundancies within the course by aligning content with specific fields of study (Nodine et al., 2013) and accelerate achievement by removing potential exit points in the developmental sequence (Baker, Edgecombe, & Silverstein, 2011).

Compressed courses. Compressed models offer students an opportunity to complete multiple developmental education courses within one semester. Normally, the content for the first course is compressed into the first-half of the semester, typically seven weeks, with the next course in the sequence following immediately thereafter during the second-half of the semester. Students would register for both courses at the beginning of the term, thereby reducing the chances of not continuing in the sequence, though if they do not pass the first course then they cannot continue to the second. Furthermore, the compressed nature of the courses results in longer meeting times each week, which proponents argue helps strengthen student-teacher relationships and may benefit student outcomes (Edgecombe, 2011). Combing two courses into a single semester also gives the instructor flexibility in how the content is organized, thus limiting

the redundancy that can occur when classes are offered in separate semesters (Bragg & Barnett, 2008). Two schools that have adopted this approach are the Community College of Denver (CCD) and Ivy Tech Community College.

CCD results. In its traditional offering, CCD had a sequence of three developmental mathematics courses: MAT 030 (Fundamentals of Math), MAT 060 (Pre-Algebra), and MAT 090 (Introductory Algebra), with each class meeting 75 minutes twice a week. In 2005, CCD launched FastStart, a program that allowed students to enroll in the paired course MAT 030-060 or MAT 060-090, with each course meeting 2 hours and 45 minutes twice a week for one semester. Additionally, FastStart students had to complete a 25-hour, one-credit lab that could include using the tutoring center on campus, forming study groups facilitated by the instructor, or completing course assignments via the designated educational software (Edgecombe, Jaggars, Baker, & Bailey, 2013).

Bragg (2009) conducted an analysis comparing FastStart students from spring 2006 through spring 2007 to baseline students in fall 2003 who would have enrolled in the individual developmental courses. Nearly 72% of students enrolled in the accelerated MAT 060-090 passed all developmental requirements and were ready for their college-level mathematics course, compared with slightly less than 50% of the students who started in the baseline MAT 060 course. Of those who enrolled in the college gatekeeper course, 35% of the FastStart students passed, compared to about 24% in the baseline group. Almost 89% of the FastStart sample in MAT 030-060 passed at least one developmental mathematics course, compared to about 66% of the students enrolled in MAT 030. The results appeared to show positive outcomes for the compressed course

initiative, though Bragg (2009) did not control for any differences in student

characteristics.

Edgecombe et al. (2013) followed up on Bragg's study by conducting a regression

analysis on FastStart participants from spring 2006 through spring 2008, with a

comparison group of students who took a non-FastStart section of MAT 030 or MAT 060

during the same period. Student characteristics were controlled for, including gender,

ethnicity, age, financial aid status, prior credits completed, and full-time or part-time

enrollment. Using this model, FastStart students were significantly more likely to pass

MAT 090 with at least a C, enroll in a college mathematics course, and pass the college

course with at least a C. However, no significant differences were found for short-term

persistence, total credits earned with at least a C, or college credits earned with at least a

C. In addition, Edgecombe et al. (2013) conducted interviews with a focus group of 10

FastStart students to gain insight into their perceptions of the program's impact on their

learning. Participants reported a high level of satisfaction with the teachers' commitment

to their success and providing them with a strong foundation for future courses. Students

also cited program advisors as providing valuable support throughout the semester, but

most described the 25-hour lab requirement as being unnecessary.

Despite these positive outcomes, one of the difficulties the FastStart program

encountered was how to scale up to meet the needs of the majority of developmental

students (Jaggars, Hodara, Cho, & Xu, 2014). Less than half of the students who were

assigned to more than one developmental course enrolled in a FastStart section, which

may be attributable to the difficulty of fitting the lengthy instructional time blocks into a

student's schedule (Edgecombe et al., 2013). Furthermore, institutions seeking to adopt

acceleration through compressed courses might have to consider appropriate professional development initiatives to support teachers adapting to the new framework, as well as external supports to help students be successful and remain in the program.

Ivy tech results. The Evansville, Indiana campus of Ivy Tech Community College embarked on a compressed course redesign in 2007 similar to the FastStart program at CCD. Program advisors assisted with the recruitment and screening of pilot participants for the two eight-week sessions of developmental mathematics courses (Edgecombe, 2011). Although the evaluation reports were predominantly descriptive, the results were positive. In particular, 71% of students enrolled in the paired low and middle levels of developmental mathematics completed the course with at least a C, compared with 52% of the students taking the same courses in the stand-alone 16-week format (Edgecombe, 2011). Other results showed that students in the accelerated sections persisted at a higher rate to the next semester and had a lower withdrawal rate than those in traditional courses.

Similar to the obstacles faced by CCD, however, only about 25% of the eligible students at Ivy Tech enrolled in the accelerated compressed sections (Epper & Baker, 2009). The struggle to capture a larger segment of the student population may help explain why the school eventually switched to a co-requisite model, which will be discussed within the Mainstreaming redesign strategy, as a means to accelerate the students through their developmental requirements.

Curricular redesign. While compressed courses may involve curriculum modifications to reduce duplications in content, curricular redesigns aim to eliminate the multi-course developmental sequence altogether. This may be accomplished by

developing a developmental bridge course that is closely connected to the college

curriculum, or by embedding the developmental content into a college-level course and

then reconfiguring how that class is taught (Edgecombe, 2011). The former approach

will be discussed through the Statway and Quantway pathways created by the Carnegie

Foundation for the Advancement of Teaching, and the latter approach will be illustrated

through the K-courses offered at Middle Tennessee State University (MTSU).

   Statway and Quantway. The president of the Carnegie Foundation for the

Advancement of Teaching once remarked, "Developmental mathematics courses

represent the graveyard of dreams and aspirations" (Merseth, 2011, p. 32). Inspired by its

mission to solve educational problems, the Carnegie Foundation partnered with college

faculty, researchers, and program developers in 2009 to design two mathematical

pathways, Statway and Quantway, to accelerate students' completion of developmental

content and achieve college credit within one year (Sowers & Yamada, 2015).

   Statway and Quantway are currently being used by about 50 colleges across the

country, with Statway covering developmental mathematics and college-level statistics,

and Quantway integrating developmental mathematics and college-level quantitative

reasoning (Edwards, Sandoval, & McNamara, 2015). Statway aims to help students

analyze and interpret data to formulate conclusions to open-ended inquiries, while

Quantway has a goal of having students use numerical reasoning to understand practical

problems, rather than memorizing procedures (Merseth, 2011). Both pathways have

several common characteristics: they are intended for students not majoring in Science,

Technology, Engineering, or Math (STEM); they engage students by having them work

collaboratively on non-routine problems with real-world applications; they include a one-

hour lab in addition to the course meeting times; and the Carnegie Foundation has a professional development system in place to support faculty with curriculum development.

Sowers and Yamada (2015) provided descriptive statistics of student performance from the community colleges that implemented either Statway (26 institutions) or Quantway (16 institutions) from the 2011 academic year through the 2013 academic year. For Statway, success was defined as completing the year-long pathway with a C or higher. Slightly more than 49% of the students enrolled in Statway over the three-year investigative period were successful. For developmental students enrolled at these colleges prior to the Statway adoption, only 6% earned college-level credit within one year and 15% reached this goal after two years. For the first semester of Quantway, which fulfills a student's developmental requirement, 56% of the students were successful. By comparison, prior to Quantway's implementation, 21% of students competed their developmental sequence within a year and 29% reached this goal after two years. For the second semester of Quantway, which provides college-level credit, 67% of the students enrolled were successful. It is important to note that no student characteristics were controlled for in the study, but the pathways may provide a promising alternative for students in non-STEM majors to complete their mathematics requirement without being assigned to traditional algebra-intensive courses that may not be suitable for their career paths.

MTSU K-courses. In response to a recommendation by the Tennessee Board of Regents (TBR) to reduce the cost of remedial and developmental education, the Complete College Tennessee Act prohibited universities from offering remedial or

developmental courses. As a result, Middle Tennessee State University redesigned its

developmental mathematics program by eliminating elementary algebra and intermediate

algebra courses and implemented an embedded instructional model. Initially, the

redesign created special sections of MATH 1010 (Mathematics for General Studies) and

MATH 1710 (College Algebra), designated by the letter K to differentiate them from the

regular sections, to satisfy the needs of underprepared students. The courses provided

three credits of general education mathematics, but included five contact hours (4 in the

classroom, 1 in a lab) each week to accommodate all learning objectives of the non-K

sections of MATH 1010 and MATH 1710, as well as allow time for additional instruction

on topics that students needed to support their learning (Lucas & McCormick, 2007).

Lucas and McCormick (2007) compared the success rates (students earning a

grade of C or higher) of students in K sections to students in non-K sections of MATH

1010 and MATH 1710 during the pilot year of 2006-2007. Although student

characteristics were not controlled for in the study, the redesign offered promising

conclusions. There were no statistically significant differences in the success rates for

students in the K sections of MATH 1010 (70.5%) and MATH 1710 (65.8%) when

compared with their peers in the regular sections (67.4% and 65.9%, respectively).

Furthermore, there was a statistically significant difference in the success rates comparing

students who had completed prior developmental course work in non-K sections of

MATH 1010 (57%) and MATH 1710 (56.6%) with students in K sections of these

courses. This suggests that the underprepared students in the K sections were well served

by the curriculum redesign since they achieved comparable pass rates as their college-

ready peers and they had better learning outcomes than their peers who had previously

completed developmental courses. In addition to the K sections satisfying the general

education mathematics requirement without having to first complete the traditional

developmental sequence, students may also experience an affective dimension of the

redesign in that immediate exposure to college content might influence their level of

motivation to succeed (Edgecombe, 2011).

Mainstreaming with Supplemental Support

A third model to accelerate developmental education is defined by underprepared

students enrolling directly in a transfer-level course that is paired with another course or

lab to provide the necessary support for concepts in need of remediation (Nodine et al.,

2013). This is termed as mainstreaming with supplemental support, or co-requisite

remediation. The aforementioned redesign implemented by MTSU is an example of

"partial mainstreaming" (Lucas & McCormick, 2007, p. 39), in that students were

enrolled in a college-level course, but the K-sections contained a homogenous population

of underprepared students and the developmental content was embedded within the

regular curriculum as needed during class instruction. In a mainstreaming model using

co-requisite remediation, however, underprepared students are enrolled in the same

gatekeeper course as their college-ready peers and both groups receive the same

instruction of the course content. The underprepared students, though, must also enroll in

a lab or paired course that coordinates the necessary developmental topics with the

college-level content.

Austin Peay State University (APSU) applied this approach in an effort to raise

retention rates while addressing the weak links that existed between their developmental

courses and two college-level core mathematics courses (Golson, 2009). At Texas State

University, the FOCUS (Fundamentals of Conceptual Understanding and Success) co-requisite model for College Algebra was created to support student success in a credit-bearing college mathematics course. The details of each initiative and their results are discussed in the following sections.

APSU's co-requisite redesign. The Tennessee Board of Regents put forth a strategic plan in 2005 that called for an increase in the success rate of students requiring developmental work as well as raise the graduation and retention rates. Factoring in a nationwide trend of reduced funding for postsecondary education (Vandal, 2010), Austin Peay State University decided to partake in a grant from the United States Department of Education to redesign its developmental education program by eliminating its two developmental mathematics courses, Elementary Algebra and Intermediate Algebra. Students who would have traditionally been placed in a developmental course were placed directly in a college-level class, either Mathematical Thought and Practice or Elements of Statistics depending on a student's major, but each course was now linked to a co-requisite lab that would assist students in removing their skill deficiencies (Golson, 2009).

The co-requisite labs utilized a Structured Learning Assistance (SLA) model (Doyle & Hooper, 1997), in which peer tutors conducted workshops that offered individualized instruction for core competencies just prior to when they would be needed in the course (Berryman & Short, 2010). Students completed assessments during the first lab meeting to identify specific mathematical skills in need of remediation and were then assigned modules within MyMathLab to target those areas (Golson, 2009). This offered a change from the traditional developmental curriculum in which the content was uniform

for all students based on the results of a placement test. In this scenario, the lab allowed

students to receive assistance with topics that were particularly needed for them to

succeed in the college-level course.

With respect to the impact on students, prior to the redesign 33% of the students

enrolled in developmental courses were successful (D or better) in Mathematical Thought

and Practice and 23% were successful in Elements of Statistics; after four semesters of

the co-requisite redesign, the success rates in Mathematical Thought and Practice and

Elements of Statistics averaged 71% and 54%, respectively (Golson, 2009).

Additionally, Boatman (2012) used a regression discontinuity to study the effects of the

redesign and found that developmental students at Austin Peay accumulated more college

credits after one and two years when compared to students at peer four-year institutions

in Tennessee. This result may be due in part to the fact that APSU developmental

students were mainstreamed into college-level courses as opposed to students at other

colleges who were enrolled in developmental courses that did not offer college credit. In

terms of persistence, prior to the redesign, enrollment in a developmental mathematics

course created a 4.3 percentage point increase in the chances of enrolling in the second

semester when compared with students placed in a college-level course; after the

redesign, the likelihood of persisting to the second semester increased by 7.6 percentage

points (Boatman, 2012). Boatman (2012), however, cautioned that these results only

applied to students at the margin of needing remediation and therefore may not apply to

students who are the most underprepared mathematically.

FOCUS co-requisite model. Seeking a way to address the attrition problem

created by a sequence of developmental mathematics courses (Hern, 2010), Texas State

University allowed students who scored just below the cut score on the placement test to enroll concurrently in a remedial mathematics course and a credit-bearing course, either College Algebra or College Algebra with Statistics (CCA, 2011). Similar to the APSU co-requisite model, the choice of college-level course was based on the individual's academic and career goals. To provide the necessary learning support for its students, the FOCUS program included mandatory participation in weekly tutoring, mentoring sessions, and monthly seminars (Mireles, Acee, & Gerber, 2014). According to Mireles et al. (2014), careful consideration was given to the choice and sequencing of developmental topics in relation to the college content to help contextualize the mathematics being taught. This highlights the importance of the co-requisite requirement not simply being an add-on course, but a resource that specifically assists students with the college-level curriculum.

Using a quasi-experimental design with a pre- and post-test of mathematical proficiency over a span of five semesters, Mireles et al. (2014) found that FOCUS students experienced a statistically significant increase from pre-test to post-test. The authors also found that FOCUS participants in College Algebra had statistically significant higher grades than their counterparts enrolled in traditional sections of College Algebra. It should be noted, though, that students who tested into developmental mathematics based on the results of a placement test were not automatically enrolled in the FOCUS program, but instead were eligible to apply for enrollment. A group of faculty chose participants for the redesign based on factors such as first-generation student, veteran status, and placement into multiple developmental courses (Mireles et al., 2014).

Chapter Summary

The role of developmental education in the postsecondary landscape is facing several critical issues. The least-prepared students sometimes face the prospect of taking three or more remedial courses before they are eligible to enroll in a credit-bearing college course to satisfy their program requirements. Stand-alone sequences of developmental courses are fraught with obstacles, including multiple potential exit points that result in high levels of attrition (Bailey & Cho, 2010), extending the time that it takes students to earn their degrees, and causing negative psychological effects of being labeled a remedial student (Scott-Clayton & Rodriguez, 2012). As a result, this creates the effect of a leaky pipeline, from which many students never successfully emerge from to enroll in their gatekeeper course (Bailey, Jeong, & Cho, 2010; Hern, 2010).

Furthermore, the responsibility for teaching developmental courses is shifting away from four-year institutions and being placed on the shoulders of two-year colleges (Jacobs, 2012). Organizations like the National Center for Academic Transformation (NCAT) and Complete College America (CCA) have partnered with colleges to implement reform initiatives for developmental education. Acceleration strategies, such as modularization, course restructuring, and mainstreaming attempt to deal with the aforementioned problems inherent in the developmental sequence structure.

Although the body of empirical studies for developmental redesigns is limited (Edgecombe, 2011; Hodara & Jaggars, 2014; Rutschow & Schneider, 2011), the research that has been conducted has produced promising results for pass rates (Bassett, 2009), persistence rates (Bragg, 2009; Boatman, 2012), and credit accumulation (Boatman, 2012). Because some of the studies were conducted at four-year institutions or used

methodologies that targeted students at the upper end of the developmental spectrum (Boatman, 2012), concern remains at how the least prepared students will fare in an accelerated reformed course (Mangan, 2015). Therefore, the community college environment with its open enrollment policy offers an opportunity to explore this important issue within a co-requisite redesign.

CHAPTER III: METHODOLOGY

The purpose of this study was to understand how underprepared students perform in a redesigned co-requisite course and the factors that affect their learning experience. Reform initiatives that have included using technology to reform the developmental curriculum (Twigg, 2003) or co-requisite models that accelerate the time required for students to enroll in their gatekeeper course (Edgecombe, 2011) have offered promising alternatives. However, it is still unclear if these efforts will benefit those students who fall far below the college-ready placement threshold (Hodara & Jaggars, 2014).

