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Mathematics Boot Camps: A Strategy for Helping Students to Bypass Remedial Courses

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Abstract

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MEd, Howard University, 1976

BA, Howard University, 1974

Dissertation Submitted in Partial Fulfillment

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Abstract

Many community colleges struggle to find the best strategy to help incoming at-risk students prepare for the placement test. The purpose of this quantitative quasi-experimental study, was to answer the question as to which of 2 programs, a 2-week, face-to-face mathematics refresher program, Math Boost-Up, or an online-only program, might increase the ACCUPLACER posttest scores of incoming community college students. The study used archival data for 136 students who self-selected to either participate in the Math Boost-Up program (the experiment group), or in the online-only program (the comparison group). Knowles's theory of adult learning, andragogy, served as the theoretical framework. Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square tests were used to measure the effect of 4 moderator variables (age, high school GPA, number of minutes spent in MyFoundationsLab, and number of days spent in face-to-face sessions) on the pre- and posttest scores of students in each group. The results indicated that students in the Math Boost-Up program experienced statistically significant gains in arithmetic and elementary algebra than did those students in the online-only program. The results also indicated that the 4 moderator variables affected gains in posttest scores. Additionally, the results disproved the andragogical premise that students would be self-directed and would self-select to participate in the intervention. A recommendation was that participation in the face-to-face refresher program should be mandatory. The study contributes to social change by providing evidence that short-term refresher programs could increase the scores of students on placement tests.

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Dedication

To my awesome family who stood by me during this journey, encouraged me every step of the way, and held steadfast in their faith that I could do this! My husband Winslow; my children Basil and Sherilyn; my brothers Philip, Allan, and Gerald; my sisters (from another mother) Lily May Johnson, Pamela Reddock, and Diane Ford; and my nieces, nephews, cousins, and close friends. To my parents, Reverend Adam Johnson and Mrs. Lucille Johnson, who began this journey with me and who are looking down from heaven with big smiles on their faces, always proud of my accomplishments. To my cousin Phyllis Cummings, who took their places, always telling me to keep going and never to give up on my dreams.

"I will give thanks to You, O Lord my God, with all my heart, and will glorify Your name forever" (Psalms 86:12).

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To my husband, Winslow Hamilton, and moreover to my children, Basil and Sherilyn, thank you for always “having my back.” Now it is your turn, Basil and Sherilyn, to carry the torch. I expect great things!

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Chapter 1: Introduction to the Study

Topic of the Study

In the United States, a high school diploma is no longer sufficient for obtaining a job that pays a sustainable wage. In a study conducted by researchers at the Georgetown University Center on Education and the Workforce, the researchers projected that 63% or more of jobs would require persons to have an associate's degree or better by 2018 (Carnevale, Smith, and Strohl, 2010). The researchers also concluded that for persons to implant themselves and become part of the middle class, they must, at a minimum, possess an associate's degree. Furthermore, according to Carnevale, Smith, and Strohl (2010), "a post-secondary education has become the threshold requirement for a middle-class family income" (p. 13). So for many Americans, community colleges have opportunities to attain economic sustainability and stability, as well as a pathway to the middle class. But the majority of students who enter a community college test into one or more remedial course. This results in students not completing the certificate or degree program, which can have serious socioeconomic implications for students and lead to dashed hopes of being able to enter and remain a part of the middle class.

This study involved evaluating the effects of a short-term intensive intervention, Math Boost-Up, on the mathematics knowledge and skills of incoming freshmen at a community college located in an urban metropolitan city. At this community college, the ACCUPLACER test developed by the College Board serves to measure the mathematics knowledge and skills of incoming students. The first implementation of the Math Boost-

Up program occurred in 2012 in an effort to decrease the number of students who test into one or more developmental sections of mathematics.

These types of short-term intensive refresher courses, sometimes called *boot camps* (Freedberg, 2010; Patton, 2012; Sherer & Grunow, 2010), serve to help students increase their scores on the mathematics or English sections of the placement test administered to students upon their entry into a community college. The capacity of students to change test scores to levels where students can avoid taking remedial courses altogether, or test into sections of the remedial courses that are closest to college-level courses, indicates the success of these types of short-term refresher interventions. This study was an evaluation of the Math Boost-Up program, and community college administrators and faculty will use the results to determine whether to scale the program to full implementation.

In my review of current research, I focused on these types of short-term intensive programs. I found that community colleges with these types of programs, such as Miami Dade College in Florida, Northampton Community College in Pennsylvania, and North Central State College in North Carolina, indicated that the programs contributed to students being able to increase their test scores to levels allowing some to bypass remedial courses altogether or test into higher level remedial courses (North Central State College, n.d.; Sherer & Grunow, 2010; Vassiliou, 2011). However, no one had empirically validated any of these claims.

Further, I was unable to identify research studies that included empirically validated evidence that these types of short-term intensive refresher programs were successful in helping students increase their test scores on placement tests (Levin & Calcagno, 2008). This research study is among the first studies that involved analyzing data from an empirically valid research design to determine whether these refresher courses are effective in reducing the number of students who tested into remedial courses.

The study contributes to the social change mission in that it provides evidence that these short-term refresher programs can help reduce the need for remedial courses. If the number of students taking remedial courses decreases, community college leaders could increase the numbers of students who persist in degree and certificate programs and earn a degree or certificate. Labor market statistics indicate that between 2008 and 2018, 63% of jobs will require some postsecondary education (Albright, 2008). Therefore, it is imperative that students persist, complete their degree or certificate programs, and obtain jobs that pay a sustainable income. Otherwise, they will enter the ranks of poverty and the underclass. Completing a degree program may provide opportunities for students to create a better quality of life for them and their families (Bautsch, 2013; Hodara, Jaggars, & Karp, 2012; Levin & Calcagno, 2008; Long, 2011).

In this chapter, I provide a background discussion of the relationship between placement tests and remedial education and the problems related to retention, persistence, and graduation rates that these placement tests create for students. I also provide an overview of the nature and purpose of the study, the research questions, and the theoretical framework of the study. The remainder of the chapter includes a description of the research design and methodology, definitions of key words, assumptions, scope, limitations, and significance.

Background

Summary of Research Literature

The majority of community colleges have an open admissions policy, which means that anyone who has a high school diploma or a General Educational Diploma (GED) can gain admission into a community college (Brock, 2010; Burdman, 2012; Zachry Rutschow & Schneider, 2012). Given the open admissions policy, it is common practice at most community colleges across the country to administer tests to incoming first-year students to determine their readiness for college-level courses (Bailey & Hughes, 2011; Belfield & Crosta, 2012).

As part of the admissions process, registration and student success specialists in community colleges use the ACCUPLACER, the Computerized Adaptive Placement Assessment and Support Systems (COMPASS), or the Assessment of Skills for Successful Entry and Transfer (ASSET; Fields & Parsad, 2012) tests to help determine the correct level in the remedial education course sequence for a student or whether the student is ready for college-level mathematics and English (Collins, 2008). Hughes and Scott-Clayton (2011) noted that at 92% of community colleges, student advisors, registration or student success specialists used scores from these tests to determine placement into remedial courses. But for thousands of prospective students all over the United States who arrive at the doors of community colleges full of hope and determination to complete their degrees or certificate programs (Hilliard, 2011; McCormick, 2011), most entering freshman test into at least one remedial course (Collins, 2010; Conley, n.d.; Patton, 2012).

Approximately 60% of incoming community college students learn that they have not met the qualifying scores needed to enroll in college-level mathematics and English courses and instead must enroll in one or more non-credit-bearing remedial courses (Bailey & Cho, 2010). At the community college where I conducted this study, based on report from ACCUPLACER, 89% of the entering students who took the ACCUPLACER test for entry into the fall 2014 semester tested into at least one remedial course.

According to the 2007-2008 report of the National Postsecondary Student Aid Study (NPSAS), forty-two percent of incoming freshmen enroll in remedial courses. The others decide either to abandon or to delay their plans, as they do not want to spend the additional money or time, especially when the courses do not count toward their degrees (Bailey, 2009a; Bailey, Jeong, & Cho, 2008); Kuh, Kinzie, Buckley, Bridges, & Hayek, 2006; P. Jenkins & Cho, 2012; Sherer & Grunow, 2010; Tait-McCutcheon, 2008). For those who decide to stay on, approximately 17% (National Center for Education Statistics (NCES), 2009) complete their programs of study and receive an associate degree or certificate of completion. Further, Bailey et al. (2008) reported that fewer than 10% of the students who place into the lowest level of remedial math completed the remedial course sequence and went on to enroll in college-level, credit-bearing math courses.

Spending a year or more in remedial education courses can be frustrating and demoralizing for students (Bailey, 2009b; Bailey et al., 2008; P. Jenkins & Cho, 2012; Sherer & Grunow, 2010) and costly to community colleges and taxpayers. According to researchers at the Bill and Melinda Gates Foundation (n.d.), remedial education costs community colleges approximately $2.5 billion each year. However, researchers at other organizations such as the Alliance for Excellent Education (2011) and Complete College America (2012) estimated these costs to be about $5.6 billion. If community college leaders could increase the number of students who bypass remedial courses altogether or test into higher level remedial courses, community colleges might come close to meeting President Obama's mandate of adding 5,000,000 graduates to the existing number of Americans possessing a college degree (White House, 2010).

In addition to the political and social costs, having to take remedial courses can be costly to students, especially since credit for these courses does not apply to any degree (Conley, 2007). The time spent taking remedial courses can lengthen the time to completing an associate degree or certificate and can have negative effects on the persistence and graduation rates among colleges (Collins, 2010; Levin & Calcagno, 2008). The new federal regulations that became effective in fall 2012 compound the problem of time to completion further.

The new regulation limits the amount of Pell Grant awards to 18 full-time quarters or 12 full-time semesters (Federal Student Aid, n.d.). Students attending community colleges who tested into one or more remedial courses may have enough money to complete their associate of arts degree programs, but not enough money to fund a bachelor of arts degree program. Belfield and Crosta (2012) contended the accurate placement of students in remedial or college-level courses was a critical step in ensuring that students persist to graduation. In conclusion, this study involved examining evidence regarding whether the Math Boost-Up program succeeded in refreshing the mathematics knowledge and skill of students who had previously tested into remedial courses so that they could test into higher level remedial math courses or into college-level mathematics courses. This study also involved exploring the capacity of these short-term intensive programs such as Math Boost-Up to increase the test scores of students on placement tests.

Gaps in the Research Literature Related to the Study

To help relieve the bottleneck of students stuck in remedial courses, many community colleges have a number of activities to help move students quickly through these courses (Bill & Melinda Gates Foundation, 2009). Some strategies include (a) combining two or more courses in one semester; (b) reaching into high schools to test students and having them complete the remedial courses while still in high school (Conley, 2007; Spence, 2009); (c) enrolling students who are not pursuing degrees in science, technology, engineering and mathematics (STEM), in courses on statistics and quantitative analysis, such as the courses developed and field-tested by analysts at the Carnegie Foundation for the Advancement of Teaching (Sherer & Grunow, 2010). These various intervention programs have mixed results in terms of their success (Bailey & Cho, 2010).

Hughes and Scott-Clayton (2011) and Collins (2010) concluded that the best remedial education programs involve working with incoming students to help them avoid having to take remedial education courses altogether by testing into college-level courses upon entry into college. But the primary question related to these types of refresher programs is whether they are successful in increasing the placement test scores of students to a level where students can either test into a higher level remedial course or into a college-level course. The answer to this question emerged from empirical evidence. Therefore, the study fills a gap in the research literature and provides empirical evidence that these short-term intensives or math boot camps could be successful in helping to reduce the numbers of students who test into remedial courses.

The study fills this gap by addressing a weakness in the research design of similar studies that primarily includeed either a one-group pretest–posttest design or a posttest only with nonequivalent group design to determine the effectiveness of the intervention (Moss & Yeaton, 2006). These designs have an inherent weakness because there is no comparison group or random assignment of participants. Levin and Calcagno (2008) noted that the absence of a comparison group and random assignment threatened the validity of the study and provided little or no evidence of the causal relationship between the intervention and the changes in test scores. This study, which includeed a quantitative quasi-experimental pretest–posttest design with a nonequivalent comparison group, has the potential of serving as a model for future studies whose researchers wish to show the effectiveness of one intervention over another approach (Shadish, Cook, & Campbell, 2002).