The proposed study is characterized as a triangulation mixed methods design (Gay, Mills, & Airasian, 2011), as the quantitative and qualitative data was collected concurrently. This chapter begins with background information on the context in which the study is situated along with details on a pilot implementation of a co-requisite Statistics course conducted in fall 2014 at the community college setting for this study. Then a description is provided of the study participants, as well as the instruments and procedures comprising data collection. Finally, the data analysis procedures for each research question are discussed along with the steps taken to address the validity of the qualitative research.

Context and Background

This study took place on the main campus of Rossvale Community College (pseudonym), located in the southeastern United States that serves a broad geographic area spanning seven counties. Demographic information displayed in Figure 3 reveals that there were 5,796 students enrolled on the main campus for the fall 2016 semester. Full-time students are those taking at least 12 credit hours; traditional students are

defined as those under the age of 25, whereas non-traditional students are characterized

as age 25 or older.
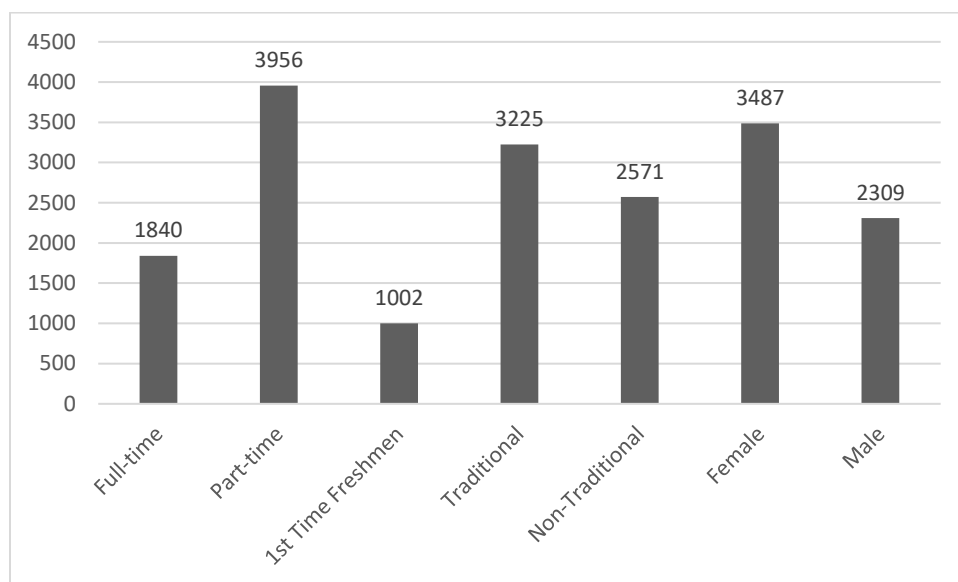
Figure 3. Demographic information from the main campus of Rossvale Community College for fall 2016. Adapted from the Office of Institutional Research, 2016.

Prior to the implementation of co-requisite courses at Rossvale Community

College, developmental mathematics requirements were offered through a sequence of

three stand-alone courses: Basic Mathematics, Elementary Algebra, and Intermediate

Algebra. These courses were offered in a lecture format and students had to pass

Intermediate Algebra before they could enroll in a college-level mathematics course. In

2011, the college transitioned to an emporium model (Twigg, 2003) for addressing the

remediation of skills for underprepared students. Components of the developmental

curriculum, along with quantitative reasoning topics, were used to create five computer-

based modules that students completed in a self-paced format. Students had to pass all

five modules before they could progress into their required mathematics course for their

degree program. Although the intent was to accelerate the time needed to get students college-ready by condensing the requirements from three semesters down to one, many students either needed at least two semesters to successfully complete all five modules or never persisted to the conclusion of the program. As a result, the emporium model shared the issues of the previous developmental sequence by creating a barrier for students' advancement into their first college-level course.

In the fall of 2014, Rossvale Community College conducted a pilot implementation of the co-requisite redesign within two sections of Statistics. The pilot classes restricted enrollment to students with an ACT mathematics sub-score of 15 to 18; students also had to receive permission from the instructor conducting the pilot to register for the course. Thirty-two students participated in the pilot and each student was co-enrolled in the Statistics course and a support lab, both of which were run by the same instructor. The course coordinator, who served as the instructor for the two pilot sections, compared final course averages across three groups of students in 12 sections of Statistics: those in the pilot co-remediation, those who had already completed their mathematics remediation requirements, and those deemed college-ready. Overall, students in the co-remediation sections outperformed the other two groups. The course average for students in the pilot sections was 72.87%. Students in traditional Statistics sections who had previously completed their mathematics remediation requirements had a course average of 66.80%; and those who were deemed college-prepared had an average of 69.81% (Nettles & Needham, 2016).

There are some important distinctions to note between the pilot implementation study and the current study. First, the pilot was limited to students with ACT

mathematics sub-scores of 15 to 18 and enrollees were initially screened by the instructor. Furthermore, the students enrolled in the two co-remediation Statistics sections were more homogeneous ability-wise given they were all classified as underprepared. In contrast, all sections of Statistics for this study were under the co-requisite redesign model; hence students self-enrolled into the course and some had ACT mathematics sub-scores below 15. In addition, the composition of the lecture course was heterogeneous as both college-ready and underprepared students enrolled in the same section. Second, during Rossvale's pilot implementation study, the support lab was facilitated by the same instructor teaching the college-level Statistics content. For this current study, the support labs were facilitated by adjuncts and the Statistics courses were taught primarily by full-time instructors. However, training protocols were established for the support lab faculty to help standardize the lab's operation.

When developmental courses at Rossvale community college were offered in a traditional sequence, the content was uniform for each student, regardless of the college-level course needed for that individual's major. In 2015, the institution adopted a co-requisite model (CCA, 2013) for most of its credit-bearing courses, including Statistics, that allowed underprepared students to enroll directly in their college-level mathematics courses while receiving any necessary remediation by co-enrolling in a one-credit support lab. Consequently, the learning support material that supplemented the college content was tailored specifically to assist students with topics for that particular course.

For the fall 2016 semester, there were 14 sections of co-requisite Statistics, with 11 offered during the day and three at night. Each section was capped at 30 students and the total enrollment was 413. Of the five instructors assigned to the different sections,

four were full-time and one was an adjunct. Students who had an ACT Mathematics sub-score below 19 or a COMPASS Algebra score below 38 and had not previously completed any coursework to remediate their skills were required to co-enroll in a one credit Statistics support lab that met once a week for two hours in a computer lab. There were two computer labs that handled nine sections of support labs, one lab with a capacity for 20 students and the other with a capacity for 25 students.

Course Resources

There were several resources available to students as part of the Statistics redesigned course that could potentially impact their learning experience. This section outlines three resources that were critical design components when the co-requisite course was created: MyStatLab, common course files, and the Statistics Support lab.

MyStatLab

My StatLab is a course management system established by the Pearson publishing company. All homework and quiz assignments were completed online through the MyStatLab software program. One of the strengths of the system was that it offered immediate feedback to the students, including frequently giving hints about how to approach a question that was answered incorrectly (see Appendix A). Students were allowed three attempts to answer a question correctly before it was marked wrong. If this occurred, students could choose to work a similar exercise and, if answered correctly, then they received full credit for the question.

Furthermore, students had access to learning aids such as *Help Me Solve This*, *View an Example*, and *Textbook* for each homework question. *Help Me Solve This* was an interactive feature in which the computer guided the student step-by-step through the

solution to the current problem, requiring the student to enter answers when prompted at each step. Once the question was completed, a similar exercise was then generated to allow the individual to attempt the problem independently. The *View an Example* learning aid created a problem similar to the current one, and then offered a step-by-step explanation of the solution (see Appendix B). The student was then returned to the original question and allowed to answer it for credit. Finally, the *Textbook* option opened an electronic copy of the textbook to the section associated with the question's content, thereby allowing one to review the topics for that assignment.

Common Course Files

Rossvale Community College used the learning management system Desire2Learn (D2L) to house the online course shells for each section of Statistics. D2L provided anytime access to course files on a central website. Since the courses were standardized, each section contained the same content within its shell. Folders were created for each test with the following documents stored within: Pencast pdf (portable document format) files, handouts for each chapter, and test review packets and formula sheets. Pencast pdfs were custom files that combined notes and audio, allowing students to review course material while listening to an instructor's explanation (see Appendix C). Handouts related to important topics within each chapter (see Appendix D) also gave students who may have missed class a chance to practice some of the necessary skills to get caught up. Lastly, test reviews in both pdf and PowerPoint formats existed for each test, with accompanying justification provided for each answer choice (see Appendix E).

Statistics Support Lab

Underprepared students were required to attend a support lab once a week for two hours in addition to their regular Statistics class. The lab afforded them dedicated time to work on any of the course assignments, including homework, quizzes, and exam reviews. The faculty member facilitating the lab was able to provide targeted instruction through one-on-one assistance for those in need. For each participant in the study, their lab instructor differed from their classroom instructor, thus providing them with a different perspective for content explanations. Furthermore, underprepared students were permitted to enroll in any support lab section, making the composition of the labs a mix of students across the various Statistics sections.

<div align="center">

Participants

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Given the purpose of this study was to investigate the impact of a redesigned co-requisite course on underprepared students, the population was defined as the set of community college students; the sample were those in the co-requisite sections; and the participants were the six randomly selected students from the sample who participated in the interviews. Particular groups within the sample were used to address the quantitative and qualitative portions of the study, described in the following sections.

As part of its registration guidelines, Rossvale Community College classified underprepared students as those having an ACT mathematics sub-score below 19 or a COMPASS Algebra score below 38; similarly, it classified college-ready students as those having an ACT Mathematics sub-score of at least 19 or a COMPASS Algebra score of at least 38. The benchmark score of 19 as established by ACT (2013) is associated with students having a 50% probability of earning at least a B in the college course and a

75% probability of earning at least a C. This same convention was used for the first research question in order to compare differences between group means for the final course average between the underprepared and college-ready students.

In an effort to gain deeper insights into the success rates of the underprepared enrollees, the second research question sought to separate the underprepared pool of students into two groups, those who were least-prepared and those who were better-prepared. Because some students enrolled in the co-requisite course based on their ACT Mathematics sub-score or their COMPASS Algebra score, the least-prepared sample was classified by an ACT Mathematics sub-score below 16 or a COMPASS score below 21, based on the relationship between the two measures as identified by ACT (2010). Therefore, students with ACT Mathematics sub-scores from 16 to 18 or a COMPASS Algebra score from 21 to 37 were identified as better prepared. Data from the underprepared enrollees in the spring 2016 Statistics course sections were considered in defining these cut scores and using the definitions above.

This mixed methods study collected both quantitative and qualitative data concurrently. The following sections describe the instruments and procedures needed for data collection.

Quantitative Data

The quantitative data were driven by course assessments assigned throughout the semester and completed by the students both in-class and within MyStatLab.

Instruments

Two comparisons were run within the Statistics co-requisite course to measure outcomes assessment: one between all underprepared and college-ready students, the other between the least-prepared and better-prepared students within the underprepared sample. In each case, group means from the final numerical course average were used for the analysis, with the course average determined by a set of homework assignments, quizzes, in-class exams, and a comprehensive final exam.

All Statistics course sections were standardized to include the same syllabus, course requirements, homework, quizzes, and exams. Homework and quizzes were administered using MyStatLab, a course management system offered through the Pearson publishing company. Assessments were comprised of three in-class exams weighted 60% of the course grade; twelve homework assignments weighted 10%; twelve quizzes weighted 10%, and a comprehensive final exam weighted 20%. The final exam grade replaced the lowest in-class exam score if the final exam grade was higher than the score it replaced. All homework and quizzes were due the day of the in-class exam that corresponded to the material associated with those assignments. Homework assignments could be taken an unlimited number of times prior to the due date and students only needed to rework missed problems in order to raise their score. Students were allowed three attempts for each quiz prior to the deadline, but could not re-work individual questions to raise their grade. The highest score of the three attempts was recorded as the grade for each quiz.

Students who were required to co-register for the one-credit support lab had additional assignments built into the homework component of MyStatLab and designed

to address the developmental content needed within each chapter. These chapter preparation assignments averaged 18 questions and students had to score at least an 80% before they could attempt the chapter homework. Similar to the regular homework assessments, students could work individual missed problems until they raised their score to the required threshold.

Procedures

During the fourth and fifth weeks of the semester, the researcher visited each co-requisite Statistics section to provide an overview of the study and collect signed informed consent forms (see Appendix K). Two hundred twenty-one students agreed to participate in the study, though two were excluded as they were under the age of 18. The classroom instructors furnished a list of students for each of their sections who were classified as college-ready and those who were underprepared. Furthermore, the Office of Institutional Research at Rossvale Community College provided the ACT Mathematics sub-score and the COMPASS Algebra test score, if applicable, as well as the high school grade point average, if available, for each student. The ACT and COMPASS scores facilitated the classification level of each student, which was the independent variable in the study. The high school grade point average served as the covariate. Delineating the data in this manner enabled the comparisons sought in the first two research questions.

During the last week of the semester, all students remaining in the redesigned co-requisite Statistics course sections took a comprehensive departmental final exam. Along with the students' homework and quiz averages, the final exam factored into determining their final numerical course average, which was the dependent variable. Once course averages were calculated, the researcher contacted each of the course instructors to

acquire that data. Any students who had withdrawn from the course before the end of the

semester had their data excluded from the analysis.

Qualitative Data

Qualitative data were obtained from two interview protocols used to guide semi-

structured interviews with participants. In addition, the researcher administered a

reflection prompt via email between interviews to each participant (see Appendix G),

conducted two observations of the support labs (see Appendix H), and collected

MyStatLab assignment reports and support lab attendance reports for each participant.

Instruments

Five randomly selected students from the underprepared group engaged in two

semi-structured, face-to-face interviews during the duration of the study. A sixth

randomly selected student participated in the first interview, but stopped attending class

and did not participate in the second interview. The interviews provided an opportunity

to reveal the meaning of peoples' experiences (Marshall & Rossman, 2015), in particular

the students' use of course materials throughout the semester and its impact on their

learning. Questions for the initial interview (see Appendix F) sought to develop an

understanding of the participants' familiarity with the available resources and the extent

to which they had applied them. Using a semi-structured interview offered the advantage

of allowing the researcher to ask follow-up questions that clarified the student's

perspective. Questions for the second interview (see Appendix I) aimed to explore any

changes that participants made in relation to their engagement in the course and its

possible impact. All interviews were taped using a digital audio recorder and hand-

written notes made during the interviews supplemented the recordings.

Procedures

To identify candidates for the interviews, the researcher contacted the instructors

of the Statistics courses after the first exam to collect a list of underprepared students

with their current course averages. These students were then divided into three

categories: those with an average below 60 (earning an F), those with an average from 60

to 79 (earning a D or C), and those with an average from 80 to 100 (earning a B or an A).

The researcher entered the students within each grade category into a spreadsheet and

assigned each record a number. A random number generator was applied to select three

students at a time from each category and potential participants were contacted via email

to schedule the initial interview. The researcher allowed four days for a response before

contacting the next randomly selected set of participants. As an incentive, students who

agreed to participate in both interviews were entered into a drawing for a $50 Amazon

gift card. By selecting students from three different grade ranges, a stratified purposeful

sampling (Creswell, 2013) was applied to facilitate comparisons between the subgroups

to determine how various course elements affected their learning outcomes.

Two students from each grade range were ultimately selected to participate in the

initial interview. Initial interviews were held from the tenth week through the thirteenth

week of the semester, at which point the first two tests had been given. After the first

interview was completed, each participant was sent a reflection prompt via email.

Responses were typed and hard copies delivered to the researcher's office. The purpose

of the reflection prompt was to maintain communication between interviews and allow

students an opportunity to assess their current level of understanding, including what

steps they would need to implement to best prepare them for the assessments at the end of

the semester. As previously indicated, one student stopped attending class and did not appear for the second interview; therefore, follow-up interviews occurred with the five remaining participants during the fifteenth and sixteenth weeks of the semester, at which point the three in-class tests had been given and participants were preparing to take the final exam. All interviews were held on Rossvale's campus in a conference room that allowed for privacy.

Data Analysis

The data analysis section is arranged around the three research questions that framed the study. Each question is listed below, followed by the analysis used to address the question.

1. Using final course averages, how do underprepared community college students in a redesigned co-requisite Statistics course compare to students deemed college-ready?

The first question was addressed using an analysis of covariance (ANCOVA), with the classification level serving as the independent variable and the final numerical course average as the dependent variable. The null hypothesis for the first question was as follows:

There is no significant difference in the final course average for underprepared students when compared with students who are college-ready, controlling for their high school grade point average.

Final course average data were entered into the Statistical Package for the Social Science (SPSS) software to test for statistically significant differences between the group means of the underprepared co-requisite students and their college-ready peers.