Need for the Study

Programs such as Math Boost-Up help students to raise their test scores on placement tests to a level that makes them eligible to avoid remediation and test into college-level mathematics courses (Sherer & Grunow, 2010). According to Sherer and Grunow (2010), these short, intensive programs are

> a high priority to investigate because their short intensive design aimed at a critical juncture when many students get lost creates a potential to move high numbers of students along (or out) of the developmental continuum in a replicable and cost effective manner. (p. 3)

If implemented correctly, boot camps could have a significant impact on student retention and persistence, particularly if they are successful in moving large numbers of students faster along or completely out of the remedial course sequence. If they are successful, then they would be worth pursuing (Sherer & Grunow, 2010).

The study involved measuring the proportion of students who were able to test into a college-level math course or a higher level remedial course due to their participation in the Math Boost-Up program compared to those students who did not participate in the program. Some researchers have contended that a refresher course might work because the content tested draws on knowledge and skills that students covered in the seventh or eighth grades, which some students have long forgotten (Bailey & Cho, 2010; Ewell, 2010; Vassiliou, 2011). The Math Boost-Up program will not improve the test scores of students who are either unfamiliar with or too weak in mathematics knowledge and skills. For these students, remedial mathematics courses are appropriate. The study was necessary because it included empirical evidence that the short-term intensive programs could refresh the mathematics knowledge and skills of incoming college freshmen so they could increase their scores on the placement tests.

Problem Statement

The problem addressed was the lack of sound, empirically based experimental studies (Christensen, 1997) that demonstrate that short-term intensive mathematics refresher programs could improve the test scores of incoming students on the mathematics portion of the placement tests. Although many community colleges have some type of short-term intensive refresher course, often called boot camps, that helps students improve their scores on the placement tests, most of the reports on these programs primarily included information about the numbers of students who were able to bypass remediation courses or who tested into higher levels of remedial courses (Sherer & Grunow, 2010; Zachry Rutschow & Schneider, 2012). None of the community colleges or organizations for which researchers had studied short-term intensive placement test preparation programs provided evidence through sound empirically based experimental studies (Christensen, 1997) that showed that the programs helped students test into higher level remedial courses or out of the remedial course sequence entirely (Sherer & Grunow, 2010). Sherer and Grunow (2010) found “none of the colleges reported data with regard to how these numbers stack up to a comparison group” (p. 32).

Community college leaders need better evidence that short-term programs work to refresh the mathematics knowledge and skills of first-time college students. Consistent efforts to prevent students from having to enroll in remedial courses could result in a substantial reduction in remediation rates by 8% in math and 12% in English (Scott-Clayton, 2012). Further, students could bypass remediation and still pass college-level math and English courses (Scott-Clayton, 2012). Accordingly, I addressed this gap in the research literature by conducting one of the first research studies with empirical evidence that indicates whether the short-term intensive refresher programs could help students learn the mathematics knowledge and skills needed to score well on the mathematics section of the placement tests and place into higher level remedial math courses or into college-level math.

Purpose of the Study

The purpose of this quantitative study was to provide sound and empirically derived evidence (Christensen, 1997) that short-term intensive mathematics refresher programs, often called boot camps, are effective in increasing the placement test scores of incoming students on arithmetic and algebra so they can either test into a higher level remedial mathematics course or into a college-level credit-bearing math course. The goal was to investigate the hypothesis that the Math Boost-Up intervention would increase the ACCUPLACER mathematics scores of incoming students. Because most students perform poorly on the mathematics section of the assessments (Bailey & Cho, 2010; Ewell, 2010), the focus of the Math Boost-Up intervention was on this section of the ACCUPLACER test to relieve the bottleneck of students in mathematics remedial courses.

Goal of the Study

The goal of the study was to determine whether the intervention, Math Boost-Up (independent variable), could increase the mathematics knowledge and skills of incoming students (the dependent variable), as measured by the ACCUPLACER. The students who participated in the Math Boost-Up intervention program were in the experimental group.

Students who did not participate in the Math Boost-Up program were members of the comparison group. Nonparametric tests helped to determine which of the moderator variables, age, high school grade-point average (GPA), length of time between graduating from high school and taking the ACCUPLACER test, length of time spent working on the modules in MyFoundationsLab, and time spent attending the face-to-face modules in Math Boost-Up, had the most impact on the posttest scores of the students in the experiment and comparison groups.

Research Questions and Hypotheses

In this study, I focused on whether a mathematics refresher course such as Math Boost-Up could increase the ACCUPLACER posttest scores of incoming students in arithmetic and elementary algebra more than students who studied on their own. The research question in this study follows:

RQ: Did participation in the Math Boost-Up program increase the ACCUPLACER posttest scores of incoming community college students in the experimental group more than the scores of students in the comparison group who did not participate in the program but studied on their own?

H_0: Students' gains in the ACCUPLACER posttest scores would essentially be the same for those in the experimental group who participated in Math Boost-Up (independent variable) and those in the comparison group who studied on their own.

H_A: Students' gains in ACCUPLACER posttest scores would be different for those in the experimental group who participated in the Math Boost-

Up program (independent variable) and those in the comparison group who studied on their own.

The independent variable of the study was the ACCUPLACER refresher program, Math Boost-Up, and the dependent variable was the mathematics knowledge and skills as measured by the ACCUPLACER.

Theoretical Framework for the Study

The core principles and assumptions associated with andragogy served as a framework for the development and implementation of the Math Boost-Up program because the basis for the development of participant recruitment, the design of the face-to-face sessions, and the independent computer-assisted learning sessions based on the learner's weaknesses in math was the premise that adults learn best when they can develop their plans for learning rather than having a plan imposed upon them (Knowles, Holton, & Swanson, 2011). Based on the self-directed nature of adult learners, Knowles et al. (2011) posited that adults feel motivated to learn if they can self-select to participate in the learning process from the beginning and are able to justify the need to participate based on their own assessment of whether participation serves their short- and long-term goals. The approach of allowing students to be self-directed in determining whether to participate in the program or not resulted in a program in which all students had a commitment to engaging in activities that would help them raise their test scores to a level that would cause them to bypass remediation courses and enroll in college-level mathematics courses.

Further, after students understood the benefits from participating in Math Boost-Up, they would want to enroll in the program. Knowles (1996) indicated that other strategies, such as making participation mandatory and dictating to learners what they needed to learn and how and when they needed to learn it, which Knowles and other adult learning theorists categorized as pedagogy, ignored the need for adults to be self-directed, and resulted in “high drop-out rates, low-motivation, and poor performance” (p. 15).

To retake the ACCUPLACER test, students had to complete an ACCUPLACER Diagnostics assessment. The ACCUPLACER Diagnostics, developed by the College Board, provided feedback to the students about the mathematics knowledge and skills they were weak in related to basic mathematics and elementary algebra. The report from the ACCUPLACER Diagnostics linked to the modules in the intervention program that provided computer-based exercises for students to complete on their own. Math Boost-Up instructors also used this information to plan the lessons covered in the face-to-face sessions. Knowles (1980) noted helping learners assess their current knowledge helps them

> to measure the gaps between their present competencies and those required by the model, so that they experience a feeling of dissatisfaction about the distance between where they are and where they would like to be, and so are able to identify specific directions of desirable growth. (p. 48)

The basis of the decision to use the ACCUPLACER Diagnostics assessment and practice modules that are a part of the MyFoundationsLab program was Knowles’s six assumptions of the characteristics of adult learners that set them apart from children and youth. Knowles et al. (2011) posited that adults differed from children and youth in the areas of (a) the need to know, (b) self-concept, (c) life experiences, (d) readiness to learn, (e) orientation to learning, and (f) motivation. These six principles of adult learning guided the design, development, and implementation of the intervention, Math Boost-Up, and I also incorporated them in the planning of professional development orientation sessions for faculty leading the intervention. A detailed description of the assumptions and hypotheses of andragogy, as they relate to the design and implementation of the study, appears in Chapter 2. Chapter 2 also includes a description of which elements from the theory of andragogy were part of the design and implementation of the Math Boost-Up program and grounded in the research literature.

Nature of the Study

Rationale for the Selection of the Research Design

The methodology that I used to explore answers to the aforementioned questions was a quantitative quasi-experimental nonequivalent comparison groups research design that was a pretest–posttest design without random assignment. Using this quasi-experimental design method allowed me to assess the efficacy of the Math Boost-Up program's ability to increase students' mathematics ACCUPLACER numeric scores compared to the students who decided not to participate in the program. A true experimental study with random assignments might have been the preferred method but was not possible at the community college where this study took place. Random assignments would have required participants to participate in programs in which they might not want to engage. Further, college leaders felt mandatory participation would have caused undue hardship to students. According to Christensen (1997), using a quasi-experiment design is acceptable when it is not possible to use random assignment. Figure 1 represents the design that was used in this study.

	Pretest ACCUPLACER Scores	*Intervention – Math Boost-Up*	*Posttest Scores*	*Difference Pretest and Posttest Scores*	
Experimental group – Math Boost-Up	Y_1	X	Y_2	Y_1-Y_2	Compare Results and Draw Conclusions
Comparison group – studied online	Y_1		Y_2	Y_1-Y_2	

Figure 1. Quasi-experimental nonequivalent comparison group design.

In this study, I conducted nonparametric tests to determine whether gains in the mathematics knowledge and skills of students (the dependent variable), as measured by the ACCUPLACER, were greater for students in the experimental group who participated in the Math Boost-Up program (independent variable) compared to students in the comparison group who studied on their own. I used nonparametric tests (Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square) to determine the effect of each variable listed in Table 1 on the posttest scores of the students in both groups. Nonparametric tests were suitable because the number of participants in each group was unequal, and the differences in the amounts of missing data between the variables were considerable.

Table 1

Independent Variable, Moderator Variables, Dependent Variable, and Data Analysis Method

Independent variable	Moderator variables	Dependent variable	Data analysis method
Math Boost-Up	Age (in years) High school grade point average Students referred to as "younger" are those who are younger than 25 years. Those students referred to as "older" are those who are 25 years and older Length of time (in minutes) spent working on the modules in MyFoundationsLab Time spent attending (in number of times/days) the face-to-face modules in Math Boost-Up	Mathematics Knowledge and Skills (gain, no gain, or decrease in ACCUPLACER test score - pretest mean scores minus posttest mean scores)	Nonparametric statistical tests (Spearman, Kruskal-Wallis, Mann-Whitney, and Chi-Square).
	Compare pretest mean scores of experiment and comparison groups		Spearman's rank correlation
	Pretest mean scores	Mathematics Knowledge and Skills (Posttest mean scores)	Mann-Whitney test

Independent, Dependent, and Moderator Variables and Analysis Plan

The independent variable of the study was the Math Boost-Up intervention, and the dependent variable was the mathematics knowledge and skills as measured by the

ACCUPLACER posttest raw scores for arithmetic and elementary algebra. The moderator variables and their relationship to the independent and dependent variables are Table 1. These moderator variables were age, length of time since graduating from high school and taking the ACCUPLACER test, high school GPA, length of time spent working on the modules in MyFoundationsLab, and time spent attending the face-to-face modules in Math Boost-Up. I used the Mann-Whitney tests to compare the pre- and posttest ACCUPLACER mean test scores of the students who participated in the Math Boost-Up program to the pre- and posttest mean test scores of the students who did not participate in Math Boost-Up, and I used other nonparametric tests to analyze the other variables. I also compared the mean posttest gains of students in the experimental group to the mean posttest gains of the students in the comparison group who did not participate in the Math Boost-Up program. I analyzed the effect of the moderator variables on mean posttest gains using nonparametric tests (Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square).

Brief Description of Methodology

Students entering the community college who did not achieve the cut scores on the arithmetic and elementary sections of the ACCUPLACER test, who wanted to improve their scores so that they could enroll in college-level mathematics courses, and who agreed to retake the test were the target population for the study. As a condition of retaking the test, students had to agree to either participate in the Math Boost-Up program (the experimental group) or to study on their own (comparison group). An outline of the study's implementation plan follows:

- Week 1: Students took the ACCUPLACER test and faculty and advisors invited them to participate in the study.
- Week 2: Students who decided to participate in the study completed the ACCUPLACER Diagnostics assessment.
- Weeks 3 and 4: Students participated in Math Boost-Up or studied on their own.
- Week 5: Students retook the ACCUPLACER test.

I provide a detailed description of the activities for each week in Chapter 3. One of the Student Success Specialist who is in charge of placement testing at the College, administered the ACCUPLACER test to students in both groups at the pre- and posttest stages of the study. For both the pre- and the posttest, the test items were different, because the ACCUPLACER test is a computer adaptive test that adjusts to each student's skills and abilities.

In summary, the students who participated in the Math Boost-Up program were in the experimental group. The students who did not participate in the program but chose to study on their own were in the comparison group. The students in the comparison group also used Pearson's MyFoundationsLab. For each of the groups, students had to retake the test within 1 week of completing the 2-week intensive.

I drew conclusions by comparing the results of both groups to determine whether participation in Math Boost-Up increased the test scores of students (experimental group) compared with the scores of the students who did not participate in the intervention but chose to study on their own (comparison group). Further, I analyzed the impact of the moderator variables (see Table 1) on the independent and dependent variables using nonparametric tests (Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square). Both groups of students had to retake the ACCUPLACER test. To minimize the risk of maturation, the posttest took place within 1 week after the intervention ended.

Population and Sampling Plan

The participants in the study were incoming students admitted to an open admissions community college in the Washington, DC, metropolitan area, and who had not achieved the cutoff scores on the ACCUPLACER test needed to enroll in a college-level mathematics course. The research design included a comparison group with nonrandom assignments, because in the research design methodology used, I naturally created the comparison group, supported by the element of choice.

A quasi-experiment research design also minimized the issues related to ethical dilemmas, as students self-selected to participate in the program or not, instead of being randomly assigned. Invitations went to approximately 1,500 students. Of this number, 250 students showed interest in participating in the program. However, only 136 students actually attended and completed the ACCUPLACER Diagnostics assessment. Of the 136 students who completed the ACCUPLACER Diagnostics, 44 students participated in the face-to-face session with Pearson’s MyFoundationsLab (Math Boost-Up) and 92 chose the online option to study on their own using Pearson’s MyFoundationsLab.

Role of the Researcher

The design also minimized the risk of bias, as I evaluated a program implemented as part of the college’s student success initiative, which I helped to develop. At the time of the development, I was a faculty member and coleader of the student success initiative at the college. I recognized the risk that my involvement at this level could potentially become a limitation of the study. However, I minimized the possibility of bias by using a quantitative methodology, not involving myself in the delivery of the intervention, and not supervising its implementation or the instructor who delivered the content. A faculty member supervised the implementation of the program and monitored activities related to the comparison group.

Definitions

The list of the terms and related definitions used throughout the study follows:

Age: In the context of this study, age refers to how old the participant was at the time of the pretest.

Cutoff scores: Also called cut scores, these are the results from a placement exam that determined the appropriate course level for a student (Scott-Clayton, 2012). The community college leaders established the cut scores for arithmetic and elementary algebra used in this study.

Developmental education: A set of courses that promotes the cognitive and affective development of students in postsecondary education to help them succeed not only in college-level courses such as mathematics and English but in college overall (Higbee & Dwinell, 1999).

Gateway courses: College-level or foundation courses relate to a program of study. Gateway courses are for college credit and apply to the course requirements of a degree program (Charles A. Dana CenterCharles A. Dana Center, Complete College America, Inc., Education Commission of the States, & Jobs for the Future, 2012).

High school grade point average (GPA): The average of the grades participants in both groups received upon graduation from high school or a GED program.

Length of time spent attending face-to-face sessions of Math Boost-Up: The days participants in the experiment group attended the face-to-face sessions.

Length of time spent in MyFoundationsLab: The number of hours and minutes participants in both groups spent completing the modules in MyFoundationsLab.

Math Boost-Up: The short-term refresher program that refreshed the mathematics knowledge and skills of students in face-to-face sessions, as well as in online modules, identified in MyFoundationsLab.

Mathematics knowledge and skills: What students know, understand, and are able to do in arithmetic and elementary algebra as measured by the ACCUPLACER test. Arithmetic knowledge has to do with knowing and understanding integers, rational numbers, real numbers, or complex numbers under addition, subtraction, multiplication, and division (College Board, 2012). Elementary algebra focuses on knowing and understanding concepts related to integers and rationals, algebraic expressions, equations, inequalities, and word problems (College Board, 2012).

Participant in Math Boost-Up: Students who completed the ACCUPLACER Diagnostics assessment, attended the face-to-face sessions, completed the computer-based interventions as prescribed by the Diagnostics, and agreed to retake the ACCUPLACER test.

Posttest scores: The scores participants in both groups received when they took the ACCUPLACER test the second time.

Pretest scores: The initial scores participants in both groups received on the ACCUPLACER test.

Programs of study: “A set of courses, learning experiences, and learning outcomes required for a postsecondary credential that are defined by academic departments within colleges and universities” (Charles A. Dana Center et al., 2012, p. i).

Remedial education: The courses that students must enroll in when they have not met the cutoff scores on placement exams. The courses are in mathematics, reading, and writing and prepare students for college-level courses in mathematics and English (Romano, 2011). Bettinger and Long (2008) used the definitions often used in the literature to describe remediation courses as courses that include material students must retake and developmental courses as courses that include material that is new to students.

Retention or retention rate: The percentage of students who enroll in classes from term to term. According to the Glossary section of Integrated Postsecondary Education Data System (IPEDS), retention is defines as the “percentage of first-time degree/certificate-seeking students from the previous fall who either re-enrolled or successfully completed their program by the current fall” (NCES, n.d.).

Underprepared: Students not adequately prepared to cope with college-level reading, writing, and mathematics (Dzubak, 2005).

Unprepared: A group of students who entered college not possessing the content knowledge and skills needed to cope with college-level reading, writing, and mathematics (Kurlaender & Howell, 2012).

I did not consider the principles of andragogy as constructs, and therefore I did not measure them. I used the following principles to help develop the design and implementation (Knowles et al., 2011):

Learner's experiences: Adult learners have prior experiences that they bring to the learning experience that the persons leading the experience must respect.

Motivation: External motivators such as a better job or increased salary drive adults to engage in a learning situation. But adults should also foster their internal motivators, such as job satisfaction or improving the quality of one's life.

Need to know: Adult learners need to know why they need to learn something.

Orientation to learning: Adults have a life-centered orientation to learning as opposed to children and youth who have a subject-centered orientation to learning. Adults "learn new knowledge, understandings, skills, values, and attitudes most effectively when they are presented in the context of the application to real-life situations" (Knowles et al., 2011, pp. 66-67).

Readiness to learn: Adult learners will learn the things they need to know that they feel will advance their purposes of engaging in the learning. The purposes might be to gain a promotion, obtain a better paying job, or increase knowledge and skills in an area of interest.

Self-concept: Adult learners feel responsible for making decisions that will affect their lives.

Assumptions

The following were some of the assumptions related to the study. I address how I checked for each assumption at the end of each assumption.

After seeing their scores on the ACCUPLACER, all students would decide whether to participate in the Math Boost-Up program. This could have been a possible sampling bias because students would self-select to participate in the program and assignment was not random. I addressed this assumption by maintaining a log of the students who were eligible to participate in the program but who chose not to participate in the Math Boost-Up Program or who decided to study on their own.

The students participating in the Math Boost-Up program would be self-directed and participate fully in the program, would attend most days, and would complete all the required computer-related activities between the face-to-face sessions. I addressed this assumption by maintaining attendance records. In MyFoundationsLab, the length of time students spent working on the modules is logged.

The students who agreed to retake the test and chose to study on their own (comparison group) would be self-directed and would take the time to complete all the modules in MyFoundationsLab needed to improve their ACCUPLACER test scores. I addressed this assumption by running reports on the length of time students in both groups spent on completing the modules in MyFoundationsLab.

The students who did not participate in Math Boost-Up (comparison group) would spend time completing the online modules in MyFoundationsLab identified by the Diagnostics program. I would analyze the relationship between length of time spent completing the online modules and posttest scores. I addressed this assumption by analyzing a report on the time spent on modules in the intervention, MyFoundationsLab, to compare the length of time spent on the modules with posttest scores.

All students would retake the test within 1 week from the end of the face-to-face session. I addressed this assumption by comparing the date of the posttest to the date each intervention session ended.

Race, ethnicity, and gender would have no impact on the pre- and posttest results of the study. I did not study these variables in this small-scale study.

The assumptions I identified here were elements that could have affected the results of the study and over which I had no control. I included them in this section to acknowledge their existence and explain how I addressed or controlled for them in the study.

Scope and Delimitations

Scope of the Research

During the research study I focused on a mathematics refresher course that had as its goal to increase the mathematics knowledge and skills in basic arithmetic and elementary algebra to a level that could raise the ACCUPLACER cut scores of students entering the community college. The goal of the study was to determine whether the mathematics intervention, Math Boost-Up, succeeded in raising the mathematics knowledge and skills of the students involved compared to students in the comparison group who did not participate in the mathematics intervention.

The study took place at an urban community college where approximately 96% of incoming students tested into at least one remedial course. The remedial course needed was often mathematics. Students who test into remedial courses are less likely to complete a program of study and graduate from college (Bailey, 2009a; Bailey et al., 2008; P. Jenkins & Cho, 2012; Sherer & Grunow, 2010). Completing some years of a postsecondary education or receiving a 2-year degree can make a big difference in a person's socioeconomic status (Calcagno & Long, 2008; Carnevale & Rose, 2011; Goldrick-Rab, 2010; Horn & McCoy, 2009; Hughes & Ritze, 2010). According to Carnevale et al. (2010), "Post-secondary education has become the threshold requirement for a middle-class family income" (p. 13). Furthermore, "by 2018, sixty-three percent of job openings will require workers with at least some college education" (Carnevale et al., 2010, p. 23).

Another reason for focusing on mathematics in the intervention was that the focus of much of the knowledge and skills assessed in the mathematics section of the ACCUPLACER test was content that students might have long forgotten (Bailey & Cho, 2010; Ewell, 2010; Vassiliou, 2011). I hoped that the mathematics intervention, Math Boost-Up, would be able to refresh the mathematics knowledge and skills of students, resulting in increased scores on the ACCUPLACER test.

Delimitations

I delimited the study to students who did not attain the cut scores needed to enroll in a community college's college-level mathematics course. Only students who had applied for fall 2014 entry into the community college and did not meet the cut scores for entry into college-level mathematics courses received an invitation to participate in the study.

I focused on the ACCUPLACER test only, and not the other placement tests: COMPASS and ASSET. The ACCUPLACER test is the only test used at the community college where the study took place. Additionally, I focused on the mathematics sections of the test and not on the English sections because more students across the country test into remedial mathematics than into remedial English (Donovan & Wheland, 2008; Medhanie, Dupuis, LeBeau, Harwell, & Post, 2011). At the community college where this study took place, 96% of incoming students entering the fall 2013 semester tested into remedial mathematics courses.

I did not include the impact of the students' English language skills, gender, race or ethnicity, or learning disabilities on the performance on the ACCUPLACER test in the study. I recognize the potential impact of these variables on the mathematics knowledge and skills of students as measured by the ACCUPLACER. Studying the impact of these variables was beyond the scope of this study but researchers should explore it in future research studies.

Generalizability of the Study

I addressed the performance on the ACCUPLACER in the results of the study. Therefore, I limited the potential generalizability only to those colleges where college personnel used the ACCUPLACER to determine readiness for college-level mathematics courses and who use a similar research design and methodology to evaluate the impact of a mathematics refresher program on incoming students. This was also one of the limitations of the study and posed a threat to external validity.