ANCOVA reduces error variance by controlling for a covariate that may have confounding effects on the dependent variable (Field, 2013). High school grade point average (GPA) was selected as the covariate due to its potential connection to students' performance in the co-requisite course. Students with higher high school GPAs and higher levels of mathematics courses completed had a greater likelihood of enrolling in a post-secondary institution and earning a college degree (Engberg & Wolniak, 2010). Although some have argued that high school GPAs have been skewed by grade inflation (Conley, 2007) and offer limited predictive value (Stephan, Davis, Lindsay, & Miller, 2015), other studies have shown that high school GPA is a strong and consistent predictor of college GPA as well as college credits earned (Belfield & Crosta, 2012; Hiss & Franks, 2014).

2. Using final course averages, how do community college students in a redesigned co-requisite Statistics course who are least-prepared compare to students classified as better-prepared?

The second research question was also addressed using ANCOVA, with the classification level serving as the independent variable and the final numerical course average as the dependent variable. Furthermore, high school GPA served as the covariate. The null hypothesis for the second question is as follows:

There is no significant difference in the final course average for least-prepared students when compared with better-prepared students, controlling for their high school grade point average.

Final course average data were entered into SPSS to test for statistically significant differences between the group means of the least-prepared co-requisite students and those identified as better-prepared within the underprepared sample.

3. What resources from a redesigned co-requisite Statistics course do underprepared community college students use and perceive to have a positive impact on their course experience?

The researcher used qualitative methods to analyze data from eleven semi-structured interviews among six participants. Each interview was transcribed, and notes were added within the transcriptions to incorporate the researcher's reflections. The researcher applied an open coding approach to generate categories of information (Creswell, 2013) associated with the resources identified by the participants. Three principal categories emerged after the initial analysis: the use of MyStatlLab, the role of the support lab, and the influence of the classroom instructor. After the three categories were classified, the researcher returned to the transcripts and used axial coding to identify specific strategies implemented by the participants and the context that influenced the strategies (Creswell, 2013). Specifically, the researcher examined each interviewee's data to find areas of agreement that helped explain how the resources were utilized, as well as differences that highlighted contrasting practices among the participants. The decision to use stratified purposeful sampling of participants from three different grade ranges for two interviews was to facilitate the development of a holistic revelatory case (Yin, 2014) for a redesign using a support lab as the co-requisite component. Including students from each grade range, along with the support lab observations and the

MyStatLab assessment reports, allowed for rich descriptions of the issues the participants encountered throughout the semester.

Issues of Trustworthiness

In qualitative research, trustworthiness is established by addressing the issues of credibility, transferability, dependability, and confirmability (Guba, 1981). These criteria are discussed in the following sections in the context of this study.

Credibility

Credibility focuses on the researcher's efforts to account for the complexities within the study so as to report accurate findings (Gay, Mills, & Airasian, 2011). To corroborate the participants' descriptions of the support lab, the researcher observed two different support labs. Detailed notes were taken during each observation on how students used their time in the lab, the instructor's role in providing assistance, and the interactions that occurred between the students and the instructor. Of the five participants who completed both interviews, four were in attendance during the lab observations. Furthermore, the researcher collected MyStatLab assessment reports for each participant to cross-check how they used the software platform for course assignments. The reports indicated how many attempts were used for quizzes and test reviews, as well as the amount of time spent on homework assignments and when they were completed in relation to the test dates.

Transferability

The criterion of transferability deals with giving the reader thorough descriptions of the study's context to permit possible comparisons with other contexts (Gay, Mills, & Airasian, 2011). The researcher attempted to satisfy this standard by producing an

overview of the research setting, detailed accounts of each participant's academic background, and comprehensive explanations of the participant's experiences in the course as communicated through their interviews and the support lab observations.

Dependability

Dependability, or the stability of the data (Guba, 1981), corresponds to the consistencies of the findings in relation to the data collected. As previously noted, multiple sources of data were used in an effort to practice triangulation. In addition, the researcher established an audit trail that included field notes from the support lab observations, interview transcriptions with reflective comments, and a journal that summarized the data collection procedures.

Confirmability

To address the issue of confirmability, it is important for the researcher to practice reflexivity in an attempt to preserve the objectivity of the data (Creswell, 2013). To that end, it is recommended that the researcher disclose any biases that may impact the study's results. In this case, the researcher is an Associate Professor at Rossvale Community College. The researcher, however, had never taught the co-requisite Statistics course under investigation and had no knowledge of the participants prior to the study.

Limitations of the Study

There were certain limitations inherent in the design of this mixed methods study. First, underprepared students were classified exclusively by academic skill and other causes were not considered, including issues related to study habits, motivation, time management, and personal factors that may have created academic interference. The

choice of using ACT and COMPASS scores for classification purposes was convenient and coincides with the criteria used by the community college for enrollment decisions. Second, the final course averages, which served as the dependent variable for the quantitative analysis, may be confounded by the fact that students could work assignments multiple times to raise their grade. Third, although course materials and assessments were uniform across all sections of Statistics, there were five different instructors across the fourteen sections and the quality of instruction may have varied among them. Responses from the interviews captured some of these differences, however the researcher did not conduct any observations of the classroom instructors.

Delimitations of the Study

Limitations related to location, course selection, and the choice of covariate were under the researcher's control. The community college used as the setting for this study may not be generalizable to other schools using a co-requisite redesign for a college-level course. Other institutions may employ a different co-requisite requirement in place of a support lab, such as enrollment in a remedial course, or implement an online course management system separate from MyStatLab. Furthermore, the quantitative component of the study only controlled for the effect of high school GPA on students' final course average and did not account for other factors that may affect performance such as class attendance or math anxiety.

Chapter Summary

A mixed methods research design was used in this study to examine how underprepared community college students perform in a co-requisite Statistics course that utilized a support lab. For the quantitative analysis, an ANCOVA was used to compare

underprepared and college-ready students on final course average, as well as compare

better-prepared and least-prepared students. To gain a deeper understanding of

underprepared students' experiences, five participants shared their insights during two

interviews. Additional data sources, including support lab observations and MyStatLab

reports, were used to corroborate themes that emerged from the interviews. Having

participants from multiple grade ranges helped develop a holistic case study of the

resources that shaped the students' involvement in the course and their understanding of

the content. The next chapter describes the data that was collected and the analyses used

to answer the research questions.

CHAPTER IV: RESULTS

Co-requisite models may offer a promising alternative to the traditional sequence of developmental mathematics courses in terms of overcoming challenges associated with retention (Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009) and success rates (Jaggars & Stacey, 2014). The direct immersion into college-level material under a co-requisite design hastens the time needed to complete degree requirements, but raises issues as to how the underprepared students will perform in an accelerated environment. In addition, it is important to consider the nature in which underprepared students utilize the resources available within the course to develop an understanding of the factors that shape their outcomes.

This study used statistical analyses to explore success rates of underprepared students, coupled with interviews of participants from that group to gain a deeper insight of their engagement in the course throughout the semester. This chapter begins with the quantitative analysis of the data, followed by the qualitative examination of the participants' semi-structured interviews, and concludes with an interpretation of the results through the lens of Activity Theory, the selected theoretical framework for the study.

Quantitative Analysis

An analysis of covariance (ANCOVA) was used to compare the final course averages between two groups in a redesigned co-requisite Statistics course: college-ready and underprepared students, and better-prepared and least-prepared students. This study applied a non-randomized controlled design because students were classified based on standardized test scores or prior coursework and could not be randomly assigned to

groups. The independent variable in each comparison was the classification level of each group, the dependent variable was the final course average, and the students' high school grade point average (GPA) served as the covariate.

Two hundred twenty-one students agreed to participate in the study, though two students were under the age of 18; so they were excluded. Of the 219 students, 22 received an FA (Failure, Attendance-related) grade, indicating that they had missed at least two consecutive weeks of class. These individuals were removed from the sample as they did not fully complete the course requirements. The remaining sample of 197 students consisted of 119 classified as college-ready, 48 classified as better-prepared, and 30 classified as least-prepared. Furthermore, six students did not have a high school GPA, five from the college-ready category and one from the least-prepared category; so they were excluded from the ANCOVA analysis.

Of the 119 college-ready participants, 28 had neither ACT nor COMPASS scores on file and 41 had an ACT or a COMPASS score that fell below the threshold for college-level classification. The researcher reviewed the transcripts of the 69 students to determine how they received college-level classification. Of the 28 that had no scores on file, six passed a developmental mathematics course at the community college where the study was conducted, 21 transferred in developmental mathematics credit or college-level mathematics credit from another institution, and one student completed the Seamless Alignment and Integrated Learning Support (SAILS) program in high school, which is a self-paced developmental mathematics curriculum designed to prepare students for college credit-bearing coursework. Of the 41 students with scores below the threshold, 15 completed SAILS, 16 passed a developmental mathematics course at the community

college where the study was conducted, six took a college-level course with a corresponding support lab at the study site, three transferred in developmental mathematics credit from another institution, and one transferred in college-level credit which overrode her COMPASS score. Thus, 69 of the 119 college-ready participants received this classification through means other than an ACT or a COMPASS score.

Final numerical course averages were recorded for the participants and applied to the following null hypotheses:

1. There is no significant difference in the final course average for students classified as college-ready in a co-requisite Statistics course when compared with students who are classified as underprepared, controlling for their high school grade point average.

2. There is no significant difference in the final course average for students classified as better-prepared in a co-requisite Statistics course when compared with students who are classified as least-prepared, controlling for their high school grade point average.

College-Ready vs. Underprepared Students

Table 2 shows the descriptive statistics for the three different classifications of students after the students with FA grades were removed, not adjusting for the covariate of high school GPA. Because six students did not have a high school GPA, the sample size for the ANCOVA analysis was reduced to 191, with 77 underprepared students and 114 college-ready students.

Table 2

Descriptive Statistics by Classification, not Including HS GPA

Classification	N	Mean	SD
Least-Prepared	30	63.12	18.48
Better-Prepared	48	76.39	16.85
College-Ready	119	78.15	18.75
Total	197	75.43	18.93

Prior to conducting the ANCOVA, SPSS was used to test the six assumptions of

the linear model. It was determined that the condition of independence of the covariate

(high school GPA) and treatment effect (classification) was violated. Field (2013) noted

that the independence condition is not a statistical requirement, but can impact the

interpretation of results. To get an understanding of the variance shared by the covariate

and the treatment effect, correlations were run between high school GPA and ACT and

COMPASS scores, yielding values of $r(108) = .387$ and $r(85) = .315$, respectively.

Given the relatively low values, it was decided to maintain high school GPA as the

covariate in the analysis.

An alpha level of .05 was used for all the statistical tests. Table 3 reveals the

adjusted final course averages for the underprepared and college-ready students when

controlling for high school GPA, along with the unadjusted standard deviations. Among

students in the co-requisite Statistics course, the final course average difference of 3.68

between underprepared and college-ready students was not statistically significant, $F(1,$

188) = 1.93, p = .167, 95% CI [-1.56, 8.93]. Therefore, the null hypothesis that there is

no significant difference in the final course average for underprepared and college-ready

students was not rejected. The covariate, high school GPA, was significantly related to

final course average, $F(1, 188) = 26.03$, $p < .001$. Further, there was a relatively small

effect with the two groups differing by a fifth of a standard deviation, $g = 0.20$.

Table 3

Adjusted Final Course Averages and Unadjusted Standard Deviations for

Underprepared and College-Ready Students

Classification	N	Mean	SD	Effect Size[a]
Underprepared	77	73.11	18.50	
College-Ready	114	76.79	19.03	
Total	191			0.20

[a]Effect size quantifies the difference between the college-ready and underprepared
students, with a positive value signifying the college-ready students scored higher.

Least-Prepared vs. Better-Prepared Students

Table 4 shows the adjusted final course averages for the better-prepared and least-

prepared students when controlling for high school GPA, along with the unadjusted

standard deviations. Among students in the co-requisite Statistics course, better-prepared

students had a higher final course average than those who were least-prepared. The final

course average difference of 11.46 was statistically significant, $F(1, 74) = 6.82$, $p = .011$,

95% CI [2.71, 20.19]. Therefore, the null hypothesis that there is no significant

difference in the final course average for better-prepared and least-prepared students was

rejected. The covariate, high school GPA, was not significantly related to final course

average, $F(1, 74) = 0.81$, $p = .372$. Further, there was a moderate effect with a difference

of over half a standard deviation between the two groups, $g = 0.65$.

Table 4

Adjusted Final Course Averages and Unadjusted Standard Deviations for Least-

Prepared and Better-Prepared Students

Classification	N	Mean	SD	Effect Size[a]
Least-Prepared	29	64.43	18.61	
Better-Prepared	48	75.89	16.85	
Total	77			0.65

[a]Effect size quantifies the difference between the better-prepared and least-prepared
students, with a positive value signifying the better-prepared students scored higher.

These results indicate that the least-prepared students exhibited a statistically

different level of performance from the better-prepared students, as measured by the final

course average. Furthermore, the better-prepared participants' scores created a

statistically non-significant difference in performance between the college-ready and

underprepared samples. Thus, the students at the higher end of the underprepared

spectrum had similar outcomes to those who were deemed college-ready. The next

section qualitatively examines the resources that some of the underprepared students

identified as having an impact on their learning experience.

Qualitative Sample

After the first test, there were 103 underprepared students that I divided into three

groups based on their current course average: Group 1 consisted of students with a course

average below 60, Group 2 consisted of students with a course average ranging from 60

to 79, and Group 3 consisted of students with a course average ranging from 80 to 100.

Two students from each group were then randomly selected to participate in two semi-

structured interviews to help identify resources from the course that impacted their

learning experience. Upon starting data analysis, I assigned pseudonyms to each

participant to protect their identities. Group 1 was comprised of Natalie and Beth, Group

2 was comprised of Katina and Danielle, and Group 3 was comprised of Casey and Tim.

During the interviews, I asked each participant to identify the last mathematics

course they had taken prior to the co-requisite Statistics to get a better understanding of

their background coming into the course. Furthermore, I analyzed the MyStatLab

gradebook reports for each interviewee to determine the number of attempts utilized on

quizzes, the amount of time spent on assignments, and whether the optional review

homework and quizzes for tests and the Final Exam were completed. The following

section includes a description of each participant organized by their group classification.

Group 1

Natalie. Natalie was an African American female who was 19 years old and

majoring in Pre-Nursing. In 2015, she completed the Seamless Alignment and Integrated

Learning Support (SAILS) program in high school. She was classified as better-prepared

based on an ACT Mathematics sub-score of 17. This was her second time taking the

Statistics course as she had failed it the previous semester. As a result of having gone

through the course once before, Natalie was comfortable with the MyStatLab platform

for completing course assignments. Her lecture class met Mondays, Wednesdays, and

Fridays for 55 minutes each day, while her support lab met Tuesdays from 2:30 to 4:30

p.m. After Test 1 she had a course average of 35, but finished the semester with a course

average of 82, earning a B in the class. Of the 12 quizzes in MyStatLab, Natalie used at least two attempts on nine quizzes. Furthermore, she completed the Review Quiz for Tests 1 and 3 as well as both the Review Quiz and the Review Homework for the Final Exam.

Beth. Beth was an African American female who was 19 years old, majoring in Pre-Health Professions. The last mathematics course that she took prior to Statistics was Algebra II in high school in 2015. Beth was classified as better-prepared based on an ACT Mathematics sub-score of 16. When she arrived for the first interview, she indicated that she was planning on withdrawing from the course due to time constraints that she faced balancing her job and three other classes. However, the deadline to withdraw had already passed by the time she made this decision. Her lecture class met Thursdays from 6 to 9 p.m. and her support lab met Tuesdays from 6 to 8 p.m. After Test 1, Beth had a course average of 55. She did not attend class or complete any assignments, though, after the ninth week of the semester, resulting in a final course average of 17 and an FA (Failure, Attendance-related) grade. Within MyStatLab, she only completed one quiz and four of the thirteen homework assignments. Two attempts were made to conduct the second interview, but Beth did not show up for either of the appointments.

Group 2

Katina. Katina was an African American female who was 18 years old, majoring in Speech Communication. Her last mathematics class was Algebra II, which she took as a senior in high school in 2015. She was classified as least-prepared based on an ACT Mathematics sub-score of 14. Katina was enrolled in a lecture class that met on Tuesdays

and Thursdays from 12:30 – 1:50 p.m., and her support lab met Tuesdays from 2:30 – 4:30 p.m. After Test 1 her course average was 76, and she finished the semester with a course average of 67, earning a D in the class. Of the 12 quizzes in MyStatLab, she used at least two attempts on three quizzes and did not take one quiz. An analysis of the time logs for MyStatLab showed that five of the seven required assignments for Test 2 were attempted the morning of the test and she averaged a 57 on these assignments. Katina attempted the optional Review Homework for the Final Exam, but only spent 25 minutes on the assignment.