Limitations

Limitations of the Study Related to the Design

A limitation of this study was the quasi-experimental design as opposed to assigning participants to groups by random assignment. However, random assignment was not possible because the leaders of the community college at which this study took place would not permit random assignment for ethical reasons and preferred participants to self-select into any intervention. Using a quasi-experimental design that does not involve randomly assigned participants, as opposed to a true experimental design that does involve randomly assigned participants, could result in or cause difficulty in controlling for the influence of variables that could pose threats to internal and external validity (Christensen, 1997).

Although these threats to internal and external validity might cause some researchers not to consider quasi-experimental designs as valid as true experiments, Shadish et al. (2002) contended that "in the best of quasi-experiments, internal validity is not much worse than with the randomized experiment" (p. 484). Using a design that matched as closely as possible the requirements of a true experiment would minimize the threats to internal and external validity (Christensen, 1997; Shadish et al., 2002). Shadish, Galindo, Wong, Steiner and Cook (2011) found that although researchers preferred randomized studies were over nonrandomized experiments, they could still with confidence conclude that the results yielded from these types of experiments were accurate.

Another limitation was that because of the inability to randomly assign participants to the experiment and comparison groups, I could not make claims that the Math Boost-Up program caused posttest scores to increase. Additionally, I was not able to state conclusively whether face-to-face instruction or time spent in MyFoundationsLab or both caused increases in scores. I could state claims of association between the two constructs but could not make definitive statements related to causality.

In the proposal, I indicated that a sample size of 152 participants was necessary to achieve an effect size of .20 (Cohen's *d*) at 80% power. I derived this number from the G*Power statistical analysis program. Because students self-selected to participate in the study, I knew that less than 152 participants were likely to volunteer for the study or that there might be uneven numbers between the two groups. This was a limitation of the study, and I closely monitored every recruitment effort to minimize the impact of low or uneven participation. Despite the scrutiny of the recruitment process, the study ended up with 136 participants, with 44 students in the Math Boost-Up program (experimental group) and 92 in the online-only program (comparison group).

Another limitation was my inability to control the amount of time that participants in the comparison group spent on completing the modules in MyFoundationsLab. Faculty leading the intervention strongly encouraged both groups to complete the modules in MyFoundationsLab. Faculty in Math Boost-Up monitored students' activities in MyFoundationsLab and scheduled time in the computer labs as part of the face-to-face sessions. Using a quasi-experimental design was a limitation of the study with regard to causality; other biases discussed below were limitations to the study as well.

Biases That Influenced the Study

Quantitative researchers such as Shadish et al. (2002) and Johnson and Christensen (2004) identified five potential biases associated with the quantitative quasi-experimental nonequivalent comparison group research design chosen for this study. The potential biases to the internal and external validity of the study were selection, maturation, instrumentation, history, and regression. A detailed description of each bias and the way I handled each one appears in Chapter 3.

Measures to Address Limitations

Quasi-experimental designs are not strong in controlling for internal validity, but researchers can resolve threats to external validity by conducting studies in a natural setting (Shadish et al., 2002). I monitored these elements carefully to ensure they did not affect the integrity of the study. I used nonparametric tests (Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square) to measure the effects of the moderator variables listed in Table 1 on the dependent variable mathematics knowledge and skills. A detailed description of how I addressed threats to internal and external validity appears in Chapter

3. The measures I used to determine effect size and the plan handling missing data also appear in Chapter 3.

Significance

Contributions of the Study in Advancing Knowledge About Refresher Programs

According to Bailey and Cho (2010), 60% of the students who take placement exams test into one or more remedial course. Belfield and Crosta (2012) revealed that this percentage could reach as high as 90% at some community colleges. Reportedly only 42% of students who take any of the placement exams used to determine readiness for college level work, actually enroll in remedial courses (NPSAS, 2007-2008). Of this number, only 17% go on to graduate (NCES, 2009). Researchers for the Alliance for Excellent Education (2011) and Complete College America (2012) estimated the cost of remediation to be approximately $5.6 billion each year.

This study is significant because it fills the gap in the research literature that addresses sound, empirically validated experimental studies that provide clear evidence of the success of short-term intensive mathematics refresher programs to move students out of remedial and into college-level mathematics courses. These placement test preparation programs can play a strategic and critical role in reducing the number of students who need remediation courses in mathematics. Through the study of the effectiveness of boot camps in preparing students to increase their knowledge and skills in mathematics, the study contributes to the social change mission by indicating how successful these short-term refresher programs are in helping students bypass remedial courses.

Contributions of the Study to Policies and Practices Related to Refresher Programs

Community college leaders need better evidence that programs that refresh the mathematics knowledge and skills of students actually work. Scott-Clayton (2012) noted that consistent efforts to prevent students from having to enroll in remedial courses could result in a substantial reduction in remediation rates by 8% in math and 12% in English. Sherer and Grunow (2010) confirmed that focusing on short, intensive programs was important.

Implications for Positive Social Change

The study will contribute to the social change mission in that it adds to the research literature on the effectiveness of strategies on helping students to achieve higher scores by preparing students to take the math section of the ACCUPLACER placement test. By reducing the number of students who test into remedial courses, the Math Boost-Up and similar programs would help to ensure students enroll in the course levels that more accurately represent their knowledge and skills and would have positive effects on the persistence, retention, and completion rates of students in community colleges across the United States. Federal regulations that became effective in fall 2012 limited the amount of the Pell Grant award to 18 full-time quarters or 12 full-time semesters, which adds to the social significance of this study (Federal Student Aid, n.d.). Even though the focus of the intervention was increasing students' scores on the mathematics section of the ACCUPLACER test, the information gleaned from this study resulted in strategies for increasing the mathematics test scores of students across all the placement tests used in community colleges to determine entry into college-level mathematics courses.

Summary

In this chapter, I introduced the study on the effect of an intervention, Math Boost-Up, on the ACCUPLACER mathematics test scores of incoming community college students. The goal of the study was to determine whether the intervention increased the test scores of students who chose to participate in the intervention compared to the test scores of students who agreed to a retest but chose not to participate in the Math Boost-Up program. The students who chose not to participate in the study completed the modules in the online program, MyFoundationsLab, that the ACCUPLACER Diagnostics program identified as being weak areas in their mathematics knowledge and skills.

In addition, this study was necessary to provide empirical evidence regarding whether a statistical and meaningful difference exists in the test scores of students who chose to participate in the intervention and those who did not. I used a quantitative quasi-experimental design nonequivalent comparison group research design with cutoff assignments because random assignment was not possible. The results of the study shed light on the effectiveness of these short-term mathematics refresher programs in increasing the ACCUPLACER test scores of students and enabling them to test into college-level math or a higher level remedial course. The research study has social significance in that it can contribute to the social change mission of any community college whose leaders wish to increase the numbers of students who persist in earning a degree or certificate and provide hope to those otherwise relegated to the ranks of the low-income population and the underclass if they are not able to complete a degree or certificate program.

In Chapter 2, I provide an overview of the current research literature related to short-term intensive placement test preparation programs in general and the elements of the theoretical framework, andragogy, specifically self-direction and motivation, for this study. The chapter also includes a review of research related to the impact of the intervention Math Boost-Up (independent variable) on mathematics knowledge and skills (dependent variable) as measured by the ACCUPLACER test. I also provide a review of the research related to the impact of the moderator variables listed in Table 1 on the mathematics knowledge and skill of the students. I conclude the chapter with a discussion of the major themes found in the literature, the gaps, and the ways the research fills one or more of the gaps.

Chapter 2: Literature Review

Introduction

Community college leaders face the task of having to ensure all students are ready to succeed in college-level courses, specifically English and mathematics. An open admissions policy could make this task more arduous when students enter lacking college-level academic skills. To accomplish this task, community college leaders have embarked on a path of placement testing and remedial education that has not yielded favorable results regarding persistence, retention, completion, and graduation rates.

Approximately 60% of incoming students do not meet the qualifying scores needed to enroll in college-level mathematics and English courses and instead must enroll in one or more non-credit-bearing remedial courses, which often leaves students frustrated and demoralized (Bailey, 2009; Bailey & Cho, 2010). Based on the disappointment that results from not being able to enroll in college-level courses, reportedly only 42% go on to enroll in remedial courses (NPSAS, 2007-2008). The others decided either to abandon or to delay their plans to enter college, as they do not want to spend the additional money or time, especially when the remedial courses do not count toward degree completion (Kuh et al., 2006; P. Jenkins & Cho, 2012; Sherer & Grunow, 2010; Tait-McCutcheon, 2008).

Of the students who decide to stay on, approximately 17% complete their programs of study and receive an associate's degree or certificate of completion (NCES, 2009). Bailey et al. (2008) reported that fewer than 10% of students who placed into the lowest level of remedial math completed the remedial course sequence and enrolled in college-level, credit-bearing math courses. Researchers from many organizations such as Complete College America and Achieving the Dream have characterized the cycle of placement testing, remedial education, and subsequent dropping out as “Higher Education’s Bridge to Nowhere” (Adams, Franklin, & Gulick, n.d.). Sugar (2010), from Complete College America, noted, “Access without success is an empty promise—and a missed opportunity with severe economic consequences for students, states and our country” (p. 31).

After students take remedial courses, they are not likely to persist to graduation (e.g., Bailey, 2009; Bailey et al., 2008; Chung & Chung, n.d.; Hodara et al., 2012). Therefore, this research study was necessary for two reasons. First, I determine whether short-term mathematics refresher programs, referred to in the literature as math boot camps, are effective in increasing the mathematics scores of students on the placement tests. Second, as outlined by Christensen (1997), the study includes sound and empirically derived evidence regarding the effectiveness of these programs in accomplishing the aforementioned task. According to Sherer and Grunow (2010), the short-term intensive programs were worthwhile investigating because they have the potential to move a large number of students into college-level courses or further along the remediation education continuum. The study adds to the research literature with information related to the effect size needed to determine the magnitude of the effect of the intervention on posttest results.

I conducted the study to add to the social change mission and to address a gap in the research literature by providing empirical evidence of the ability of short-term refresher programs to increase the test scores of students on the mathematics section of placement tests. An increase in test scores may result in more students testing out of remedial mathematics courses. When students test into college-level courses or into a higher level remedial math course, they shorten the time needed to complete a degree, and the student is more likely to persist to graduation.

The next sections of Chapter 2 include an overview of the strategies that I used to locate research studies related to this study; the theoretical framework, andragogy, used to guide the study; an analysis of information in the research literature related to the hypothesis that a Math Boost-Up intervention would increase the ACCUPLACER mathematics scores of incoming students; and the relationship between the independent variable (Math Boost-Up) and dependent variable (mathematics knowledge and skill) as measured by the ACCUPLACER. The chapter ends with a summary and discussion of the major themes found in the literature that provided insight into where the gaps were and future research needed to expand knowledge about the effectiveness of mathematics boot camps.

The reason for math boot camps is to increase the mathematical knowledge and skills of incoming freshmen to a level wherein students can increase the scores they receive in basic arithmetic and elementary algebra on the ACCUPLACER test. By virtue of their participation in the intervention, Math Boost-Up, I hoped students would be able to test out of remedial math courses and into a college-level math course or test out of basic mathematics and into the higher level remedial course, that is closest to the college level course.

Literature Search Strategy

I conducted an exhaustive search of electronic databases available through the Walden and the University of the District of Columbia libraries, in order to find research articles related to the subject of the study, mathematics boot camps. Through my access to the University of the District of Columbia library, I also had access to resources at the eight other university libraries that comprise the Washington Research Library Consortium. Specific databases accessed included Education Resource Information Center (ERIC), Education Research Complete, Education: SAGE Full-Text, JSTOR, and Academic Search Complete/Premier. I identified dissertations similar to the topic of this study by accessing the ProQuest database, the Dissertation and Thesis database, and education dissertations indexed in ERIC.

From this search, I compiled a list of articles on the topic of this research study. I started out by using very general terms such as studying for the placement test, problems with the placement tests and improving placement test scores. Because these terms yielded few results, I expanded the search to include Google Scholar; Google; and community college research organizations such as the American Association of Community Colleges, Community College Research Center, Complete College America, Achieve, National Center for Developmental Education, National Center for Postsecondary Research, Achieving the Dream, and Indiana Pathways to College Network. Using the electronic databases, search engines, and research organizations that have community college issues as their focus, I compiled search terms that covered the global aspect of community college placement test preparation programs. I started out by using search terms such as *placement testing, placement testing at community colleges, reasons students fail placement tests, do preparation programs help, issues with placement tests, problems with placement tests,* and *MyFoundationsLab and placement tests*. I then expanded the search terms to include *Accuplacer, Accuplacer testing, COMPASS, boot camps, ASSET, math boot camps, bridge programs, persistence, retention, graduation rates and community colleges, development education programs, remedial education, remedial courses and mathematics,* and *test preparation and community colleges.* Because of limited results from these database resources, I used the terms to search within journals such as the *Journal of Developmental Education, Community College Journal of Research Practice,* and *Research in Developmental Education*.

In conducting the literature search, my primary focus was on peer-reviewed, full-text articles dating from 2007 to 2013. I used the same databases and search engines to search for literature related to the adult learning theory andragogy. Some of the terms used were *adult learning theory, teaching adults, adults and learning, andragogy, motivation, self-directed learning, andragogy and Malcolm Knowles, andragogy and community college students, andragogy and boot camps, adult learning and boot camps,* and *adults learning and mathematics*. I began by focusing on research literature from 2007 to 2013 but had to expand the search to include literature prior to 2007. I read books by Malcolm Knowles and other leading experts on the subjects of andragogy and adult education theories such as Sharan Merriman and Rosemary Caffarella **,** John Henschke (who studied with Knowles), Allen Tough and Cyril Houle.

As I previously indicated, research on the subject of boot camps and preparing community college students to take placement tests was lacking. An expanded search that included SAT and ACT preparation also yielded limited results. Because of the limited research on the subject, I decided to search the websites of community colleges that indicated that they provided placement test preparation programs. This search revealed that although many community colleges provided these programs, the results they reported included only the number of persons who participated in the program and the number of participants who increased their scores and tested into higher level mathematics courses (Barnett, Bork, Mayer, Pretlow, Wathington, & Weiss, (2012); Barns & Suess, 2010).

More research exists on testing students while they are in high school and using these results to fill the gaps in knowledge and skill while they are still in high school (Safran & Visher, 2010; Sherer & Grunow, 2010) than on short intensive mathematics placement test preparation programs of the type studied in this study. The strategy of testing and remediating mathematics knowledge and skills while students are still in high school was at the top of the agenda of Achieve, an organization with a focus on ensuring that students leave high school ready for college, careers, and citizenship. Achieve personnel work with representatives in school systems across the United States to "build measures of college and career readiness into their high school assessment systems to determine whether students are on track for credit-bearing postsecondary courses and careers before their senior year" (Achieve, 2011, para. 1.

Using the strategies discussed above yielded 1,133 articles. From this set, I selected 654 articles that related to the theoretical and design frameworks, hypotheses, and independent and dependent variables of this study. I also reviewed 15 dissertations related to the study, primarily for additional resources and research design options.

Theoretical Foundation

The basis of the theoretical foundation of this study was the core adult learning principles advanced by Knowles (Knowles et al., 2011). Andragogy served to inform the framework for designing and implementing the Math Boost-Up program. I did not consider the principles of andragogy as constructs to study but used them to develop the design and implementation of the study. The principles or assumptions that underlie Knowles's theoretical framework are as follows (Knowles et al., 2011):

1. Need to know: Adult learners need to know why they need to learn something before they engage in a particular learning activity.
2. Self-concept: Adult learners feel responsible for making decisions that will affect their lives.
3. Learners' experiences: Adult learners have prior experiences that they bring to the learning experience and that the persons leading the experience must respect.
4. Readiness to learn: Adult learners will learn the things they need to know that they feel will advance their purposes of engaging in the learning. These purposes might be to gain a promotion, obtain a better paying job, or increase knowledge and skills in an area of interest.

5. Orientation to learning: Adults have a life or problem-centered orientation to learning, as opposed to children and youth who have a subject-centered orientation to learning.
6. Motivation: External motivators such as a better job or increased salary might motivate adults to engage in a learning situation, but learners should foster in themselves, internal motivators such as job satisfaction or improving the quality of one’s life.

To understand the research related to andragogy, a discussion about its origin, theoretical propositions, and assumptions was necessary, as it provided a context for understanding why andragogy was appropriate as a framework for this study and its application.

Origins of Andragogy

In the literature on andragogy, adult education, and adult learning theory, researchers often refer to Knowles as the father of andragogy, adult learning, and adult education (Clardy, 2005; Elsey & Henschke, 2011; Henschke & Cooper, 2006; Knowles, 1995; Misch, 2002). Dutch adult educator Ger van Enckevort, who Knowles, Holton, and Swanson (2005) acknowledged as having written the “most exhaustive study of the origins and use of the term andragogy” (p. 59), traced the term back to 1833. According to van Enckevort (as cited in Knowles et al., 2005), Alexander Kapp, a German schoolteacher, first used the term in the book entitled, *Plato’s Erziehungslehre* (*Plato’s Educational Ideas*). In the book, Kapp explained Greek philosopher Plato’s view of education as being one of life-long learning, as well as his own view that teaching adults differed from teaching children because adults learn primarily through self-reflection and life experiences, which is something that children would have difficulty doing (Knowles et al., 2011; Reischmann, 2004).

Years later, according to van Enckevort (as cited in Knowles et al., 2005), Johan Friedrich Herbart, a well-respected philosopher, opposed the use of the term andragogy. The term disappeared from use for almost 100 years until it resurfaced in 1921. Rosenstock (1921) contended andragogy was more than just a term to distinguish the teaching of adults from the teaching of children. Rosenstock posited that the term denotes a far deeper meaning having to do with the conditions under which adults learn best and that the relationship between teacher and student is one of coach or collaborator. From 1951 to 1966, the term appeared in a number of books and dissertations throughout Europe, in countries such as France, Germany, Yugoslavia, Russia, and Britain (Henschke, 2010).

In the United States, Eduard Lindeman and Martha Anderson first used the term andragogy in 1926 and 1927 (Esposito, 2005). Knowles later popularized its use in 1967 in an article titled, “Androgogy, not Pedagogy” (Knowles et al., 2005). Introduced to the term by the Yugoslavian adult educator Dusan Savicevic, Knowles actually spelled the word incorrectly and later corrected the spelling of the word after consulting with Merriam-Webster. According to Knowles (1980), andragogy is “the art and science of helping adults learn” (p. 43), which differs from the term pedagogy, which is the “art and science of teaching children” (p. 43). In higher education, researchers commonly use pedagogy to describe teaching strategies for teaching adults to learn. However, the term has expanded to include strategies related to andragogy. In addition to the differences in definition, differences also exist in the assumptions that underlie each of the terms. The assumptions of each approach and the differences between the two appear in the next section.

Theoretical Propositions and Assumptions

Six assumptions or principles are at the core of Knowles et al.'s (2005) andragogical framework that articulate how best to support adult learning. The six assumptions are (a) adults need to know what they need to learn and why they need to learn it; (b) adults are different from children in that they determine what it is they need to learn because of their life or work experiences, and so they are more self-directed than children and take responsibility for their own learning; (c) adult learners feel motivated to learn for a variety of reasons that are both external and internal; (d) adult learners learn new concepts in the context of prior experiences; (e) adult learners learn whatever they need to learn to be more effective on the job or in related real-life situations; and (f) because of the aforementioned assumptions being a part of what the teacher or facilitator creates in the learning experience, adults become motivated to learn (Knowles et al., 2011).

The theory of andragogy was not without criticism. When Knowles popularized andragogy as an adult learning theory in the early 1970s in the United States, he received a lot of criticism and debate from several leading adult learning educators, such as Merriam, Pratt, and Brookfield, who referred to andragogy as a set of guidelines, a philosophy, and assumptions, respectively (p. 1). Houle, who taught Knowles in graduate school, was among the first to criticize Knowles and referred to andragogy as a set of techniques (as cited in Davenport & Davenport, 1985, p. 153). Davenport and Davenport (1985) also noted that researchers referred to andragogy in the literature as being "a theory of adult education, theory of adult learning, theory of technology of adult learning, method of adult education, technique of adult education, and a set of assumptions" (p. 157). Knowles's (1980) definition of andragogy as "the art and science of helping adults learn" (p. 43) received a lot of criticism from Merriam et al. (2007), Pratt (1993) and Rachal (2002), who argued that andragogy was not measurable and therefore was not really a science (Taylor & Kroth, 2009). Rachal (2002) further maintained, "Due to the elasticity of meanings of andragogy and the consequent variability of interpretations, empirical examinations of andragogy—its science . . . have tended to be inconclusive, contradictory, and few" (p. 211). The information that predominates in the literature related to andragogy is mostly anecdotal (Taylor & Kroth, 2009). Empirical evidence of the efficacy of andragogy as the science of helping adults learn is lacking, as maintained by Knowles (Quinney, Smith, & Galbraith, 2013). Blondy (2007) noted that the criticisms continued to prevail because teachers of adults developed the theory of andragogy based on experience, observations, and many theories, some of which were pedagogical (Blondy, 2007; Knowles et al., 2005).

Merriam (2001) maintained that no one theory or model that could explain how adults learn, how teachers should teach them, and the various processes that adults go through to learn. After much controversy and debate, Knowles (as cited in Merriam, 2001) reached the conclusion that andragogy was more of "a model of assumptions about learning or a conceptual framework that serves as a basis for an emergent theory" (p. 5).

Andragogy serves as a foundation for developing effective learning processes for adults in any adult educational setting by adhering to the core principles of adult learning advanced by Knowles (Knowles et al., 2011). Knowles (2011) indicated researchers should refer to the six assumptions that underlie andragogy as principles of adult learning.

Despite the controversy, andragogy has provided a model for faculty who teach adults to help adults construct knowledge and understanding out of any learning situation. In discussing the controversy, Merriam (1993) concluded,

> It is doubtful that a phenomenon as complex as adult learning will ever be explained by a single theory, model, or set of principles. Instead, we have a case of the proverbial elephant being described differently depending on who is talking and on which part of the animal is examined. . . . Where we are headed, it seems, is toward a multifaceted understanding of adult learning, reflecting the inherent richness and complexity for the phenomenon. (p. 12)

Whether or not researchers consider it a theory, andragogy serves as a sound framework for the development, design, and implementation of the Math Boost-Up program. As noted by Merriam (2001), andragogy has endured as the best and most popular theoretical framework when designing studies and programs having to do with adult learning (Merriam, 2001).

Review of the Literature and Research on Andragogy

The aim of the study was to determine whether short-term intensive mathematics boot camps can increase the mathematics knowledge and skills of students to a level that would result in them testing into college-level mathematics courses or into higher level remedial mathematics courses. Andragogy aligns best with the goals and purposes of programs that help adults succeed because its focus is the strategies related to how to help adults learn, as opposed to pedagogy, which has the teaching methodologies used when working with children as a focus (Cooke, 2010; Finn, 2011; Galbraith, 2010; Galbraith & Fouch, 2007). The principles of andragogy help faculty become facilitators of the learning process and develop a close working relationship with the learners based on mutual respect (Bear, 2012; Boden et al., 2008). Viewing learners as capable and able to take control of their own learning would help faculty members accept their roles as cocreators of the learning situation with students and more accepting of their roles as coaches and not as sages on a stage, which they would be if they used pedagogical approaches to teaching (Cooke, 2010; Finn, 2011).

Studies in which researchers have applied and used andragogy to enhance learning in the college classroom as well as in programs in which adults enroll have yielded successful results, thereby confirming the reliability and validity of an andragogical approach to teaching and learning (Henschke, 2010). According to Savicevic (2006), researchers can validate the underlying assumptions of andragogy in empirical research. The studies that used andragogy as their theoretical framework have affirmed that the six assumptions that underlie Knowles's theory of adult learning can provide a sound framework for any study that involves adult learners (Baumgartner, 2008). However, even when using andragogy as a theoretical framework, many researchers focused their studies on one or both of the main elements of Knowles's six assumptions: self-directed learning and motivation. The research studies discussed in this chapter serve as examples of how an andragogical approach can work to engage more adults in learning and provide a context for understanding why and how faculty who teach adults could and have used an andragogical approach to design and implement programs such as Math Boost-Up. Especially the learning situations in which adults must play an active role in their own learning. The discussion moves from the general to the specific, first with a focus on those studies that had the general framework of andragogy and then to those studies that focused on the impact of self-directed learning and motivation.