     Danielle. Danielle was an African American female who was 37 years old, majoring in Health Sciences. The last mathematics course that she took was Algebra II in 1997 when she was in high school. Danielle was classified as least-prepared based on a COMPASS Math score of 17. Having been out of school for 20 years, she described the process of getting accustomed to the MyStatLab software as "overloading" (Interview 2, December 8, 2016). Danielle was originally enrolled in a day section for both the lecture and support lab classes, but due to a scheduling change with her job, she switched to a lecture class that met Thursday nights from 6 to 9 p.m. and a support lab that met Tuesday nights from 6 to 8 p.m. When she switched sections, her Statistics instructor remained the same, but her support lab instructor changed. Due to a misunderstanding about when the schedule change went into effect, she missed Test 2 and had to use the score on the Final Exam to replace that missed test. Her course average after Test 1 was 63 and she finished the semester with a course average of 60, earning a D in the class. Of the 12 quizzes in MyStatLab, she used at least two attempts on three quizzes and did not take five quizzes. For the optional test review assignments, Danielle opened the Review

Quiz for Test 1 but never completed it, and she attempted the Review Homework for the

Final Exam.

Group 3

   Casey. Casey was a white male who was 32 years old and majoring in Pre-

Nursing. He had not been in a college classroom since 2005 and Geometry was the last

mathematics course he took as a high school senior in 2002. Casey was classified as

better-prepared based on a COMPASS Math score of 22. Prior to returning to college, he

served in the military as an intelligence analyst. Casey was enrolled in the Statistics

course one night a week for three hours, with the support lab meeting in the afternoon for

two hours prior to his night class. After the first test, he had a course average of 90 and

finished the semester with the same average, hence earning an A in the class. Of the 12

quizzes in MyStatLab, where three attempts were allowed for each quiz, he used at least

two attempts on seven quizzes. For the optional test review materials posted in

MyStatLab, Casey completed the Review Quiz for Test 1 and the Review Homework for

the Final Exam, the latter of which he indicated prepared him very well for the Final

Exam.

   Tim. Tim was a white male who was 28 years old, pursuing an Associate's degree

in Pre-Health Professions. His last reported mathematics class was AP Statistics, which

he took as a high school senior in 2006. He was classified as better-prepared based on a

COMPASS Math score of 23. During the interview, he indicated that he has a

background in gaming, including playing poker, backgammon, and fantasy sports. These

activities provided some familiarity with probability and statistics, which diminished any

anxiety that he may have had enrolling in a college Statistics course. Tim's lecture class

met Mondays, Wednesdays, and Fridays for 55 minutes each day, and his support lab met

Tuesday mornings from 8 to 10 a.m. His course average after Test 1 was 100 and he

finished the semester with a course average of 99, earning an A in the class. Of the 12

quizzes in MyStatLab, he used at least two attempts on four quizzes, and for the optional

test review material, he completed both the Review Homework and the Review Quiz for

the Final Exam.

Table 5 provides an overview of the six interviewees based on their group

membership.

Table 5

Demographic Data of the Interviewees

Group	Name	Age	Ethnicity	Gender	Classification	Final Course Grade
1	Natalie	19	African-American	Female	Better-Prepared	B
	Beth	19	African-American	Female	Better-Prepared	FA
2	Katina	18	African-American	Female	Least-Prepared	D
	Danielle	37	African-American	Female	Least-Prepared	D
3	Casey	32	White	Male	Better-Prepared	A
	Tim	28	White	Male	Better-Prepared	A

Three prominent themes emerged from the interviews that illustrated the impact

of various resources on the participants' course experience: the use of MyStatLab for

homework and quizzes, the effect of the support lab and the lab instructor, and the role of the classroom instructor. These themes are presented in the following sections from the interviewees' perspectives.

MyStatLab

In both interviews, the researcher asked the participants to discuss their perception of the software, MyStatLab, including its usefulness in completing the homework and quiz assignments. They identified two components related to the positive impact that the software had on their learning experience: the learning aids' capacity to provide step-by-step explanations of homework exercises and the opportunity to rework questions multiple times to strengthen one's understanding. The latter factor was cited as beneficial for both completing the mandatory homework and quizzes as well as preparing for tests. Some obstacles associated with how MyStatLab addressed the use of technology within certain applications were also raised, along with a potential suggestion for improving the course. These issues are discussed in the subsequent sections by reflecting on the participants' experiences within the course.

Learning Aids

The two learning aids most often cited as providing a benefit to completing course assignments were *View an Example* and *Help Me Solve This*. Each resource offered assistance while students were completing homework questions or reviewing a submitted quiz, with *View an Example* giving a sample exercise to illustrate the concept being assessed and *Help Me Solve This* guiding students through the solution to the problem at hand. In each case, the level of detail within the explanations was a critical component in helping students maintain progress. The researcher opened the initial interview by

asking, "How useful have you found MyStatLab for doing the homework and the quiz assignments?" Casey's response follows.

> Casey: It's awesome when it comes to, uh, the question help that is available
> while you're doing the problems. It's step-by-step and it, it's actually helped me
> learn the criteria on my own, not even having to look towards doing any solutions
> or anything else like that in the book, as well as I'm learning it. [October 31,
> 2016]

Beth echoed these sentiments by remarking, "It breaks it [homework questions] down for you very thoroughly, like how to do step 1, exactly how to do step 2, how to do step 3" (Interview 1, October 28, 2016). Katina indicated that the MyStatLab learning aids "really break down one by one exactly what I need to do," (Interview 1, November 15, 2016) and later expounded further on its impact in helping her prepare for tests:

> Katina: It's [MyStatLab] like a home tutor basically. It just breaks down what
> you need to know, how you need to do it, like step-by-step in order to like
> succeed for the tests and quizzes and stuff like that. [Interview 2, December 8,
> 2016]

Part of the perceived benefit of MyStatLab's learning aids in preparing Katina for the tests may stem from her ability to take notes off the computer-generated examples. During both interviews, she mentioned that she was diligent about generating a written copy of the solutions to exercises on which she solicited help that she could reference later if needed.

Beyond the opportunity to take notes from the comprehensive explanations, the *Help Me Solve This* feature had the added value of requiring students to enter answers

into MyStatLab within the breakdown of the exercise as a means for checking their work. When asked if she found one of the learning aids, *View an Example* or *Help Me Solve This*, more beneficial than the other, Natalie identified *Help Me Solve This* because she had to figure out parts of the problem for herself before being able to proceed further. Danielle also picked *Help Me Solve This* as the more beneficial resource as it combined features of *View an Example* with the chance to check her understanding:

> Danielle: It [*Help Me Solve This*] gives you like more of a breakdown of an
>
> example and it allows you to interact and help answer the question, so that you
>
> can try to get it right. So when it gives you the same question…but a different
>
> scenario…you learn from that example, from the *Help Me Solve* [*This*], and then
>
> you can do that problem to get it right. [Interview 1, November 10, 2016]

Repeated Question Attempts

Within MyStatLab, students are allowed three attempts at each homework question before it is marked wrong. After each incorrect attempt, a hint is provided to assist the student prior to entering the next answer. If the correct answer is not entered by the third attempt, there is an option to work a similar exercise to receive full credit for the question. Quizzes must be worked to completion and submitted before questions are graded, but students are then afforded the chance to review the assignment and have two additional attempts to raise their grade.

In the first interview, Tim rated MyStatLab a 9 out of 10 in part because he could retake problems to both raise his grade and solidify his understanding. Particularly when preparing for Test 1, he made sure that he achieved 100% on each homework assignment

and used all three attempts on the first three quizzes. He described how he followed the advice of his teacher on how to space out the multiple quiz attempts prior to the test:

> Tim: So a few weeks before the test…one thing the teacher recommends is you could take it [a quiz], take it a couple of times with the book and then maybe the night before the test just try the quizzes without the book. Like the second time I took it [Quiz 1], I just did it without the book and I still got a 100 on it. So, but I still wanted to take it a third time just to make sure I knew [the content] exactly.
>
> [Interview 1, October 25, 2016]

Natalie, Casey, and Tim all identified taking the first three quizzes multiple times to prepare them for the first test. Although Tim only used multiple attempts on one quiz after Test 1, he finished the course with the highest average of those interviewed. The two students who finished the course with the next highest averages, Casey and Natalie, used multiple attempts seven and nine times, respectively, on the 12 quizzes. Alternatively, Katina and Danielle each used multiple attempts on only three of the 12 quizzes and missed six quizzes combined.

Danielle acknowledged during the second interview that having to juggle the responsibilities of being a single parent, working, and attending classes made it difficult to stay on schedule with course assignments. When doing homework, she felt like she could at least gain an initial understanding of the problems by reworking them, if necessary: "Even if I had to repeat it over and over to get it right, that's the one thing I did like about the homework 'cause [*sic*] you could always go back and do it over" (Interview 2, December 8, 2016). According to Danielle, though, her comprehension faded as she would often go at least three days without practicing any material. Casey,

too, pointed to consistent practice as being the key to understanding the homework, frequently using the phrase, "repetition, repetition, repetition" (Interview 1, October 31, 2016). From his perspective, the tools in MyStatLab modeled the way students should develop mathematical proficiency: "You can't just, you know, do one problem and say, 'Oh, I'm done, 'cause [*sic*] it's something that you're gonna [*sic*] be doing consistently if you ever have to it…and that's how math people succeed (laughs)" (Interview 2, November 28, 2016).

Within MyStatLab, there were 12 quizzes and 12 homework assignments, each comprising 10% of the course grade. Given that a student could attempt each quiz three times and the homework problems an unlimited number of times prior to the due date, Tim observed that this reduced the stress normally associated with a quiz. In a traditional setting, a quiz may be administered in-class with a time limit and if there is only one attempt, it may be perceived as a high stakes assessment which raises one's anxiety level. Under the course redesign, however, each quiz is worth a relatively small percentage of the overall grade and with multiple attempts available, Tim therefore viewed the quizzes as a means to reinforce the content rather than obsessing about the grade on a single try.

Technology Obstacle

MyStatLab received very positive reviews among the six interviewees for how they believed the software could support their learning. Some issues with the software, though, were raised by Casey, Katina, and Danielle based on material they were studying towards the end of the course. In the reflection prompt administered between the two interviews, participants were asked to consider any obstacles they may have faced in the course and how they addressed them. Casey explained that several examples in

MyStatLab associated with hypothesis testing relied on technology to calculate a test statistic without showing the calculator commands used to generate the result. Instead, *View an Example* has the phrase, "use technology to determine the test statistic," built in to its solution explanation before providing the answer. During the second interview, Casey stated that since his support lab met prior to the lecture, and this was typically when he did his homework, he sometimes grew frustrated as he had to suspend his work until he learned the necessary calculator commands in class.

Katina faced a similar obstacle in that she struggled to translate the wording in the hypothesis test questions "to know which test to use and which formula to use," (Interview 2, December 8, 2016) and this was further compounded when MyStatLab "didn't necessarily tell you what test in statistics to use on there" (Interview 2, December 8, 2016). As a suggestion for improving the course, Danielle recommend that a "Calculator Function" (Interview 2, December 8, 2016) learning aid be added to appropriate homework questions that would show students how to run the statistical tests in the calculator. Implementing such a change, however, may not be feasible given that the software is marketed to schools across the country that may be using a variety of technology platforms.

Support Lab

Every student enrolled in the co-requisite Statistics course who was classified as underprepared was required to register in a support lab that met once a week for two hours. Although the course syllabus communicated mandatory attendance in the lab, the grading system in the lab featured pass/fail. It linked directly to the Statistics course; that is, a passing grade in the Statistics course produced a passing grade in the lab and failing

the course translated into failing the lab. All the interviewees had a different lab instructor from their classroom instructor. Three themes emerged from the interviews that participants identified as affecting their experience in the course. First, the support lab acted as a time management mechanism that some students used to facilitate completing course assignments. Second, certain participants used the dedicated time in the lab to work ahead of the pacing schedule in the lecture, though attendance was an issue for those not taking advantage of this opportunity. Third, the assistance provided by the support lab instructor was primarily viewed as an asset, however the emphasis given for the explanations of particular applications differed from the classroom instructor in a fundamental way. Each of these factors are discussed in the following sections within the context of the participants' interviews.

Time Management

The Statistics syllabus cautioned students not to wait until the last minute to complete course assignments as they could encounter technical difficulties or run out of time as they attempted to submit their work. Furthermore, with firm deadlines on homework and quizzes, the syllabus warned students that putting off course work would diminish the potential learning effect and hamper their success in the class. For Natalie, Tim, and Casey, the support lab addressed these points by helping them set aside a dedicated time for their Statistics work. Reflecting upon her experience in the course, Natalie opined that she would not have been as successful without the support lab requirement:

> Natalie: I don't think I would have took [*sic*] the time out to do the homework as much as I did with the class because I had more time, and I had like two hours

versus if I was at home, I would procrastinate and like wait until like it was the

day before it was due to try to do all of it. [Interview 2, December 2, 2016]

Tim also described himself as a procrastinator and with a busy schedule balancing

both a job and school, he was grateful to have two hours each week where he could focus

solely on academics. He deliberately only took two classes during the semester in which

he enrolled in Statistics because he had been out of school for several years and was

concerned about his ability to manage the work load. The support lab had such a positive

effect on his ability to properly budget his time that he went one step further by

discussing plans to incorporate a lab-like structure into his future schedule:

> Tim: I'm looking to take maybe like four more classes…next semester and I
>
> think…the idea of just having those two hours, you know, every week, you're
>
> always gonna [*sic*] work on this subject for those two hours every week. I won't
>
> be in class for it, but just on my own, I'm gonna [*sic*] try to set out two, two or
>
> three or four hours every week to work on one subject. [Interview 1, October 25,
>
> 2016]

Classified as a full-time student, Casey enrolled in 13 hours during the fall

semester, including the support lab. He intentionally registered for the support lab that

met in the afternoon prior to his Statistics evening class so the information gained in the

lab would likely get reinforced immediately in the lecture. Having a two-hour block in

his schedule every week meant he could concentrate on homework during that period

without having to consciously carve out time to work on math. The support lab helped

strengthen Casey's level of preparation as he used MyStatLab to practice homework questions repeatedly, which he felt gave him an advantage over some of his peers: "A lot of people, they'll wait til [*sic*] the very end, um, do the homework real quick and then they'll go take a test, which is not necessarily the best thing to do" (Interview 1, October 31, 2016). Casey was self-disciplined, due in part perhaps to his military background, as he stated that he devoted time outside the lab to work on assignments, particularly quizzes. By completing the quizzes at home, he knew he could then dedicate the lab time for homework or test reviews.

Ahead of Schedule

As a part of the interview process, the researcher asked the participants how they primarily spent their time while in the lab. The three students who finished with the highest course averages among the interviewees – Natalie, Tim, and Casey – all indicated that they utilized the lab to complete chapter assessments beyond what had previously been taught in class and considered the impact that it had on their success in the course. Beyond the lab serving as a tool for properly managing their time, these three students primarily maximized their time in the lab by staying ahead of schedule. For some others that did not take advantage of this opportunity, attendance and motivation may explain their actions.

Natalie was in a situation where her Statistics course met every Monday, Wednesday, and Friday, with her lab set on Tuesdays. She was also repeating the course; so compared to her peers, she may have had an added benefit in that she had a measure of familiarity with the content prior to opening an assignment. During the initial interview, Natalie described using the lab to stay on pace with her lecture class:

Natalie: Like I get most of my homework done and then it gets me prepared for

when I go to class and we start on a new chapter and I already know the stuff

from the previous chapter because of the class [lab]. [November 4, 2016]

When asked to reflect on her experience in the lab over the course of the entire semester

in the follow-up interview, there was a subtle shift in her response:

Natalie: I was ahead like just because I had a class, a support class, and I could do

like the homework and stuff in class. 'Cause [*sic*] when I asked other people who

didn't have the class [lab], they were still on like a chapter or two behind, versus

me where I was on the right chapters, starting on the next one. [December 2,

2016]

Throughout the researcher's observation of Natalie's support lab, she reviewed a quiz

that had been previously taken, retook the quiz, and then started on the homework for the

next chapter. She worked independently, though sought help from the lab instructor

while reviewing her quiz. Although Natalie was on her cell phone a few times to view

text messages, she stayed in the lab for the full two hours and primarily remained on task.

In contrast, Katina had her support lab on Tuesday afternoons, directly after her

Statistics course which met twice a week on Tuesdays and Thursdays. When asked in the

second interview about the effect the lab had on her ability to stay current or ahead on the

homework assignments, her reply revealed an attitude of indifference about the lab's

importance: "I really wish like after I got done with like certain material that I could've

like left, but like once you're in the class, like you're in there, like you can't leave,

really" (Interview 2, December 8, 2016). She admitted that she did not attend the lab

regularly, showing up eight times over a 15-week semester, as she opted to visit the

tutoring center in the library during some of the lab times. Part of her rationale for this decision was that there was only one lab instructor available, as compared to multiple tutors in the library, which could make it more difficult to get immediate assistance in the lab. However, on the day that Katina's support lab was observed, only 8 of 19 students were in attendance and the instructor circulated around the room multiple times inquiring if anyone needed help.

Attendance, in general, was an issue with the support lab. Tim corroborated the problem with attendance in his own lab, noting that typically only six or seven students, including himself, were present on a regular basis. Some of this may be explained by students recognizing that their participation in the lab would not directly affect their lab grade as that was controlled by their grade in the Statistics course. Regardless, the interviewees who used that time to work ahead experienced tangible benefits as illustrated in the following section.