Andragogy in general. Woodard (2007) used andragogy as the framework to redesign a training program for new hires. Participants completed a pre- and postsurvey of their perceptions of the course. The results from previous evaluations of the course indicated that participants felt the training did not adequately prepare them for the work they had to do. Participants in the redesigned training program reported that the training was engaging and their knowledge and skills related to the job responsibilities increased. Woodard attributed the participants' perceptions related to the effectiveness of the new training to using andragogy as the framework for the redesign.

Johnson and Wisniewski (2012) proposed that while theorists may not consider andragogy to be a learning theory, it could be an instructional design theory. Johnson and Wisniewski posited that andragogy should serve as a framework for developing professional development programs, particularly those designed to help faculty adopt the use of instructional technology in the classroom. According to Johnson and Wisniewski

(2012), an andragogical approach would help faculty to "better comprehend the appropriateness and usefulness of instructional technology, and as a result, demonstrate less resistance to technology adoption in teaching" (p. 64). Johnson and Wisniewski used andragogy and the transfer of learning theory to develop a 3-day boot camp for faculty to help them learn to use the technologies needed in an online environment. The results of the survey indicated that the "Boot Camp was successful in increasing the number of faculty who use technology by about twenty-five percent" (p. 64). Johnson and Wisniewski concluded, "When faculty understand the principles of andragogy and integrate them into their teaching, they can more easily transfer this knowledge to enhance the learning environment with technology and be successful" (p. 64).

Using the Turkish version of the Educational Orientation Questionnaire developed by Christian in 1983, Deveci (2007) found that 60 adults in an English language class in Turkey benefited from both pedagogical and andragogical strategies. Moreover, Devici found that "learners with an andragogical orientation expect the teacher to provide an environment that enhances learning, have at least some control over the process of learning, and encourage higher levels of self-direction" (p. 18). A number of researchers have addressed this aspect of the self-directed nature of adults that also underlies one of the six assumptions of andragogy. Knowles (1975) defined self-directed learning

> as a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying

> human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes. (p. 18)

Brockett and Hiemstra defined self-directed learning as a "process in which a learner assumes primary responsibility for planning, implementing, and evaluating the learning process (as cited in Owen, 2002, p. 24). Many researchers agreed that a self-directed learner had a good chance of doing better in any learning situation than a learner who relied on the teacher to provide all knowledge and information about a particular concept or topic (Bear, 2012; Chou, 2013; Edmondson, Boyer, & Artis, 2012; Francis & Flanigan, 2012; Garst & Ried, 1999; Harper & Ross, 2011; Quinney et al., 2013; Wichadee, 2011).

Self-directed learning. In a learning situation in which self-direction served as the design framework, control over the learning situation lay with the learner and as a result yielded positive results for both learners and teachers (Meredith & Lowry, 1989). Self-direction was a key assumption of Knowles and referred to the belief that as individuals become more mature, they learned best when allowed to take control of their own learning (Merriam, 2004). A connection existed between the need to be in control and the learner's self-concept and motivation to learn (Knowles, 1980). According to Knowles (1996), when adult learners had the opportunity to be self-directed, they had a tendency to become motivated to learn and became confident in their ability to learn (Knowles, 1996). Self-directed learners were independent, took the initiative to learn something, persisted in learning it, were self-disciplined, were confident in their abilities to learn, and wanted to learn more (Owen, 2002). These were the same characteristics that faculty aimed to nurture in the participants in the Math Boost-Up program by applying the principles of andragogy. Researchers such as Chou (2013), Koski, Kurhila and Pasanen (2008), and Edmondson et al. (2012) conducted studies that highlighted the impact of designing learning programs that had self-directed learning as the organizing framework. A discussion of each study follows. Before discussing these studies, I will put the discussion in context by briefly describing the pioneering work on self-directed learning that Allen Tough began studying in the 1960s.

In many of his books, Knowles referenced and gave Tough's work credit for helping him advance one of the assumptions related to self-directed learning discussed in the previous paragraph. Tough (1978) maintained that adults take time to explore various learning projects that are of interest to them. Tough defined a learning project as "a highly deliberate effort to gain and retain certain definite knowledge and skill, or change in some other way" (p. 250). According to Tough, adults around the world engage in these various projects developed by institutions or planned by adults themselves or by peers. Based on survey results, Tough found that more than 70% of the adults surveyed engaged in projects of their own choosing. Each project was approximately 100 hours long. Tough found that adults spent an average of 500 hours each year on these projects. The results of the survey led Tough to conclude that it was natural for adults to be self-directed in their learning efforts. Tough (2002) found that in 30 years of research on the subject, 90% of adults chose to engage in some type of informal or self-directed learning activity that was of their own choosing. The natural inclination to be self-directed motivates adults to learn and persist with tasks that are of interest to them. Therefore, the strategy to have adults self-select to participate in the Math Boost-Up program fostered the qualities of self-direction and motivation.

The studies discussed below serve as evidence of adults' natural inclination to be self-directed, which resulted in students becoming more motivated to learn, persist with completing difficult tasks, and take responsibility for their own learning. As self-directed learners, students receive encouragement to seek out knowledge and strategies that could help fill gaps in their current knowledge and understanding (Koski, Kurhila, & Pasanen, 2008), all under careful guidance and support from faculty.

Using a qualitative design, Chou (2013) examined the extent to which self-directed learning affected academic performance in online graduate-level courses. Based on the course structures, students had to use their time wisely, find solutions to their own problems, and find and use resources to support class activities and course requirements. The results of the study indicated a direct correlation between high achievement and high levels of self-directedness (Chou, 2013). Chou also noted a high level of motivation to complete assigned tasks despite heavy course loads and other competing priorities. Most of the students commented that they learned more in the online course than in the face-to-face course. The students attributed this to having to conduct research on their own and to having to dig deeper into the course content to develop a better understanding of course concepts. Moore and Kearsley (as cited in Chou, 2013) found that in a learning environment that promoted self-direction, learners "design their own learning objectives, identify resources that will help them achieve their objectives, choose methods to achieve the objectives and test and evaluate their performances" (p. 120).

Koski et al. (2008) investigated the use of Lego Mindstorms robots to help students learn about artificial intelligence in a computer science course. The instructor chose three different settings to test the teaching strategies based on self-directed learning theory. Course outcomes called for students to "understand subjects such as theoretical aspects of computation, algorithmic reasoning and intelligence of machines" (Koski et al., 2008, p. 2). With the help of the robots, the students learned basic programming, computing, and controlling skills. Students had to program the robots to find characters on a grid and navigate their way around a room with obstacles on a circular path (Koski et al., 2008). The students reported that because the instructors made them take responsibility for their own learning, they had to find solutions to their own problems. Similar to the students in Chou's (2013) study, they had to seek out resources beyond the textbook to help them complete their assignments. Koski et al. reported that the students felt more motivated to learn and they learned more about programming on their own than they would have had the instructor taught them. The instructors were also impressed with the level of success students achieved in the class, even in the areas considered too difficult for students to learn on their own (Koski et al., 2008).

Edmondson et al. (2012) conducted a meta-analysis of 36 studies to determine the correlation between self-directed learning and five constructs. The constructs were academic performance, future aspiration, creativity, curiosity, and life satisfactions. The relationship between self-direction and these five constructs underwent an examination in the context of marketing and business education. The meta-analysis of the articles revealed that self-directed students were more curious, creative, resourceful, and likely to realize their full potential. Moreover, self-directed students had a higher commitment and felt more motivated to acquire the knowledge and skills needed to achieve their educational goals than other students. The more the students became self-directed, the more they became committed to learning topics that helped to further their professional goals and aspirations. As a result of this positive and significant relationship between self-directed learning and the five constructs, Edmonson et al. concluded that faculty members should intentionally plan activities that help students become self-directed learners.

Motivation. The studies discussed above provided evidence that self-directed learners are independent, willing to take the initiative in pursuing their educational and professional goals, persistent and driven to succeed, self-disciplined, self-confident, and always eager to learn (Cercone, 2008). Knowles et al. (2005) recognized that self-directed learning played a critical role in adult education and included this element as one of the six assumptions or principles in helping adults learn. In addition to self-direction, another element that Knowles et al. (1998, 2005) believed provided the impetus for adults to become self-directed was motivation. Self-directed people must also have motivation (Pew, 2007).

Brennen (as cited in Pew, 2007) defined motivation as “the level of effort an individual is willing to expend toward the achievement of a certain goal” (p. 14). Gom (2009) believed motivation was inherent in all human beings and was the driving force in adult learning. As the sixth assumption, Knowles et al. (2005, 2011) explained that internal as well as external factors motivated adults to learn. Some of the external factors are “better jobs, promotions, and higher salaries” (p. 68). Some examples of internal factors are “the desire for increased job satisfaction, self-esteem, and quality of life” (p. 68). Researchers referred to the external factors in the literature on motivation and self-determination theory as extrinsic motivation and the internal factors as intrinsic motivation (Gom, 2009; Pew, 2007; Ryan & Deci, 2000).

Although adults differed in their levels of motivation to learn and participate in programs that might be of benefit to them, knowing what factors motivated the individual was key to understanding why some adults engaged in learning activities and others did not (Gom, 2009). Gom (2009) contended that it was critical that teachers understand why a learner decided to participate in a particular learning situation. Based on this understanding, the teacher would be in a better position to facilitate and optimize learning. According to Gom (2009), “with extrinsic motivation, learners are motivated to learn to achieve rewards or avoid punitive actions. With intrinsic motivation, learners are motivated to learn because of the personal satisfaction gained from acquiring new knowledge or skills” (p. 23). For Math Boost-Up, students might have felt motivated to participate in the refresher program for extrinsic reasons having to do with acquiring better pay, retaining Temporary Assistance for Needy Families (TANF) benefits, or competing for a promotion. Completing their degrees or certificates faster would provide an incentive to want to avoid having to take remediation courses for 1 year. The teacher as facilitator would acknowledge these extrinsic factors while emphasizing the long-term benefits related to participating in the program. The teacher or facilitator will emphasize the benefits of acquiring a degree, such as improving their socioeconomic position in society or being a role model for their children and family members in an effort to foster the development of intrinsic motivation in students. These intrinsic factors would help students persist in the program. Intrinsic motivation sustains a student over time, especially in times when they feel overwhelmed, as it helps them persist in pursuing their educational goals and sustains the reason why they decided to pursue a higher education (Pew, 2007).

To determine which strategies worked best to help students become motivated to succeed in their learning activities, Hussain (2013) analyzed the results of a survey of students' reflections on the types of support that tutors provided in a distance education program and reported that students cited four factors that affected their success. First, tutors were supportive and encouraged students to access additional resources; second, in times when students encountered difficulties in understanding a particular concept, the students received encouragement to relate the new learning concepts to real life or prior experiences; third, the tutors provided support to students based on the individual learning needs and technological skills of each learner; and fourth, the facilitators were encouraging and respectful (Hussain, 2013). These factors taken together encouraged the learners to acquire the knowledge and skills needed to succeed in the course.

Wheaton and Toya (2012) and Wichadee (2011) reported that motivation is key to help students become self-directed in acquiring the knowledge and skills needed to increase their writing and reading proficiencies. Additionally, Voode (2009) found that in training police cadets, motivation, as it relates to self-directed learning, was a critical factor in increasing the knowledge and skill of cadets while they were undergoing training. The researchers of the study acknowledged that intrinsically motivated learners were more likely to succeed than extrinsically motivated learners. Ormrod (as cited in Vodde, 2009) explained that extrinsically motivated students usually exerted minimal effort in pursuing the learning objectives of the course, “while intrinsically motivated learners are more likely to be cognitively engaged, pursue tasks on their own initiative, evidence persistence, learn in a more meaningful way, and overall, experience pleasure in what they are doing” (p. 57). Researchers cited these elements as characteristic of all learners and important factors to consider in planning activities, especially when andragogy serves as the framework for designing learning programs that involve adult learners (Gom, 2009; Pew, 2007; Vodde, 2009; Wheaton & Toya, 2012; Wichadee, 2011).

In conclusion, for the purposes of the Math Boost-Up program, motivation, in the context of andragogy and as it supports the development of self-directedness in the learner, would play a key role in encouraging and engaging students in the program. Motivation and self-direction and their implications for this study received support in the context of andragogy, which includes a focus on “facilitating a holistic, integrative and collaborative approach to learning” (Vodde, 2009, p. 42). With more adults enrolling in community colleges, educators should understand the characteristics of adult learners and the nature of adult learning (Cercone, 2008). Andragogy would help to provide such an understanding and would provide a framework for designing and implementing learning activities and experiences for adult learners that would equip them with the knowledge, skills, and dispositions needed to persist to program completion (Deveci, 2007; Hussain, 2013; Quinney et al., 2013; Subramaniam, 2009; Taylor & Kroth, 2009; Wheaton & Toya, 2012; Wichadee, 2011).

Rationale for Choosing an Andragogical Framework

In deciding which theoretical framework to use for this study, I considered pedagogy and andragogy. According to Knowles et al. (2005, 2011), the differences between andragogy and pedagogy go beyond the Greek meaning of the words to the assumptions that underlie each term that relate to the role the teacher and the learner play in the learning process. Table 1 includes a summary of these differences based on Knowles et al.'s (1980, 1996, 2005, 2011) six assumptions of adult learners.

Table 2

The Differences Between Andragogy and Pedagogy

Assumptions	Pedagogy	Andragogy
1. The need to know	The teacher determines what learners need to know and decides how learners will learn about it. Learners are only focused on learning the content that will help them to pass and do not care how the content applies to everyday life (Knowles, 2011, p. 61).	What is learned and how it is learned resides with the learner. As learners, adults need to know the purpose of learning a particular concept or why a body of knowledge is important to understand. Teachers are facilitators of learning, as adults are in charge of their own learning. Facilitators must convince adult learners of what is worthwhile knowing and learning. Knowles et al. (2005, 2011) referenced Paulo Freire as an example of how facilitators convinced the peasants that learning to read was linked to their political freedom and empowerment (Knowles, 2011, p. 63).
2. The learner's self-concept	The teacher perceives learners as dependent. Equally, learners perceive themselves as dependent upon the teacher for all learning. All learning stems from and is derived from the teacher (Knowles, 2011, p. 61).	Adults are responsible for their own learning and must be self-directed in their own learning. Adults reject any notion of learning imposed by teachers and directed by teachers. Although adult learners recognize they must depend on the teacher initially, the teacher as facilitator of the learning process must quickly move into the learner state of control over the learning, so that the adult learner could be accountable for his or her own learning (Knowles, 2011, pp. 63-64).
3. The role of the learner's experience	The teacher does not acknowledge learners' prior knowledge and experience. The teacher lectures and learners must listen attentively and take notes (Knowles, 2011, p. 62).	Because they have lived longer and have more experience to draw from, adult learners bring to the learning situation a wide variety of experiences, backgrounds, points of reference, learning styles, levels of motivation, interests, and needs. Because of this variety, they would need individualization of learning and teaching activities, as well as strategies. These activities and experiences taken together are internalized by adult learners and tend to define their self-identity as learners. This self-identity that adult learners possess could have both

Assumptions	Pedagogy	Andragogy
		negative and positive effects on their capacity to learn. Therefore, teachers as facilitators may have to help learners examine their biases and become more open to change (Knowles, 2011, pp. 64-65).
4. Readiness to learn	The teacher does not take into consideration when learners are ready to learn a particular concept or whether they possess the prior knowledge needed to learn the concepts being taught. The teacher decides what learner must learn to pass the test (Knowles, 2011, pp. 62).	Adults learn best when what they are learning is linked to real-life situations in ways that the new body of knowledge could improve performance and understanding now or in the future (Knowles, 2011, pp. 65-66).
5. Orientation to learning	Learners are perceived to be only interested in acquiring knowledge for the sake of knowledge. Teachers teach the content in incremental and sequential steps, as dictated by the subject content (Knowles, 2011, p. 62)	Adult learners need to see clearly how acquiring a particular body of knowledge and skill could improve their current and future level of understanding and skill (p. 67). According to Knowles et al. (2005), "they learn new knowledge, understanding, skills, values, and attitudes most effectively when they are presented in the context of application to real-life situations" (Knowles, 2011, pp. 65-66).
6. Motivation	External rewards, intimidation, and threats of punishment are techniques used to motivate learners (Knowles, 2011, p. 62).	Adult learners are motivated to learn when they can see the benefits related to "better jobs, promotions, higher salaries, and the like" (p. 66). Teachers as facilitators must link learning activities and the acquisition of knowledge and skills to these external motivators (Knowles, 2011, p. 66).

Although there are differences between how adults and children learn, the task that adult educators face is deciding which approach, pedagogy or andragogy, best fits a particular learning situation, as one is not better or worse than the other (Cercone, 2008; McGrath, 2009). Knowles conceded that sometimes a pedagogical strategy is appropriate, particularly when the content is new to learners (Knowles et al., 2005). The teacher as *andragog* must build on adult learners' prior knowledge and experience and move adult learners into a position of being responsible for their own learning. Using this approach motivates the adult to learn and excel in the learning situation.

This study could have included both pedagogy and andragogy. Subramaniam (2009) studied the use of both pedagogy and andragogy in teaching adults at a community college in Malaysia. Subramaniam used a mix of quantitative and qualitative data-gathering strategies to identify the teaching practices that catered to individual and group needs, engaged learners in experiential learning, and focused on the role of the instructor as one that switches from authoritative to facilitative depending on the needs of students. The study consisted of a sample of 111 students and involved two lecturers and seven courses. Questionnaires designed for target groups involved in this study served as a source of quantitative data. The qualitative data from observations and interviews helped to gain insight into the results obtained from quantitative data. Interviews took place in real time in the form of an “amiable chat during the teaching and learning process” (Subramaniam, 2009, p. 119). Based on the results of the questionnaires, and from the observations and interviews, the researcher concluded that the mix of andragogical and pedagogical approaches served the needs of the learners when they were unfamiliar with the content (pedagogy) and when they needed to apply what they learned in context (andragogy). Subramaniam (2009) noted that these findings concurred with Knowles’s revised position that the pedagogical and andragogical models were entirely different from each. According to Merriam (2004), Knowles later conceded that each of the approaches, pedagogy and andragogy, were valuable strategies to use depending on the learning situation.

Similar to Subramaniam (2009), Tasir et al. (2008) found that a combination of both pedagogical and andragogical strategies supported preservice teachers’ learning in an online environment. Tasir et al. conducted a quantitative study of 433 preservice teachers chosen at random from three teacher preparation programs in Malaysia and in the final year of their teacher preparation program. A survey distributed to the preservice teachers helped to determine their pedagogical or andragogical orientation. The results of the survey indicated that preservice teachers in their final year favored the strategies that allowed them to be self-directed in their learning. The preservice teachers also noted they appreciated the times when they were able to seek guidance from faculty. Tasir et al. concluded that both teaching strategies worked to help the preservice teachers who were ready and able to take full responsibility for planning and implementing their teaching lessons and those who still needed the support and guidance from faculty. Therefore, the integration of both pedagogy and andragogy received consideration in developing the learning environment. Adults may prefer teaching strategies that are pedagogically inclined to those based on andragogy, because these were the strategies with which they were most familiar (Deveci, 2007; Edmondson et al., 2012). To create a successful environment for adult learners, teachers (facilitators) must employ andragogical strategies, as a pedagogical approach is contradictory to the natural orientation of adults (Dable et al., 2012; Deveci, 2007). Students need to change their view of education from something people do to them to one in which they become actively involved (Beer, Chiel, & Drushel, as cited in Koski et al., 2008).

Knowles (1980) acknowledged that there are times when pedagogy would be appropriate but on a limited basis. As soon as the learner understands the concept, the teacher as facilitator should relinquish control and allow the learner to become self-directed (Knowles, 1980, p. 43). The basis of the decision to use andragogy over pedagogy as a framework for the study was the understanding of the differences between the two approaches to teaching adults, along with Knowles's words of warning about using pedagogy when andragogy would be the better strategy. However, the adult educator should employ pedagogical strategies on a limited basis and use this strategy only when the learner had difficulty understanding a particular concept (Knowles, 2011).

Moreover, the rationale for choosing andragogy as the framework to help conceptualize the design, management, and implementation of the Math Boost-Up program, as well as plan professional development for the facilitators, was that the average age of students attending a community college is between 24 and 29 years (James, 2006; Kerrigan & Slater, 2010; Vassiliou, 2011). More adults are entering or returning to college because some postsecondary education is a requirement in more jobs (Carnevale et al., 2010). According to Carnevale et al. (2010), by 2018, approximately 46,800,000 new and replacement jobs will exist, of which 63% will require a bachelor’s degree, an associate’s degree, or some college credits and 37% will only need a high school diploma. If students are going persist from semester to semester, and complete their programs of study leading to a certificate or an associate’s degree, andragogy serves as a sound framework for designing and implementing programs for adults (Cooke, 2010).

In conclusion, an andragogical approach was the best framework to use to inform the design, development, and implementation of the Math Boost-Up program because adults are more problem solving in their approach to learning. Adults are more problem solving in their approach to learning because they have amassed a wealth of life and work experiences that made them more critical of what they need to learn and why they need to learn it prior to engaging in the learning experience (Burholt, Nash, Naylor, & Windle, 2010). The adults were also more self-directed in their approach to learning, even when they needed the teacher's help from time to time, which is unlike the characteristics of children who only learn information to pass a test or get a good grade (Burholt et al., 2010). To succeed, educators must create an environment in which adults can take responsibility for their own learning and feel as if teachers respect the experiences and knowledge they brought to the learning situation (Knowles, 1980). Andragogy serves as a framework for capturing all the various elements that best support the teaching and learning of adults (Knowles, 1980; Strawbridge, 1999).

The Relationship Between Andragogy and the Math Boost-Up Program

The relationship between andragogy and the study helped to provide a framework for the development and implementation of the study. Each of Knowles et al.'s (2005) six assumptions or principles helped to frame the design of the intervention itself, helped determine how to recruit participants, provided a context for training the facilitators, and served as strategies for implementing and managing the program. My goal was not to view each assumption as a construct of the Math Boost-Up program to measure and analyze.

At the beginning of the dissertation study, students took the ACCUPLACER test and from this group, students were invited to participate in the refresher program. The strategy of beginning with an assessment of what participants know, understand, and are able to do and using the results to advise them of next steps made the participants, not the teacher, responsible for their own learning (Knowles, 1980). In a study on improving safety in a science lab, Galbraith and Fouch (2007) found that letting participants know where the gaps were in their knowledge and skills and what they need to learn at the beginning of any learning situation engaged learners from the beginning and motivated them to want to learn. The strategy of letting learners know where they stood was in line with Assumptions 1 (the need to know), 2 (the learner's self-concept), and 6 (motivation) of Knowles's theory or approach, as shown in Table 2 (Knowles, 1980, 1981, 2005). The study conducted by Galbraith and Fouch also confirmed that if learners were going to succeed in learning, they needed to know what they needed to learn to be successful. Other researchers (Boden et al., 2008; Burholt et al., 2010; Chou, 2013; Deveci, 2007; Edmondson et al., 2012; Francis & Flanigan, 2012; Merriam, 2001; Quinney et al., 2013; Strawbridge, 1999; Tasir et al., 2008; Wichadee, 2011) confirmed Knowles's assumptions that self-directed learners become intrinsically motivated to learn, despite external motivators such as higher pay, job promotion, meeting mandatory requirements that might have caused them to enroll in college. The nature of the intervention tool, along with the face-to-face sessions with faculty, drew on what Tough (1978) referred to as the natural inclination of adults to be self-directed, which in turn is the underlying characteristic of motivation (Gom, 2009; Pew, 2007; Ryan & Deci, 2000).