Casey was the only participant who enrolled in a Statistics class that met one night a week and had his support lab on the same day as the lecture. He outlined why this was a successful formula for him when thinking back about his lab experience during the second interview:

Casey: Having the support learning prior to actually going to your class, like same day, has been the easiest experience for me. And that's why I've shown more efficiency when it comes to test days because I already know the material going in. I know people that do their support learning on a different day than going into the class and it, it's like they're not learning it. And that's 'cause [*sic*] they don't

have that consistency. I learn it, then it's verified [in the lecture], and then I'm off

to do my next chapter and it's really nice that way. [November 28, 2016]

Casey's previous comments about the learning aids in MyStatLab breaking down

solution explanations in a step-by-step fashion, coupled with the structured schedule of

the lab each week, enabled him to work beyond the material taught by the classroom

instructor the week before. The homework associated with the new concepts he

attempted in the lab could then get reinforced in lecture the same night or any questions

that may have arisen from the assignments could be brought to class and resolved

immediately. Casey never missed a lab session and his diligent study habits kept him

ahead of schedule throughout the term.

Along with building confidence in his understanding by practicing homework

assignments prior to class, Casey could solidify that understanding by explaining what he

had learned to one of his peers. Casey and his best friend had the same course schedule

and sat next to one another in the support lab. As previously noted, to optimize his time

in the lab Casey finished his quizzes at home so that lab time could be dedicated to

homework and assisting his friend, if needed. This collaboration was witnessed during

the researcher's lab observation, as Casey and his friend communicated frequently

throughout the period. Casey was one chapter ahead of his friend on the homework, but

offered help on multiple occasions. Furthermore, he initiated a discussion with his

classmate on a question that he missed on his own assignment, presumably to see if his

friend had any insights, but it may also have afforded him the chance to explain his

thought process to make sense of his logic. When the researcher asked Casey about the

collaboration in the lab, he summarized it as follows:

Casey: I'm getting that repetition. His numbers that are in the problem are gonna [*sic*] be different than what I had, so it's just, it's literally me doing another problem in the same format. So I'm learning while teaching him at the same time. I'm getting that repetition that's gonna [*sic*] help me understand. [Interview 2, November 28, 2016]

Tim also identified as having used the lab some to work ahead, though not as consistently as Casey. His background in gaming and fantasy sports, which provided him some familiarity with probability and statistics, may have made the introductory course material easier to grasp. As the material progressed into hypothesis testing and became more challenging, however, he made a concerted effort to stay ahead, explaining his motivation during the second interview:

Tim: I would say you always understand more when you have experienced the [*sic*] what you're talking about beforehand. Some of the stuff like the hypothesis test, it's a lot of information, so it's hard to take it all in right when the teacher is telling you all this. So, if you were like taking some time in the lab or just on your own to try to get ahead on the harder chapters, it's definitely beneficial for your performance in class. [November 30, 2016]

Tim missed the support lab three times, and was not present when the researcher conducted his observation. He conceded that early in the semester he would leave the lab early once he had completed the chapter homework, but felt that it did not set him back as he had a solid understanding of the initial chapters. Based on his overall performance in the course, as well as his aforementioned comments about how the lab helped manage his

time, Tim came to recognize the value of the support lab and used it wisely to strengthen his understanding.

Support Lab Instructor

There were nine sections of the Statistics support lab led by three different instructors. All the interviewees had a different lab instructor from their classroom instructor. The researcher assigned pseudonyms to each support lab instructor. Danielle and Beth attended a lab run by Ms. Emerson, whereas Casey, Tim, Katina, and Natalie were enrolled in labs facilitated by Mr. Humphries.

Ms. Emerson. I observed Ms. Emerson's lab on a Tuesday evening. Four students were already present in the lab prior to her arrival, signed in to MyStatLab and working on course assignments. The lab was comprised of 25 student computer stations, with 16 computers situated on four rows of tables, 9 computers arranged along two walls of the room, and a desk with a computer at the front of the room for the instructor. Shortly after Ms. Emerson's arrival, she proceeded to draw a table on the whiteboard with symbols for sample and population measures that would be referenced later in class when helping students with their homework questions. In addition, she sketched a graph of a normal distribution with corresponding probabilities inserted. Several minutes thereafter as students were deep into their homework or quizzes, she went to a separate whiteboard to outline the possible wording that could appear in null and alternative hypotheses for hypothesis testing.

A total of nine students attended the lab and the atmosphere was lively as students communicated freely with both the instructor and their peers when seeking assistance. The classroom norm appeared to establish peers as equals in the learning

process as collaboration was common throughout the period. Students discussed the

progress of homework assignments with each other, offering motivation to remain on

task. At one point a student who just completed a homework question rotated to the first

row of work stations to show another student how to solve that exercise on the calculator.

Moments later, a different student from the first row shifted to the second row to answer

a question for a classmate. When Ms. Emerson was called upon for help, she would

answer questions individually as well as use the whiteboard to illustrate various concepts

to the whole lab. Although Beth was not in attendance when the observation took place,

she referenced the positive atmosphere in her interview:

> Beth: We all feel like a team and a family. If we don't get something, we have a
>
> group discussion or she writes it on the board, "Hey, step by step, this is this and
>
> this is what you guys need to do. Let's write notes, we're gonna [*sic*] get through
>
> this." It's always great, it's a great feeling going into that class. [Interview 1,
>
> October 28, 2016]

Early in the lab session, Ms. Emerson offered to download apps on to the students'

graphing calculators that would make computations easier. Later, she announced to the

class, "You will need to know these calculator apps for the test. Ask me questions! I can

show you how to do this on the calculator." Ms. Emerson was very patient when

answering questions and many of the explanations focused on how to execute calculator

commands to solve problems. Danielle voiced support for the technology demonstrations

in the lab, commenting during the second interview, "My support teacher showed us a

shortcut way, versus my [classroom] instructor showing the long drawn out way (laughs).

So it was like I got the best of both worlds to learn to do both" (Interview 2, December 8, 2016).

Danielle did not begin the semester in Ms. Emerson's lab. A conflict with her work schedule required her to switch both her classroom and lab sections about midway through the semester to offerings that met in the evenings. Prior to the schedule change, Danielle missed the support lab three times due to a family emergency as well as frustration with the first lab instructor's teaching style. She complained that too many times the steps demonstrated to solve an exercise followed "the long drawn out way" (Interview 2, December 8, 2016), similar to the classroom instruction, and she preferred to be shown an "easier way to get this understanding" (Interview 2, December 8, 2016). Ms. Emerson's lab had a profound effect on Danielle's motivation as detailed in her response to a question in the first interview about any changes in her attendance after the transition:

> Danielle: I'm more like, I gotta [*sic*] go to class 'cause [*sic*] I know that once I get there, I know she's gonna [*sic*] be willing to help. I know it's gonna [*sic*] be examples on the board, I know it's gonna [*sic*] be a handout paper she's gonna [*sic*] hand out that I don't want to miss so that I could try to work on the problems at home. Like it, it has me more interested in trying to learn statistical math, when at first it was like I, I'm not really gonna [*sic*] use this when I'm out of class. [November 10, 2016]

Danielle only missed one meeting after moving to Ms. Emerson's lab. She worked individually on a quiz the night of the researcher's observation and solicited Ms. Emerson's help to review the quiz prior to initiating a second attempt. Thinking about

the support lab at the conclusion of the second interview, Danielle communicated

appreciation for the level of attention and engagement she received there and speculated

that she would have withdrawn from the Statistics course if the lab was not an available

resource.

Mr. Humphries. The researcher observed Mr. Humphries' support lab on a

Tuesday afternoon and nine students were present, including Katina, Casey, and Natalie.

The lab consisted of 20 computer stations which lined three walls of a rectangular

classroom; and a desk with a computer was at the front of the room for the instructor.

Students primarily worked individually at their stations, though Casey and his best friend

periodically communicated with each other during the session about homework

problems. When the researcher entered the lab, Mr. Humphries was seated at his desk

doing work on his computer. About every 25 minutes he would circulate around the lab,

inquiring if individual students needed help. When helping someone, he would sit next to

the person and, if needed, use their notebook to write down information to coincide with

his explanation. He often employed a Socratic method approach by prompting the

student with questions, such as, "Is it a one-tail or two-tail test? Right-tail or left-tail?" as

he guided the person through the solution.

As Mr. Humphries walked by, Casey indicated that he was getting the correct

answers to the questions associated with hypothesis testing, but did not understand some

of the conceptual basis behind the topic. The lab instructor proceeded to explain the

meaning of the null and alternative hypotheses, with Casey actively providing feedback

as they progressed through an example. Some clarification was sought on right-tail tests

and two-tailed tests, with the discussion lasting about five minutes. When Mr.

Humphries finished, Casey said, "You definitely explained a lot more than I was understanding previously." The ability to receive personalized assistance was one of the positive attributes of the lab that Casey highlighted during the first interview: "Being in the support learning for this [class] has made this [content] amazingly easy 'cause [*sic*], like I said, it's like having a tutor there anytime you have a specific question that you just don't quite understand" (October 31, 2016).

Towards the end of the lab session, Casey answered a homework question incorrectly, after which he referenced the *View an Example* learning aid multiple times along with pre-printed notes that he had with him. He expressed his frustration to Mr. Humphries about hypothesis testing, stating, "I guess I'll have to wait until class to understand this as the material just seems to jump around." Mr. Humphries sat down with him to discuss critical values in relation to the type of test being used. When they were done, Casey thanked him and stated, "Ok, now I'm starting to get it." Casey was the only interviewee that sought the instructor's help during the researcher's observation. Mr. Humphries asked if Katina or Natalie needed any assistance on multiple occasions, including after Natalie had completed a quiz, but both politely declined.

Emphasis of Explanations

As a part of each interview, the participants were asked to compare the instruction they received in the support lab and the classroom. Natalie drew a distinction between the two:

Natalie: The class [lab] instructor tells us like what [calculator] program to use or just…what formula to use…but with the instructor in my regular class, he would

just go step by step on how to get into the formula and how to plug it in to the

calculator, and also how to do it by hand. [Interview 1, November 4, 2016]

In the midst of the second interview as Casey described the struggles he encountered with

some of the hypothesis testing applications that utilized the graphing calculator for the

solutions, he offered a similar sentiment to Natalie's comment above:

Casey: It's [explanations from the support lab instructor] pretty much like…a

quick fix. The instructor…knew what he was talking about, but I wasn't able to

technically fully comprehend what was going on, or I understand what you had

me do, but I don't understand why you had me do it. That's where the lecture

came in…because he [classroom instructor] does it more than one time, you

know, and…as he's doing a problem it's a lot easier explained [*sic*]. [November

28, 2016]

Casey was quick to clarify that he was not being critical of the support lab instructor,

adding, "Having 20 people and having to assist them all, he is limited on the ability to go

into detail as much as a professor can when he's doing his lecture" (Interview 2,

November 28, 2016).

In general, the feedback on the support lab and the instruction received was very

positive, but these reflections appear to mark a difference in the emphasis of the

explanations between the support lab and classroom. Casey's phrase "quick fix"

(Interview 2, November 28, 2016) aligns with a setting where the lab promoted

developing procedural fluency, whereas Natalie's remark about the lecture paints a

picture where conceptual understanding was given greater attention. Although this was

not necessarily evident throughout the researcher's observation of Mr. Humphries' lab,

Ms. Emerson's lab clearly displayed the importance of using the calculator to solve homework and quiz questions, prompting Danielle to term it the "shortcut method" (Interview 2, December 8, 2016). Both Casey and Danielle recognized the balance between the two deliveries, with Danielle saying she had the "best of both worlds" (Interview 2, December 8, 2016) and Casey referring to the lab and lecture as two sources that could solidify his understanding.

Classroom Instructor

Towards the conclusion of the second interview, participants were asked to identify what aspect of the course, if any, had the greatest benefit in helping them learn the course content. Natalie, Tim, and Casey each named their classroom teacher as the resource that had the biggest impact on their learning experience, while Danielle said it was a tie between her classroom teacher and support lab instructor. Coincidentally, they all had different classroom instructors and offered varied reasons for their responses, including detailed explanations within the lecture, increased motivation via communication of course design, effective test reviews, and a topic's blend of its conceptual details with the necessary technology manipulation when appropriate. Pseudonyms are used for the classroom instructors in the subsequent sections.

Connection with MyStatLab

One of the prevalent features of MyStatLab's learning aids that the interviewees lauded was the level of detail given in the solution explanations. Similarly, both Natalie and Danielle felt like their classroom instructors' ability to break down the content into easy-to-follow steps enhanced their understanding. Natalie said she had difficulty connecting to her teacher in the previous semester when she failed the course as it

consisted of "just a lot of notes on the board," (Interview 2, December 2, 2016) whereas her current professor kept her engaged through an organized presentation of the material combined with elements of active learning:

> Natalie: This teacher that I have now, he goes through and he explains the steps and then if we don't get it, he goes back and then he explains it until like we understand it. And then we…work through the problems together, we don't just write the notes down. [Interview 1, November 4, 2016]

She described course content as being introduced through whole class discussions of problem-solving strategies for exercises taken from weekly worksheets created by the teacher.

Danielle also praised her classroom instructor, Mr. Ingram, for the guidance he extended when presenting course material:

> Danielle: One thing I like about Mr. Ingram is that he, he details every example. He's like one of those Help Me Solve problems too. Like he'll detail everything, he'll go through it step by step and it makes it easier for me to do my homework. [Interview 1, November 10, 2016]

She qualified her comment, however, by adding, "But when I learn a shortcut on the calculator, that makes it go faster" (Interview 1, November 10, 2016). Her support lab instructor clearly put a priority on using the graphing calculator to solve exercises whereas Mr. Ingram stressed the process required to arrive at a solution. Her desire to generate answers in an expeditious manner may have come at the expense of developing a foundation for conceptual knowledge, which could explain some of the difficulties she faced retaining the content when it came time to take the tests.

Motivational Attributes

Similar to Natalie and Danielle, Tim was very complimentary of his classroom instructor's teaching style, labeling Ms. Owens as "absolutely excellent" (Interview 2, November 30, 2016). In particular, he credited her with having a "ton of personality" (Interview 2, November 30, 2016), which helped capture and maintain his attention, coupled with her ability to clearly explain complex course topics. Ms. Owens had an extensive background in the field, having obtained a terminal degree in Statistics combined with over a decade's worth of teaching experience. Beyond the experience in the classroom, Tim was impressed with how consistently she communicated with her students outside of class by e-mailing them reminders about due dates for upcoming assignments, handouts that supplemented their course notes, and words of encouragement to keep them on schedule, especially as test dates were approaching. To this last point, Tim received a motivational boost to complete the course assignments based on his teacher's periodic announcements that the homework and quizzes were intentionally created to be a little harder than the questions they would encounter on the tests. With this in mind, Tim recognized early in the term that "if you know how to do the homework and quizzes, you can conceivably go into the test and do really well" (Interview 1, October 25, 2016).

Because the homework assignments were uniform for each section of Statistics, Casey also became aware of the level of difficulty on the homework and how it prepared him for the second test. "I love the way he [classroom instructor] challenged you on [chapters] four, five, and six when it came to the homework because he incorporated his own instructor questions that were gonna [*sic*] be more geared towards what were gonna

[*sic*] be on our tests" (Interview 1, October 31, 2016), he declared when reflecting on the

material for the second test. The instructor questions that Casey referred to were

questions written by the Statistics discipline committee when creating the course that

supplemented the computer-generated exercises already available within MyStatLab.

The concepts from chapters four, five, and six were incorporated into the second test,

which Casey scored 10 points higher on compared to the first test.

Test Preparation and Technology

Casey was one of only two participants who enrolled in a Statistics course that

met one night a week for three hours. He explained that he deliberately selected his

section because it met on the same day as his support lab and provided consistency in his

exposure to the content. In discussing his reasons for selecting his classroom instructor,

Mr. Tyson, as the resource yielding the most positive influence, one of the unintended

benefits was that on test days Mr. Tyson would devote the first half of class for review

and the second half of class for the test. Casey said this approach was a "saving grace"

(Interview 2, November 28, 2016) as it kept the test topics fresh in his mind.

Furthermore, having the support lab before class allowed him to review course material

associated with the test and identify any issues that he could present to his instructor

during the review session.

Previously, Casey expounded on a frustration he ran into towards the end of the

semester with MyStatLab's learning aids specifying that technology was required to

solve an exercise without explicitly showing how that technology would be executed. He

later tagged the support lab instructor as providing a "quick fix" (Interview 2, November

28, 2016) in some of these situations, whereby Casey was able to follow what calculator

commands were needed but not necessarily why they were being used. Mr. Tyson's instruction ultimately afforded a "long-term fix" (Interview 2, November 28, 2106), according to Casey, as he received a demonstration of the required technology coupled with the mechanics of how to solve the problem on his own, if available:

> Casey: The lecture is what helps me 'cause [*sic*] he'll go over four or five different problems with explanations. He would enforce the technology aspect. He would make sure off the bat you knew if there was a manual way of doing it, like a long-handed version, he would want you to do that first. [Interview 2, November 28, 2016]

This presentation strategy was especially beneficial for the tests as they included a combination of multiple-choice questions and free-response problems that required work to be shown to receive full credit. Although she had a different classroom instructor, Natalie echoed a point similar to Casey's in that her instructor would tailor the explanations in lecture to coincide with the format of the test questions. For objectives that were connected to multiple-choice assessments in which work was not expected, the calculator was used as the demonstration tool in class. Alternatively, an application like hypothesis testing required students to show their steps to support their conclusion; therefore, students were instructed on the appropriate way to interpret the given information to form their hypotheses, run the statistical tests, and write a summary of the results.

Casey concluded his assessment of Mr. Tyson by recognizing the importance of the lecture reinforcing the information he gained from his own efforts within the support lab and the overall effect it had on his course experience:

Casey: That's [lecture class] where you're gonna [*sic*] learn more than anything else. It's amazing how he lectures and…so that lecture portion pretty much solidified everything I learned from the [support] lab, plus gave me additional knowledge when it came to calculator functions and technology. For me not taking a math class for over 13 years now, I've learned quite a bit pretty fast. [Interview 2, November 28, 2016]

Prior to Rossvale Community College's implementation of its co-requisite model, MyStatlab was still used for all the homework and quiz assignments. Maintaining the software as a part of the redesign clearly benefitted the underprepared students by giving them direct access to assistance via the learning aids. In addition, the Statistics discipline committee's decision to implement the support lab as its co-requisite component served the purpose of addressing academic needs by having the lab instructor readily available to answer questions, but it also had the unintended benefits of helping students manage their time and stay ahead of schedule. Finally, the experience of the classroom instructors, coupled with the standardized curriculum they followed, may have contributed to the interviewees' positive perception of their teachers' ability to convey the material in an organized fashion that strengthened their understanding.

It is noteworthy that the three resources identified by the interviewees were ones that required their participation, whether through completing course assignments,

attending the support lab, or attending class. Almost none of them cited the common

course files as having any significant impact on their learning experience. This may be

due in part to that fact that some of the classroom instructors provided copies of those

files to their students, but there was also no requirement for the students to visit the

course shell to access those materials.

The next section considers the results of the qualitative data through the lens of

the Activity Theory framework. Three primary relationships are discussed via the

alignment and conflict that existed within each relationship.

Theoretical Framework Analysis

Activity Theory was selected as the theoretical framework to examine how the

participants' perception of their learning was affected by the interrelationship between

subjects (interviewees), objects (course assignments), and community (academic

institution). Activity Theory is a descriptive tool rather than a predictive theory (Nardi,

1996), and three relationships are discussed within the context of student learning: first,

the relationship between interviewees and course assignments, mediated by the learning

technology tool MyStatLab; second, the relationship between course assignments and the

academic institution, mediated by the division of labor among the support lab instructor

and the classroom instructor; and third, the relationship between the interviewees and the

academic institution, mediated by the norms that exist within the institution.

Interviewees, Course Assignments, and MyStatLab

Alignment. Unlike a traditional mathematics course where homework is typically

relegated to a static setting of completing exercises from a textbook, the MyStatLab

utilized in the redesigned co-requisite Statistics course offered a dynamic platform in

which learning aids gave access to immediate assistance; students also had the option of working similar exercises to increase their practice on the assignments. Beth, Katina, and Casey each identified the step-by-step fashion in which the learning aids outlined the solutions as contributing to their understanding of the course material. MyStatLab afforded students the ability to continue working through an exercise even if their initial response was incorrect by consulting the tools such as *View an Example* or *Help Me Solve This*. The interactive nature of *Help Me Solve This*, in which students were prompted to enter answers through the explanation to check their understanding, helped Danielle "learn from that example" (Interview 1, November 10, 2016) when she then had to complete a problem on her own to receive full credit. Furthermore, Casey's comment that "It's [MyStatLab] actually helped me learn the [material] on my own," (Interview 1, October 31, 2016) illustrated that he used the technology to become a self-directed learner, which may have strengthened his perseverance to consistently remain ahead of schedule on assignments.

MyStatLab's option to generate similar exercises on homework assignments and attempt quizzes multiple times to increase the amount of practice also appeared to positively impact the participants' learning. Tim pinpointed his repeated attempts on homework questions and quizzes as simultaneously raising his grade and strengthening his understanding. Casey frequently referenced the phrase "repetition, repetition, repetition" (Interview 1, October 31, 2016) when describing the strength of MyStatLab's platform in helping him maintain a solid grasp of the concepts presented throughout the semester. In addition, there was a connection between the number of quiz attempts and the final course average, as the three students (Tim, Casey, and Natalie) who finished

with the highest averages each used multiple quiz attempts on at least a third of the quizzes. Natalie, who improved from an F course average after the first test to a final grade of B, completed multiple attempts on 75% of the quizzes.

Conflict. One of the conflicts that arose with respect to the students' interaction with the course assignments in MyStatLab was the lack of specificity in the learning aids as to how to apply the calculator for some of the hypothesis testing applications. Both Katina and Casey detailed their frustration with the software for this instance, with Casey finding resolution in the lectures provided later by his classroom instructor. Katina, however, often consulted YouTube videos to seek an illustration of how the calculator commands should be executed. Although not addressing this particular issue, Tim also said that he periodically searched for YouTube videos on course content as the brief visual representations captured his attention better than the written solutions in the learning aids. In fact, Tim recommended that more videos be incorporated within the assistance for homework questions to support those with a preference for visual learning.

Course Assignments, Academic Institution, and Division of Labor

Alignment. The researcher's observations of the support labs, coupled with the interviews of Natalie, Danielle, and Casey, revealed a distinction in the depth of instruction given by the lab instructor and the classroom instructor. Ms. Emerson emphasized the graphing calculator as a primary means to solve exercises in MyStatLab and Casey characterized Mr. Humphries' assistance with technology as a "quick fix" (Interview 2, November 28, 2016). This was not surprising given a certain degree of efficiency that the support lab instructors are trying to achieve by providing help to as many students as possible in a limited period of time. Alternatively, the classroom

instructor was praised by most of the interviewees as delivering detailed, step-by-step illustrations of course content that included a blend of conceptual knowledge with the corresponding calculator tutorial when applicable. Casey viewed the two teaching styles as complementary, citing that his knowledge was "solidified" (Interview 2, November 28, 2016) by the lecture, though the classroom instruction may have led to a more comprehensive understanding of the material by building upon the procedural fluency received in the support lab.

When it came to preparing for tests, students were provided a paper copy of review questions for each test; as well there were optional review homework and quiz assignments in MyStatLab for extra practice. Although students had an opportunity to ask questions related to review quizzes in the support lab, test preparations were handled more formally by the classroom instructor, with a class period prior to the test dedicated for review. In Casey's case, having the review the same night as the test was a "saving grace" (Interview 2, November 28, 2016) as it was easier to retain the information. Katina described review days as "most helpful" (Interview 2, December 8, 2016) given the number of questions that students brought in and the lively participation that ensued. And according to Natalie, one of the advantages of the classroom instructor's use of the paper review packet was her ability to take notes on it that she could then reference later independently.

Conflict. It was evident that Danielle felt a strong connection to Ms. Emerson after transferring to her support lab because of a scheduling conflict. Danielle valued her upbeat personality and hands-on approach when helping students, including the handouts and notes she supplied. While Danielle acknowledged the strength of her classroom

instructor, she made clear her desire to know how to solve exercises on the calculator as the "shortcut method" (Interview 2, December 8, 2016) made the problem-solving process quicker. Ms. Emerson satisfied this need with her invitation to download calculator apps and encouraged students to become proficient with using their calculators to facilitate their progress through the assignments. Relying too heavily on the calculator to produce answers may have contributed to Danielle assessing her level of understanding as a 5 on a scale of 1 to 10 in the reflection prompt between interviews. She complained that on test days she would "mentally freeze up and go blank" (Interview 1, November 10, 2016). Her conceptual knowledge base may not have been solid enough to support her retention efforts on tests if she was primarily dependent on the calculator. Furthermore, she mentioned that Ms. Emerson would sometimes check her quizzes before she submitted them, allowing her to make corrections on the front end. This would have allowed her to earn a higher grade, but perhaps at the expense of using the multiple attempts to improve her understanding.

Interviewees, Academic Institution, and Norms

Alignment. As part of the college's course redesign efforts, registration rules stipulated that underprepared students taking Statistics enroll in the co-requisite support lab. The lab proved to be one of the most valuable resources among the interviewees on multiple levels in how it affected their course experience. Natalie, Tim, and Casey each found value in the way the support lab helped manage their schedule by having specific blocks of time that were dedicated to working on course assignments. Natalie and Tim in particular recognized that having weekly two-hour blocks for mathematics stemmed their tendency to procrastinate. All three of them used the lab to work on material beyond

what had already been taught in class, improving their familiarity with new concepts when they returned to the lecture. Being able to regularly remain ahead of schedule was a critical factor in strengthening Casey's understanding of the material and building his confidence that he could be successful after not having attended college in over a decade.

Another requirement set forth by the discipline committee creating the co-requisite Statistics course is that the content had to be uniform across all sections. Part of the rationale is that it would be easier to assess the program's effectiveness if all the students completed the same homework and quizzes in MyStatLab and the tests were standardized. In addition, the assignments that students would work on in the support lab coincided with the graded content for the course, including the preparatory material that the underprepared students had to complete prior to accessing the chapter homework, creating consistency between the lab and lecture. This eliminated any potential frustration that might have been present in a traditional developmental mathematics course where the material may be broader in coverage and not necessarily align with the student's educational goals. Furthermore, because students from different lecture sections could enroll in the same lab, these norms allowed students in Ms. Emerson's lab to easily collaborate with one another on homework and quizzes as their course shells in MyStatLab were identical, regardless of the classroom instructor. Similarly, Casey's ability to assist his best friend in the lab, which ultimately reinforced his own learning, was facilitated by MyStatLab's feature of retaining the same concept within the homework exercises while producing different numerical values.

Conflict. The discipline committee for the Statistics course also decided to set the grading outcome for the support lab as pass or fail, with the outcome tied to the college-

level course. So, if a student passed the Statistics course with a D or above, then the individual automatically passed the support lab and an F in the course resulted in failing the lab. The support lab syllabus indicated that attendance was mandatory, but as students come to realize that their lab grade is connected to their performance in the course, the motivation to attend regularly may diminish. Attendance in the support lab was poor after the midterm, typically averaging less than 50% of the enrollment. Students may forgo the resource believing that they can complete the course assignments on their own time, rather than having to do work during the allotted two-hour blocks.

This mindset may have influenced Katina's decision to only attend the lab eight out of 15 times during the semester, as well as her desire to leave the lab early once she had completed certain material. She made the decision to visit the tutoring center housed in the school's library in lieu of the support lab on various occasions, stating that there were more tutors available in the library. The library, however, has a limited number of tutors on staff who usually need to help students from a variety of courses. As a result, they can be restricted to the amount of one-on-one time they can afford students, especially during peak times of the semester. Alternatively, the support lab instructor was dedicated specifically to helping with Statistics and there was sufficient time to allow for individualized attention. For students who were self-motivated, such as Casey and Tim, the attendance issue did not dissuade them from using the support lab on a regular basis. For students classified as least-prepared, such as Katina, lab participation may need to be maximized to scaffold a successful outcome in the course and the current grading regulations might not align with this goal.

Chapter Summary

The purpose of this study was to examine how underprepared students perform in a co-requisite Statistics course and investigate their perception of how the resources available to them affected their performance. The researcher used an ANCOVA to compare college-ready and underprepared students, as well as better-prepared and least-prepared students, controlling for high school GPA. In addition, the researcher conducted 11 interviews with six randomly selected underprepared students to understand the nature in which course resources influenced their learning.

The results of this study demonstrated that college-ready and underprepared students did not differ significantly on their final course averages, due mainly to the outcomes of the better-prepared students. There was a significant difference in the final course averages between the better-prepared and least-prepared samples. Data from the interviews revealed that MyStatLab's learning aids offered appropriate guidance on homework and quizzes; the support lab served as a time management mechanism that some students used to stay ahead on course assignments; and the classroom instructors provided detailed conceptual explanations that complemented the assistance received in the support labs. The next chapter discusses the results of the study and the implications for future research.

CHAPTER V: DISCUSSION

This study examined one of the acceleration models for reforming the delivery of developmental mathematics, namely the co-requisite redesign. Specifically, one of the goals of the study was to learn about the achievement of underprepared students and the strategies they enacted to handle the demands of direct placement in a college-level course. This chapter begins with a summary of the research problem and a review of the methodology, followed by a discussion of the quantitative and qualitative results. Finally, the chapter concludes with implications for developmental mathematics education and future areas of research.

The Research Problem

Developmental mathematics education plays a critical role in addressing the needs of students who enter post-secondary institutions underprepared for college-level coursework. Traditional stand-alone remedial courses have created numerous obstacles for student success, including low persistence rates (Jaggars & Stacey, 2014), increased time and tuition expenses (Bailey, Jeong, & Cho, 2010), and negative self-perceptions (Scott-Clayton & Rodriguez, 2012). Acceleration models have attempted to address these issues by redesigning courses to shorten the time required to remediate students. Technology is typically employed to facilitate the assessment of content through guided feedback and repeated practice (Epper & Baker, 2009). Co-requisite courses represent a possible solution by enrolling underprepared students directly in a college-level class while offering some form of additional academic support to focus on their needs. Some concerns have been expressed, however, about the challenges least-prepared students may encounter having to balance their mathematical deficiencies with the rigors of

college content. In addition, there is limited evidence in the literature about the efficacy

of co-requisite redesigns for individuals with the greatest needs (Edgecombe, 2011).

Understanding how co-requisite courses impact these students can help shape the

discussions about best practices for developmental education.

Review of Methodology

A mixed-methods design was used to analyze the success of underprepared

students in a co-requisite Statistics course and the resources they utilized throughout the

term. Two analyses of covariance compared participants on the final course average:

college-ready and underprepared; the underprepared sample was then split into two sub-

groups: better-prepared and least-prepared. Six underprepared students were selected to

participate in two interviews to gain insight into the factors that impacted their experience

in the course. Additional sources of data were collected to verify information gathered

from the interviews. The researcher looked for common themes across the interviewees'

experiences to develop a holistic case study that was then interpreted within the Activity

Theory framework. The results from the quantitative and qualitative components are

discussed in the following sections.

Discussion of the Results

Quantitative Results

The results of the quantitative analysis showed that the least-prepared students

had the lowest outcomes in the co-requisite Statistics course. Only 33% of them passed

the course with a final course average of at least a 70, resonating the concern that the

weakest students might struggle with the demands of a co-requisite model (Mangan,

2015). Under a traditional developmental mathematics sequence, however, these

students would have faced at least two remedial courses before having a chance to enroll in a college-mathematics course. Given that about 20% of students assigned to the lowest level of remedial education even enroll or complete a gatekeeper course (Bailey, Jeong, & Cho, 2010; Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009), there is some promise that a third of the least-prepared students earned college credit in one semester.

Within the underprepared sample, there was a statistically significant difference in the final course average between the least-prepared ($M = 64.43$, $SD = 18.61$) and better-prepared ($M = 75.89$, $SD = 16.85$) participants, indicating that those closer to the college-ready classification exhibited greater success in achieving their college-level mathematics requirement. The relatively moderate effect size helps explain that the performance of the better-prepared students contributed to the non-statistically significant difference between the underprepared ($M = 73.11$, $SD = 18.50$) and college-ready ($M = 76.79$, $SD = 19.03$) groups. As a result of Calcgno and Long's (2008) study, coupled with Boatman and Long's (2010) research, that discovered negative effects on degree completion for those assigned to developmental courses near the margin of remediation, the co-requisite model appears to offer encouraging outcomes for these students as they were able to perform on par with their college-ready peers and thereby accelerate their progress towards satisfying their degree plan. Furthermore, the redesign structure also shows that better-prepared students can be successful in a heterogeneous class, extending the results found by Lucas and McCormick (2007) for underprepared students in a homogeneous environment.

Qualitative Results

Interviews were conducted with six randomly selected underprepared students from the co-requisite Statistics course to identify any resources that impacted their learning experience. Three resources emerged to the forefront of the data: the role of MyStatLab for completing homework and quizzes; the assistance received in the support lab and the organizational benefit it provided; and the effect of the classroom instructor's explanations. Each of these themes is discussed in the following sections.

MyStatLab. The National Center for Academic Transformation (NCAT) was a pioneer in advocating technology as a means to reform how developmental education was delivered (Twigg, 2003). Austin Peay State University (APSU) collaborated with NCAT when they redesigned their developmental mathematics courses and the students completed assessments within MyMathLab, a software product produced by the same publisher as MyStatLab. Based on the success of APSU's redesign, the research site for this study developed their co-requisite model to parallel what APSU had done, including using similar technology to manage course assignments.

The learning aids within MyStatLab, specifically the *View an Example* and *Help Me Solve This*, were emphasized by nearly all interviewees as having an important influence on their ability to complete homework and quizzes. The step-by-step nature of the explanations gave students the guidance they required, a feature that Katina described as a "home tutor" (Interview 2, December 8, 2016). Having the learning aids accessible on the screen with the question display made it convenient for students to get help without having to flip through pages of a textbook to search for a similar example. It also created a measure of independence and persistence by allowing individuals to forge

ahead with the available support, minimizing the inclination to wait until class to ask the teacher for help. This was especially true with *Help Me Solve This*, where both Natalie and Danielle benefitted from the requirement of entering their answers within the explanations to check their understanding.

Some of the attention given to MyStatLab may also be explained by the fact that homework and quizzes each counted 10% of the course grade. In a course where technology is not utilized for assessments, homework might be assigned from a textbook with the expectation that students will complete the exercises to prepare themselves for the tests. But having graded assignments adds extra motivation to complete the work and earn the highest possible score. The ability to generate similar exercises in the homework and attempt each quiz three times was an integral component in the success of Tim, Casey, and Natalie. Tim used both features to earn perfect scores on the homework and quizzes leading up to Test 1; he then scored 105 on the test with the completion of a bonus question. Casey and Natalie, who achieved an A and a B in the course, respectively, each used multiple attempts on over half the quizzes. Moreover, Casey regularly used the phrase "repetition, repetition, repetition" (Interview 1, October 31, 2016), when describing how MyStatLab strengthened his understanding via consistent practice.

Support lab. One of the recommendations set forth by Complete College America (2013) for co-requisite redesigns is that the academic content intended to assist underprepared students align with the course outcomes. This was an intentional design characteristic of the Statistics co-requisite course as preparation assignments were built into MyStatLab for the underprepared students to give them a review of foundational

material needed prior to starting the chapter homework. The content alignment may explain, in part, why the support lab was viewed so positively by many of the interviewees. When they attended the lab, they were certain to be doing work that tied directly to course content and thus avoided any frustration that might occur if the tasks were deemed superfluous.

An unintended benefit of the support lab was how it helped Natalie, Tim, and Casey allocate periods of time each week to complete course work. Nodine et al. (2013) found that the self-paced structure of modularized courses, like those implemented in the Tennessee redesign, may not be effective for those who have difficulty managing their time. The co-requisite course addressed this issue by having specific deadlines set for homework and quizzes. Coupled with this policy, the required support lab established two-hour blocks each week that facilitated some students' efforts to either stay on pace or move ahead of the classroom schedule. Casey may have experienced the greatest benefit from the lab by attending it just prior to his Statistics class. The concepts that he started to learn as he worked ahead in the lab were then explained in further detail in the lecture, strengthening his understanding in a relatively short time frame.

The support lab instructors added another layer of assistance for the underprepared students beyond the time management aspect. Although the Statistics co-requisite course was based on APSU's redesign, the support lab was staffed by adjunct instructors rather than peer tutors (Berryman & Short, 2010). Beth and Danielle both expressed enthusiasm with the atmosphere and attention they received in Ms. Emerson's lab. In fact, Danielle credited Ms. Emerson with motivating her to persist in the course after considering withdrawing due to the struggles she faced. Casey also found value in

the individualized tutoring given by Mr. Humphries, especially when trying to comprehend hypothesis testing. In each lab, however, emphasis was often given to finding an efficient solution and applying technology where applicable. This could lead to promoting procedural fluency over conceptual understanding, which may have contributed to some of the struggles that Danielle encountered on her tests with retaining information.

Classroom Instructor. The co-requisite course afforded a division of labor between the support lab instructor and the classroom instructor (Scanlon & Issroff, 2005), so the procedural emphasis in the support lab was frequently supplemented with conceptual explanations in the classroom. Both Natalie and Casey spoke about the appropriate attention to detail given by their classroom instructors based on the complexity of the topic being discussed, as well as the expectation of how much work would be required on the tests to justify their solutions. In a similar manner, Danielle commended her classroom instructor's methodical demonstrations and the way they translated into helping her complete the homework. Some of the difference in the instructional styles between the lab and the classroom may be explained by the nature of the lab instructor trying to assist as many students individually in a limited period of time. The classroom instructors, though, also had a strong foundation of experience teaching Statistics, with each of them having taught multiple sections of the course for at least three years.

When Edgecombe et al. (2013) interviewed participants in the Community College of Denver's FastStart program, a redesign of developmental mathematics education through compressed courses, they expressed a strong approval for the

classroom instructor's commitment to their success in the program. Similarly, Tim appreciated his instructor's efforts in not only keeping him engaged during class with her presentation style, but consistently communicating motivational words of encouragement throughout the semester. Although Tim was already doing well in the course, these efforts appeared to support his solid work habits by keeping him focused on the tasks ahead.

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Implications

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The results of this study have implications for mathematics education as it relates to co-requisite course redesign. The course structure and the affective impact it can have on students all have the potential to reform the delivery of developmental education. The following paragraphs address these implications.

Course Structure

Various acceleration models have been initiated to reduce the time needed to remediate academic deficiencies for underprepared students, including self-paced modularized courses and compressing two courses into one semester. In addition to the aforementioned concerns about time management in a self-paced environment, Nodine et al. (2013) argued that a modularized curriculum carries the risk of students developing shortcuts that produce correct answers while potentially sacrificing a meaningful comprehension of the content. Students may be inclined to look for patterns within solutions that help them complete the modules as quickly as possible. Although there was some evidence that the assistance given in the support lab emphasized procedures to solve an exercise, the presence of an experienced classroom teacher as a part of the co-requisite model creates the opportunity to supplement that assistance with a strong

knowledge base. Although this would be difficult to implement when the support lab

enrolls students from multiple sections with different instructors, a collaboration between

the classroom instructor and support lab instructor could strengthen the presentation for

certain topics.

Compressed courses, like those implemented at the Community College of

Denver and Ivy Tech Community College, typically require students to enroll in paired

courses within the same semester. The courses may be taken concurrently or split into

blocks, where one course is completed during the first half of the semester and the other

during the second half of the semester. In either case, an extended block of time is

required in a person's schedule to accommodate the necessary contact hours, creating a

potential burden on the student (Edgecombe et al., 2013). While a co-requisite redesign

requires a support lab in addition to the lecture course, none of the participants in this

study cited the weekly two-hour commitment as having a negative effect on their

academic schedule. And the positive outcomes achieved by the better-prepared students

in terms of time management and staying ahead of schedule demonstrated the support lab

was a valuable resource.

Some consideration may be needed, however, to improve the attendance in the lab

to potentially target improving the success rate in the lecture course for the least-prepared

students. A grading policy that is pass/fail and tied to the performance in the college-

level course does not necessarily promote participation in the support lab. Instead,

incentives could be established so that meeting a certain attendance benchmark might

translate into extra credit on a test. Considering how Casey solidified his learning by

tutoring his friend in the lab, peer mentorships could also be created between better-

prepared and least-prepared students. This could facilitate collaboration within the lab that would give least-prepared students an extra resource to both ask questions and develop a social connection that might stem the inclination to give up when things get tough. In this study, nearly 17% of the least-prepared participants received an FA, indicating that they simply stopped attending the course. Initiatives that keep these students engaged in the resources available to them might translate into a higher persistence and success rate.

Student Attitudes

Students placed in a traditional sequence of developmental mathematics courses may experience numerous obstacles in persisting within their program of study (Bailey, Jeong, & Cho, 2010). Scott-Clayton and Rodriguez (2012) found that some better-prepared students were discouraged at being assigned to a remedial course, in part because of the stigma attached to the placement. In the co-requisite model, underprepared students are not only enrolled in a college-level course, but their participation in the support lab can remain anonymous. All students complete the same chapter assignments and the academic content designed to address any remediation is simply embedded within the individual's assessments as pre-requisite material. None of the participants expressed negative attitudes related to the mandatory enrollment in the support lab. In fact, some planned on creating a similar structure in their schedules for future terms to help manage their work load.

Future Areas of Research

The quantitative component of this study focused on a comparison between college-ready and underprepared students in a co-requisite model, while controlling for

their high school grade point average. Because not every student has a high school GPA and the calculation for this measure is not uniform across school districts, a pre-test/post-test design could capture differences between the two groups using a standardized instrument applied to all participants. In addition, such a design would give insight into the effect of the co-requisite model on student growth over the course of a semester. Research is also needed to determine the most effective implementation strategies for the co-requisite component. This study examined a required support lab for the underprepared students, but other co-requisite designs have students co-enroll in a remedial course. Given the struggles of the least-prepared students, it would be beneficial to investigate a co-requisite component that not only focused on their academic skills, but also addressed factors like study habits and mindset. Such an approach might help those students most in need develop practices that promote perseverance while strengthening their knowledge base.

Chapter Summary

Reforming developmental mathematics education requires a delicate balance of ensuring that students receive the remediation needed while maintaining steady progress within their program of study. Co-requisite models aim to achieve both goals by allowing students to earn college credit while receiving the necessary support within the same semester. By aligning the support with the course content, students may find greater value in what they are learning (CCA, 2013). The results of this study showed that underprepared students did not exhibit any negative attitudes related to their placement that are sometimes found among students placed in developmental courses (Scott-Clayton & Rodriguez, 2012). Furthermore, the better-prepared students performed

nearly on par with their college-ready peers, demonstrating a positive outcome of placing students near the threshold of college-level assignment directly in a college course.

Alternatively, the least-prepared students scored significantly lower than their better-prepared classmates. This suggests that interventions are still needed to help at-risk students succeed in an accelerated environment. Value was found, however, in many of the available resources, including the support labs and the technology used to complete course assignments. Therefore, further research is required to identify practices that help transform effective resources in co-requisite models into greater success outcomes for those most in need. As a result, developmental mathematics education could undergo a shift from a system that too often impedes progress to one that allows students to reach their full potential.

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APPENDICES

APPENDIX A

Feedback screen shot from MyStatLab

Homework: Homework 3 - Chapter 3 (for Test 1)

Save

Score: 0 of 1 pt   ◄   26 of 40 (0 complete) ▼   ►   **HW Score:** 0%, 0 of 40 pts

ⓧ 3.3.33   ☰ Question Help   ⚙

A certain group of test subjects had pulse rates with a mean of 72.2 beats per minute and a standard deviation of 12.7 beats per minute. Would it be unusual for one of the test subjects to have a pulse rate of 117.6 beats per minute?

Minimum "usual" value = $\boxed{34}$ beats per minute
(Type an integer or a decimal.)

✖ Sorry, that's not correct.   X

If the standard deviation is known, it can be used to find a rough estimate of the minimum "usual" sample value by using the following equation.

minimum "usual" value = (mean) − 2 × (standard deviation)

OK

Enter your answer in the answer box and then click Check Answer.   ?

2 parts remaining   ▬▬▬▬▬▭▭   Clear All   Check Answer   ◄ ►

APPENDIX B

View an Example screen shot from MyStatLab

Homework: Homework 1 - Chapter 1 (for Test 1)

Save

Score: 0 of 1 pt   ◄ 16 of 39 (8 complete) ▼ ►   **HW Score:** 12.82%, 5 of 39 pts

1.3.13   ☰ Question Help ⚙

Determine whether the given value is from a discrete or continuous data set.

When a car is randomly selected, it is found to have an engine with 4 cylinders.

Choose the correct answer below.

○ A. It is from a continuous data set because the number of possible values is infinite and not countable.
○ B. It is from a continuous data set because the number of possible values is infinite and countable.
○ C. It is from a discrete data set because the number of possible values is finite or countable.
○ D. The data set is neither continuous nor discrete.

ⓘ View an Example   ✕

⚙

Determine whether the given value is from a discrete or continuous data set.

When a bicycle is randomly selected, it is found to have eighteen gears.

Discrete data result when the data values are quantitative and the number of values is finite or countable. If there are infinitely many values, the collection of values is countable if it is possible to count them individually, such as the number of tosses of a coin before getting tails.

Continuous data result from infinitely many possible quantitative values, where the collection of values is not countable. That is, it is impossible to count the individual items because at least some of them are on a continuous scale, such as the lengths from 0 cm to 12 cm.

The possible values for the number of gears is countable.

Use this information to determine whether the given value is from a discrete or continuous data set.

Question is complete.   ❓

Click to select your answer and then click Check Ans

All parts showing ▬▬▬▬   Close   ❓

All parts showing ▬▬▬   ►

APPENDIX C

Sample Pencast pdf file

PRACTICE WITH CHAPTER 4.
↓ PEDESTRIANS ↓

		INTOX	NOT INTOX	TOTAL
DRIVERS	INTOX	120	60	180
	NOT INTOX	40	80	120
	TOTAL	160	140	300

GRAND TOTAL

FIND PROB DRIVER (OR) PED WAS INTOX.

"OR" MEANS ADD, BUT WATCH FOR OVERLAP.

YES, OVERLAP = 120   OVERLAP ↓

$P(DRIVER\ INTOX) + P(PED\ INTOX) - P\binom{BOTH}{INTOX}$

$$\frac{180 + 160 - 120}{300} = \frac{220}{300} = \frac{11}{15}\ .73$$

$P(PED\ INTOX\ \underline{OR}\ DRIVER\ IS\ \underline{NOT})$

IS THERE OVERLAP? YES. 40 IN OVERLAP

$P(PED\ INTOX) + P(DRIVER\ IS\ NOT) - P\binom{PED\ IS}{DRIVER\ NOT}$

$$\frac{160 + 120 - 40}{300} = \frac{240}{300} = \frac{4}{5}\ OR\ 0.8$$

$P(PED\ INT\ |\ DRIVER\ INT)$ $= \frac{120}{180\ INTOX\ DRINK} = \frac{2}{3}\ OR\ .667$

$P(DRIVER\ NOT\ |\ PED\ INTOX) = \frac{40}{160\ PED\ INTOX} = \frac{1}{4} = 0.25$

APPENDIX D

Sample Chapter Handout

Section 7.2 Estimating a Population Proportion - Facts and Practice Problems

From this point on, we will focus on **inferential statistics** - that is to say, we will use a given **sample statistic** to try and draw conclusions about the larger population the sample is pulled from. Because we are trying to draw conclusions that go beyond the immediate data that we have in our possession we need to create some flexibility so that we are not trying to claim too much. In section 7.2, we will use a sample proportion, notated with the symbol $\hat{p}$, (p-hat), to find a range of values (called a **confidence interval**) that we can be confident will contain the **true population proportion**, p.

Fact, the sample proportion, $\hat{p}$, is called a **point estimate**. It is the best single value estimate of p, the **true** population proportion. Point estimates are not used as often as confidence intervals.

We use additional information (the sample size n) to create a **confidence interval** which provides us a range of values surrounding $\hat{p}$ that we can be confident will contain p, the true proportion of the entire population.

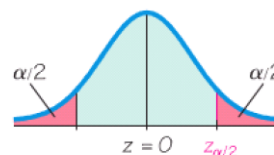**A. Requirements for using the formulas in section 7.2**

1. We must have a simple random sample (unless stated otherwise, this is generally assumed)
2. The conditions for a Binomial Procedure must be satisfied (you'll need to review section 5.3)
3. There must be at least 5 successes and 5 failures. Verify that $n\hat{p} \geq 5$ and $n\hat{q} \geq 5$.

B. Finding **critical values** of the form $z_{\alpha/2}$ for **confidence levels**. ($z_{\alpha/2}$ is the z **score** separating an area of $\alpha/2$ in the *right* tail of the standard normal distribution). A critical value is **not** an area. It is a value that serves as a cut-off point to form a specified area.

$z_{\alpha/2}$ is the critical value that forms a tail to the right with area $\alpha/2$. Read the steps below or use the table for common critical values.

Step 1. We'll be given a level in the problem (such as 95% or 99%.). Let α = the complement of the level. Example: For 95%, $\alpha = 0.05$.

Step 2. $\alpha/2$ is found by replacing α with its value (found in step 1) and dividing that number by 2. Example: if $\alpha = 0.05$ then $\alpha/2 = 0.025$.

Step 3. Find $z_{\alpha/2}$. The **Critical Value** $z_{\alpha/2}$ is the z **score** that corresponds to the **area** of $\alpha/2$ (the number found in step 2) in the *right* tail of the z table. Look up the given area on the negative side of the table, find the z value associated with the area, then drop the negative sign. Using symmetry, the critical value $z_{\alpha/2}$ is associated with the right tail ($z_{\alpha/2}$ is positive).

Please read through this example, following the steps above for help on your homework.

Example: Step 1: For the 95% confidence level, $\alpha = 0.05$. Step 2: Divide 0.05 by 2 to get 0.025. Step 3: look up 0.025 in the **probability/area portion** of the negative side of the z table to find the corresponding z. We find. $z = -1.96$. For the critical value, drop the sign using **symmetry**, and $z_{\alpha/2} = 1.96$ is our critical value.

On the bottom right hand corner of the **positive** z table, we are given a table of **Common Critical Values**.

Common Critical Values	
Confidence Level	Critical value $z_{\alpha/2}$
90% or 0.90	$z_{\alpha/2} = 1.645$
95% or 0.95	$z_{\alpha/2} = 1.96$
99% or 0.99	$z_{\alpha/2} = 2.575$

Fact: The **higher** the confidence level, the **more** confident you can be that the **true** population proportion, p, is in the confidence interval you create. That means that the margin of error, E, gets **bigger** as the confidence level increases and so the confidence interval gets **bigger** too, surrounding your sample proportion $\hat{p}$.

C. Formulas for section 7.2 - Estimating a Population <u>Proportion</u> (provided on the formula packet)

    1. **Margin of Error:** To find E, the **margin of error** for the given sample, use the following formula:

    $E = z_{\alpha/2} \sqrt{\dfrac{\hat{p}\hat{q}}{n}}$ where $\hat{p}$ is the sample proportion of successes, $\hat{q}$ is the sample proportion of failures, and n is the sample size. You will determine the **critical value** $z_{\alpha/2}$ as defined above in part **B**.

    2. **Minimum Sample Size:** To find the **minimum sample size, n,** needed, we use the formula:

    $n = \dfrac{\left[z_{\alpha/2} \right]^2 \hat{p}\hat{q}}{E^2}$. We use the given information about $\hat{p}$ (and $\hat{q}$). Don't forget to square and always round up to next whole number so that you don't lose a single person.

Practice Problems!

1. A poll of 1200 randomly selected adults showed that 87% of them have an email account. Determine if the necessary requirements are satisfied for section 7.2. If they are, calculate the margin of error, E, that corresponds to a 95% confidence level.

Is condition 1 met? Why?

Is condition 2 met? Why?

Is condition 3 met? $n =$ _____, so $x = n\hat{p} =$ _____ $\times$ _____ $=$ _____ and $n\hat{q} =$ _____ - _____ $=$ _____

We use for the critical value $z_{\alpha/2} =$ _____ since the level is 95% (from the table).

Find E, round to 4 decimal places.

2. A poll of 2400 randomly selected adults showed that 1800 of them have cell phone plans. Determine if the necessary requirements are satisfied for section 7.2. If they are, calculate the margin of error, E, that corresponds to a 95% confidence level.

Is condition 1 met? Why?

Is condition 2 met? Why?

Is condition 3 met?

Again, the critical value $z_{\alpha/2} =$ _____ since the level is 95% (from the table). Now find E, round to 4 decimal place.

APPENDIX E

Sample Test Review

Review Sheet – Test 2 –While this review sheet is comprehensive, you are responsible for all the material covered in Chapters 4-6. Try to take this review sheet like a test! Then review the ones you miss.

For the multiple choice problems select the correct answer choice – but be able to show your work!

1. How many ways can a 4 member subcommittee be picked from a larger 10 member committee?
    a) There are 210 subcommittees since order does not matter.
    b) There are 210 subcommittees since order matters.
    c) There are 5,040 subcommittees since order does not matter.
    d) There are 5,040 subcommittees since order matters.

2. How many ways can a new administration be formed if there are four offices (President, Vice President, Secretary, and Treasurer) and there are 15 people interested in running for any position they can get?
    a) There are 32,760 different administrations since order does not matter.
    b) There are 32,760 different administrations since order matters.
    c) There are 1,365 different administrations since order does not matter.
    d) There are 1,365 different administrations since order matters.

3. There are 10 kids who all want to sit together at the movies. There are only 8 seats available together. How many ways can 8 of the 10 kids be arranged to sit together?
    a) There are 45 different arrangements since order does not matter.
    b) There are 45 different arrangements since order matters.
    c) There are 1,814,400 different arrangements since order does not matter.
    d) There are 1,814,400 different arrangements since order matters.

4. How many ways can a sample of 8 objects be drawn from a population of 15 objects?
    a) There are 259,459,200 different samples since order does not matter.
    b) There are 259,459,200 different samples since order matters.
    c) There are 6,435 different samples since order does not matter.
    d) There are 6,435 different samples since order matters.

5. There are 14 red, 12 blue and 18 green marbles in a jar. If one marble is randomly selected, what is the probability that the marble is red? Write your answer as a **reduced** fraction.
    a) $\frac{7}{22}$ b) $\frac{7}{15}$ c) $\frac{1}{14}$ d) $\frac{14}{30}$

6. There are 14 red, 12 blue and 18 green marbles in a jar. If you select a marble from the jar, record the color, **don't** replace it, then select a second marble, what is the probability the second marble is blue, **given** that the first marble was also blue? Write your answer as a **reduced** fraction.
    a) $\frac{3}{11}$ b) $\frac{11}{43}$ c) $\frac{1}{4}$ d) $\frac{3}{43}$

7. There are 14 red, 12 blue and 18 green marbles in a jar. If you select a marble from the jar, record the color, **don't** replace it, then select a second marble, what is the probability the second marble is blue, **given** that the first marble was **not** blue? Write your answer as a **reduced** fraction.
    a) $\frac{12}{43}$ b) $\frac{1}{4}$ c) $\frac{11}{43}$ d) $\frac{36}{473}$

8. There are 14 red, 12 blue and 18 green marbles in a jar. If you select a marble from the jar, record the color, **don't** replace it, then select a second marble, what is the probability the first marble is blue **and** the second marble is blue? Write your answer as a **reduced** fraction.
    a) $\frac{12}{43}$ b) $\frac{3}{43}$ c) $\frac{9}{121}$ d) $\frac{36}{473}$

Use the table to the right to answer questions **9-15**. Round decimals to the thousandths place.

	Republican	Democrat	Independent
Male	37	61	15
Female	23	34	27

9. If we randomly select one person, what is the probability of getting a Republican female?

    a) 0.117   b) 0.383   c) 0.626   d) 0.274

10. If we randomly select one person, what is the probability of getting either a Democrat or an Independent?

    a) 0.482   b) 0.383   c) 0.695   d) 0.213

11. If we randomly select one person, what is the probability of getting either a female or an Independent?

    a) 0.639   b) 0.640   c) 0.643   d) 0.503

12. If we randomly select one person, what is the probability of getting either a Republican or a male?

    a) 0.878   b) 0.690   c) 0.643   d) 0.327

13. If we select one person, what is the probability of getting a female, given that an Independent was selected?

    a) 0.643   b) 0.640   c) 0.321   d) 0.503

14. If we select one person, what is the probability of getting an Independent, given that a female was selected?

    a) 0.643   b) 0.640   c) 0.321   d) 0.503

15. If we select one person, what is the probability of getting a Republican, given that a male was selected?

    a) 0.617   b) 0.327   c) 0.878   d) 0.690

Four males with an X-linked genetic disorder have one child each. The random variable x in the table to the right is the number of children among the four men who inherit the X-linked genetic disorder. Use the table to answer questions **16-22**.

x	$P(x)$
0	0.4230
1	0.3205
2	0.1410
3	0.1003
4	0.0152

16. What is the probability that all of their children have the disorder?

a) 1   b) 0.0152   c) 0.4230   d) 0.1410

17. What is the probability that either 3 or 4 of their children have the disorder?

a) 0.1003   b) 0.0152   c) 0.0015   d) 0.1155

18. What is the probability that at least two of their children have the disorder?

a) 0.2565   b) 0.7435   c) 0.8845   d) 0.1410

19. What is the probability that at most one of their children have the disorder?

a) 0.3205   b) 0.7435   c) 0.5770   d) 0.2565

20. Find the **mean, μ**, of the probability distribution.

a) 0.9642   b) 0.1410   c) 0.1928   d) 0.2000

21. Find the **standard deviation, σ,** of the probability distribution.

a) 1.1008   b) 1.4249   c) 0.9642   d) 1.0492

22. Round the answer to question **20** to the nearest whole number. What does this number represent?

a) The number represents the **total** number of the men's children that have the disorder.
b) The number represents the **expected** number of the men's children that have the disorder.
c) The number represents the **smallest** number of the men's children that have the disorder.
d) The number represents the **largest** number of the men's children that have the disorder.

APPENDIX F

Initial Interview Protocol: After Exam 1

Time of interview:

Date:

Location:

Interviewee:

Questions:

1. How useful have you found MyStatLab for completing your homework and quiz assignments?

    Probe: Specifically, what has been the greatest strength (or weakness) of the

    software?

2. What strategies have you used if you do not understand a homework question?

3. How has the support lab affected your experience with learning the content in the

    course?

4. Are there any resources in D2L that you have used to supplement the information you were taught in class? If so, what are they and what benefit, if any, did they serve?

5. Describe how you prepared for the first test.

    Probe: How did the review materials in MyStatLab or D2L impact, if at all, your

    level of preparation for the test?

APPENDIX G

Reflection Prompt Between Interviews

Dear (Student),

Thank you for taking the time to participate in the initial interview. Your reflections on your experiences in the course are an important contribution to this study. I have a few questions that I would like you to consider and respond to by the end of the week.

Please type your responses, print a hard copy, and return them in a sealed envelope to my office. My office is on the second floor of the library building, in the Math and Science suite.

1. How would you describe your current level of understanding in the course and what factors have contributed to that?

2. What are some of the obstacles that you have faced in the course and how have you dealt with them?

3. What strategies do you think you may need to implement to best prepare yourself for the next exam?

APPENDIX H

Support Lab Observation Protocol

Date:

Length of Activity:

Location of Support Lab:

Support Lab Instructor:

Student(s) being observed:

Support Lab Observation	
Descriptive Notes	**Reflective Notes**
• Identify the time that the student entered the lab and the actions that followed after taking a seat.	
	• How does the student make use of the lab time?
	• What type of communication is there between the student and lab instructor?
• Is there any communication between the student and his or her peers?	

APPENDIX I

Second Interview Protocol: Prior to Final Exam

Time of interview:

Date:

Location:

Interviewee:

Questions:

1. What is your perception of MyStatLab?

   Probe: What experiences have shaped that perception?

2. What is your perception of the resources available in D2L?

   Probe: Are there any changes that you would recommend to improve the

   resources available in D2L?

3. How did you use your time when you were in the support lab?

4. Did the way you prepare for exams change at all from the beginning of the
   semester to the end? If so, how?

5. Considering your experience over the course of the semester, what aspect was
   most beneficial in helping you learn the course material?

APPENDIX J

Institutional Review Board Approval

IRB

INSTITUTIONAL REVIEW BOARD

Office of Research
Compliance, 010A Sam
Ingram Building, 2269
Middle Tennessee Blvd
Murfreesboro, TN 37129

IRBN001 - EXPEDITED PROTOCOL APPROVAL NOTICE

Thursday, September 08, 2016

Investigator(s):   Derek K. Smith (Student PI) and Michaele Chappel (FA)
Investigator(s') Email(s): *ds3i@mtmail.mtsu.edu; michaele.chappel@.mtsu.edu*
Department: Mathematical Sciences

Study Title: ***An examination of resources that impact the learning
experience of underprepared community college students in
a redesigned co-requisite statistics course***

Protocol ID: **17-2006**

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU Institutional Review
Board (IRB) through the **EXPEDITED** mechanism under 45 CFR 46.110 and 21 CFR 56.110
within the category *(7) Research on individual or group characteristics or behavior* A summary of
the IRB action and other particulars in regard to this protocol application is tabulated as shown
below:

IRB Action	APPROVED for one year from the date of this notification
Date of expiration	9/30/2017
Sample Size	420 (FOUR HUNDRED AND TWENTY)
Participant Pool	**Adult students enrolled in MATH1530 (Probability/Statistics) AND adult instructors of statistics courses**

Exceptions	(1) Collection of voice recording is permitted but the audio files must be deleted once the data are compiled (2) Short-term storage of research materials is permitted but the research records must be stored in a secure location by the Faculty Advisor	
Restrictions	**Mandatory signed informed consent**	
Comments	NONE	
Amendments	**Date**	**Post-approval Amendments**
		NONE

This protocol can be continued for up to THREE years (9/30/2019) by obtaining a continuation approval prior to 9/30/2017. Refer to the following schedule to plan your annual project reports and be aware that you may not receive a separate reminder to complete your continuing reviews. Failure in obtaining an approval for continuation will automatically result in cancellation of this protocol. Moreover, the completion of this study MUST be notified to the Office of Compliance by filing a final report in order to close-out the protocol.

Continuing Review Schedule:

Reporting Period	Requisition Deadline	IRB Comments
First year report	8/30/2017	INCOMPLETE
Second year report	8/30/2018	INCOMPLETE
Final report	8/30/2019	INCOMPLETE

The investigator(s) indicated in this notification should read and abide by all of the post-approval conditions imposed with this approval. Refer to the post-approval guidelines posted in the MTSU IRB's website. Any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918 within 48 hours of the incident. Amendments to this protocol must be approved by the IRB. Inclusion of new researchers must also be approved by the Office of Compliance before they begin to work on the project.

All of the research-related records, which include signed consent forms, investigator information and other documents related to the study, must be retained by the PI or the faculty advisor (if the PI is a student) at the secure location mentioned in the protocol application. The data storage must be maintained for at least three (3) years after study completion. Subsequently, the researcher may destroy the data in a manner that maintains confidentiality and anonymity. IRB reserves the right to modify, change or cancel the terms of this letter without prior notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

APPENDIX K

Informed Consent Form

Principal Investigator: Derek K. Smith
Study Title: An Examination of Resources that Impact the Learning Experience of Underprepared
Community College Students in a Redesigned Co-Requisite Statistics Course
Institution: Middle Tennessee State University

Dear MATH 1530 Student:

The following information is provided to inform you about the research project and your participation in it. Please read this form carefully and feel free to ask any questions you may have about this study and the information given below. You will be given an opportunity to ask questions, and your questions will be answered. Also, you will be given a copy of this consent form.

Your participation in this research study is voluntary. You are also free to withdraw from this study at any time. In the event new information becomes available that may affect the risks or benefits associated with this research study or your willingness to participate in it, you will be notified so that you can make an informed decision whether or not to continue your participation in this study.

For additional information about giving consent or your rights as a participant in this study, please feel free to contact the MTSU Office of Compliance at (615) 494-8918.

1. **Purpose of the study:** You are being asked to participate in a research study because the researcher is interested in examining how students perform in a redesigned co-requisite Statistics course and the factors that affect their performance in the class.

2. **Description of procedures to be followed and approximate duration of the study:** There is a quantitative and a qualitative component to the study. The quantitative component of the study will collect final numerical course averages for analysis. For the qualitative component of the study, a random selection of students will be selected to partake in two interviews during the semester, one after the first exam and the second one prior to the third exam. These interviews will include questions that ask you to reflect on your experiences with the learning resources available to you in the Statistics course. To follow up on the first interview, you will be asked to respond to e-mail prompts between interviews that aim to monitor your progress in the course, in particular your perceptions of the impact of the course resources on your learning outcomes. I may also visit the support lab that you are enrolled in to observe your interaction with the course materials in that environment.   The duration of the study will span about 10 weeks during the fall 2016 semester.

3. **Expected costs:** There will be no cost to the participant.

4. **Description of the discomforts, inconveniences, and/or risks that can be reasonably expected as a result of participation in this study:** There is a time commitment involved for participating in the study. The two interviews may last about 30 minutes each and the e-mail communication in between the interviews will require some time each week for you to reflect on your experiences in the course. There are no known risks associated with the research.

5. **Compensation in case of study-related injury:** MTSU will not compensate study-related injuries.
6. **Anticipated benefits from this study:**

There are no benefits to you for participating in the study. However, this research may benefit society by demonstrating the impact a co-requisite course has on reducing the time required for students to achieve college-level credit while addressing any necessary skill remediation. Moreover, it may help identify the resources within the course that positively influenced the students' learning experience.

7. **Alternative treatments available:** N/A

8. **Compensation for participation:** There is no compensation, but students willing to participate in both interviews and the e-mail communication in between will be entered into a drawing for a $50 Amazon gift card that will be awarded at the end of the semester.

9. **Circumstances under which the Principal Investigator may withdraw you from study participation:** If you are under 18, then you will not be eligible to participate in the study.

10. **What happens if you choose to withdraw from study participation:** There is no penalty if you choose to withdraw from the study and you may withdraw at any time.

11. **Contact Information.** If you should have any questions about this research study or possible injury, please feel free to contact Derek Smith at 615-353-3025 or my Faculty Advisor**,** Dr. Michaele Chappell at 615-898-2393.

12. **Confidentiality.** All efforts, within reason, will be made to keep the personal information in your research record private but total privacy cannot be promised. Your information may be shared with MTSU or the government, such as the Middle Tennessee State University Institutional Review Board, Federal Government Office for Human Research Protections, if you or someone else is in danger or if we are required to do so by law. Your name, or any other identifying information, will not be included in the written results of the study or any presentations related to the study.

13. <u>**STATEMENT BY PERSON AGREEING TO PARTICIPATE IN THIS STUDY**</u>
    I have read this informed consent document and the material contained in it has been explained to me verbally. I understand each part of the document, all my questions have been answered, and I freely and voluntarily choose to participate in this study. By signing below, I agree to allow my final numerical course average to be included in the quantitative data and agree to remain in the sample for potential interview candidates. I understand that participation in this study has no impact on my course average and I may withdraw from the study at any time without penalty.

Date	Signature of student