After students agreed to participate in the refresher program, they took a second assessment. This assessment diagnosed the students' level of mathematical knowledge and skills and mapped the results to modules that students must use to help them improve. According to Galbraith and Fouch (2007), the way to put learners at ease is to help them acknowledge what they did not know or understand and could not do, thereby creating a safe environment for learning. Faculty also created a safe environment for learning by respecting what the learner already knew and allowed the learner to pace the activities (Galbraith & Fouch, 2007). The aspect of respecting what learners bring to the learning situation and supporting the learner through the process has a connection to Knowles et al.'s (2011) Assumptions 4 (readiness to learn) and 5 (orientation to learning). After students were enrolled, and their areas of strengths and weaknesses, Assumption 3 (the role of the learners' experiences) came into play. Faculty made every effort to link activities to the real-life experiences of the learners (Knowles et al., 2005).

The basis of the strategies related to the implementation and recruitment of students for the program was an andragogical framework because, as Knowles (1980, 1990, 1996) posited, adults are likely to participate in programs when they perceive the program as having value to them in the short term as well as the long term. Therefore, adults choose to participate in programs when they perceive the benefits of participation to align with their goals for job and career advancement, securing a better paying job, or retooling for a new career (Knowles, 1980, 1981, 2005). According to Knowles (1980), the element of choice capitalizes on the self-directed nature of adults and fuels the motivation to participate in and complete a program.

Examples of how allowing adults to choose whether they would like to participate in a study supported the development of self-directedness and motivation appeared in two studies. The focus of the first one, conducted by Bear (2012), was on helping participants learn how to use the various functionalities of eBay, and in the second study, Quinney et al. (2013) focused on how to help library staff members increase their technology skills.

In each study, when participants were able to be self-directed in choosing whether to participate in a program, their motivation to learn and explore all aspects of the technological components of the various program offerings increased. According to Knowles (1975), as self-directed learners, adults are capable of determining, on their own, what they needed to know and understand, how they learned best, the resources they needed to help them learn and to assess whether they have learned what ever it is they needed to know and understand (Knowles, 1975). This need for adults to be self-directed in their learning had implications for the Math Boost-Up program because much of what participants had to do to test out of or into a higher level mathematics course depended on self-direction and feeling motivated to want to participate in the program, complete the modules outlined in the self-study plan, persist in the program, and retake the test.

The role that faculty played in the intervention, was that of facilitators in the learning process and not as teachers who primarily took charge of what, when, and how students were to learn concepts. A review of the literature indicated faculty chosen to lead any program that involved adults must become coaches or facilitators who view learners through the lens of andragogy (Alewine & Phil, 2010; Boden et al., 2008; Cooke, 2010; Finn, 2011; Galbraith & Fouch, 2007). Through the lens of andragogy, teachers see themselves as facilitators of the learning process and develop a close working relationship with the learner based on mutual respect (Bear, 2012; Boden et al., 2008). Viewing learners as capable and able to take control of their own learning would help faculty to accept their roles as cocreators of the learning situation with students and to accept their roles as coaches and not sages on the stage (Cooke, 2010; Finn, 2011).

The Relationship Between the Theory and the Study

Andragogy served as a framework for the structure and implementation of the Math Boost-Up program and built upon the body of research on how best to prepare students to increase their mathematical knowledge and skills within a short time frame. Further, using andragogy as the framework optimized the learning potential of adults who lacked knowledge and skills in basic arithmetic and elementary algebra and gave others working on this issue a critical perspective on the results of using an andragogical approach as opposed to a pedagogical approach to teaching adults in this context. In building a case for an andragogical over a pedagogical methodology, Guffey et al. (1998) contended a paradigm shift was necessary in teaching underprepared students entering community colleges because traditional pedagogical approaches were not working. Pedagogical strategies characterized by the teacher pouring information into the minds of students, a factor that Freire (1996) referred to as the “banking approach to education” (p. 53), still resulted in failure for many students. Because the majority of students who enter the community college are adults with life and work experiences, it makes sense to approach teaching and learning from a framework that works best with adults as opposed to children (Guffey et al., 1998). Using an andragogical methodology, the adult educator facilitates the learning process and works with the adults to help them learn by putting the responsibility on the learners to acquire the knowledge and skills needed to succeed.

The review of literature did not reveal any studies with an andragogical approach to design and implement short-term boot-camp-like programs that would help students increase their scores on the ACCUPLACER. No one mentioned either a theoretical or a conceptual framework used to support the design of the refresher programs. This study advanced the discussion on the efficacy of these short-term refresher programs and included a framework for how to use andragogy to guide the design and implementation of similar intervention programs in the future.

Literature Review Related to Key Variables and Concepts

In this study, I investigated whether incoming students enrolled in short-term refresher programs such as Math Boost-Up were able to increase their mathematics knowledge and skills compared with other incoming students who studied on their own. This section of the literature review begins by providing a context for understanding the problems associated with remedial education, persistence, retention, and completion before reviewing studies related to the constructs of interest, chosen methodology, and methods used to study these problems. Providing this context was important because it helped to explain why I chose the constructs to be the subject of this study. Next, I examined how other researchers approached the study of these issues and discussed the strengths and weaknesses of each approach. Following this discussion, I analyze the research literature to provide a rationale for selecting the key variables of the study. The chapter ends with a synthesis of the study’s related independent and dependent variables, covariates, research questions, and hypotheses.

Studies Related to the Constructs of Interest

The constructs of the study were the mathematics knowledge and skills in arithmetic and elementary algebra that a person must possess to enroll in a college-level mathematics course. I measured this knowledge and skill using the ACCUPLACER. I discuss the studies related to these constructs in the context of the problems and challenges associated with remedial and developmental education and the ways college leaders determine readiness to enroll in college-level courses.

Background information. In his February 24, 2009, State of the Union Address to the Joint Session of Congress, President Barack Obama stated that the recovery and strengthening of the U.S. economy rested on its ability to compete in a global economy (White House, 2010). More specifically, President Obama maintained that for the United States to become the number one in the world for degree attainment, community colleges will have to produce 5,000,000 graduates by 2020 (White House, 2010). To accomplish this task, President Obama maintained that Americans would have to equip themselves with 21st-century skills to be able to meet the demand for more skilled workers, as more jobs were going to require at least an associate's degree (Burns, 2010; Ewell, 2010; Milano, Reed, & Weinstein, 2009; White House, 2010). In a study conducted by researchers at the Georgetown University Center on Education and the Workforce, Carnevale et al. (2010) projected that by 2018, the majority of jobs would require persons to have an associate's degree or better. Carnevale et al. and researchers such as Rose (2011), Quint, Jaggars, Byndloss, and Magazinnik (2013), Kallison and Stader (2012), and Handel and Williams (2011) maintained that for persons to implant themselves firmly and become part of the middle class, they must possess an associate's degree at a minimum. According to President Obama (2009), the most likely place for Americans to obtain these skills was at a community college (Handel & Williams, 2011; Schneider & Yin, 2011; White House, n.d.). To accomplish this goal, President Obama proposed that if every American would commit to completing at least 1 year of postsecondary education or career training, businesses would no longer have to go overseas to find skilled workers to fill the need for more qualified workers (Carnevale et al., 2010; Mulvey, 2008; White House n.d.).

To meet the need for a more qualified workforce, President Obama, through the American Recovery and Reinvestment Act, made the commitment that the administration would add $3.5 billion to the Pell Grant fund, over $1 billion to workforce development and training initiatives, and $40,000,000 to work study programs (White House, n.d.). Whether this commitment in funding and support would increase the number of students who persist in college and then graduate lies in the capacity of community college leaders to implement policies that would either move students quickly and effectively through remedial courses to credit-bearing courses and on to program completion or prevent them from entering remedial education in the first place (Bailey & Cho, 2010; Feldman & Zimbler, 2012; Handel & Williams, 2011a; Kurlaender & Howell, 2012). Before answering these two questions, it is important to understand what remedial education is and how it can prohibit students from completing a degree program.

Remedial education. Before beginning to discuss the problems and challenges related to remedial education, understanding what remedial education means is important.

Sometimes referred to as developmental education, college prep, or basic skills (Merisotis & Phipps, 2000), remedial education has many definitions. Researchers at Complete College America defined remedial education as

> required instruction and support for students who are assessed by their institution of choice as being academically under-prepared for postsecondary education. The goal of remedial education is to educate students in the skills that are required to successfully complete gateway courses, and enter and complete a program of study. (Charles A. Dana Center et al., 2012)

Adding to this definition, Parsad et al. (2003), in an NCES report on the state of remedial education in postsecondary education, defined remedial education as “courses in reading, writing, or mathematics for College level students lacking those skills necessary to perform College level work at the level required by the institution” (p. 1). The focus of the two definitions of remedial education was the courses in which students enrolled. Whereas the term developmental education refers to the various support services and mechanisms provided to support students in remedial education courses (Bailey, Jeong, & Cho, 2010), I used the terms remedial education and developmental education interchangeably in this study, as done in the literature.

Numerous definitions and terms refer to remedial education, but they all indicate there are provisions in postsecondary education programs to prepare students for college-level work in mathematics, reading, and writing. Understanding what remedial education means is only a small part in developing an overall understanding of why remedial education can pose problems to certificate and degree attainment. The topics discussed in the next sections include the challenges, controversy, and criticisms associated with remedial and developmental education programs.

Challenges related to remedial and developmental education. Having to take remedial education courses is the major reason why students are not completing a certificate or degree program (Adams et al., n.d.; Handel & Williams, 2011; Howell, 2011; Kurlaender & Howell, 2012; Levin & Calcagno, 2008; Long, 2011). According to Astin,

> The education of the "remedial" student is the most important educational problem in America today, more important than educational funding, affirmative action, vouchers, merit pay, teacher education, financial aid, curriculum reform, and the rest. Providing effective "remedial" education would do more to alleviate our most social and economic problems than almost any other action we could take. (As cited in Parker, Bustillos, & Behringer, 2010, p. 2)

This statement puts into perspective the need to reduce the numbers of students who test into remedial education. Further, if the numbers of students who take remedial education do not decrease, President Obama's goal to reposition the United States as the country having the most citizens with postsecondary degrees and certificates by 2025 and adding 5,000,000 graduates from community colleges to the existing pool of Americans possessing a college degree or certificate, community college leaders must increase the graduation rate of 17% to well above 60% (Aud et al., 2011; Bustillos, 2012; Lee, Edwards, Menson, & Rawls, 2011; Vandal, 2010; White House, n.d.). Remedial education poses a threat to meeting these two goals.

The majority of researchers who have conducted studies on remedial education have reached the same conclusion: placing students in remedial education is for the most part an ineffective strategy for preparing students for college-level work and is counterproductive to the goal of increasing the number of graduates from postsecondary institutions (Bailey, 2009; Bustillos, 2012; Calcagno & Long, 2009; Parker et al., 2010; Rose, 2012; Tierney & Garcia, 2008; Vandal, 2010). According to Bailey and Cho (2010), 60% of the students who take placement exams test into one or more remedial course. Belfield and Crosta (2012) revealed that at some community colleges, this percentage reached as high as 90%. Only 42% of the students who take the placement exam enroll in remedial courses (NPSAS, 2007-2008). Of this number, only 17% graduated (NCES, 2009). This is typical of what happens at the majority of community colleges in the United States. At the community college studied, 96% of the entering students who took the ACCUPLACER test for entry into the college in the fall 2012 semester tested into at least one remedial course (*UDC-CC ATD Report*, 2012). The same report revealed that only 45% of those students enrolled in the community college. With dismal graduation and drop-out rates, notwithstanding the high costs associated with providing remedial education, community college leaders are facing increased pressure to increase graduation and program completion rates by reducing the numbers of students who enroll in remedial courses.

Many researchers have highlighted the various problems associated with students having to complete remedial courses before entering college-level courses, such as the negative impact on graduation and completion rates, persistence, and retention (Bailey, 2009; Burns, 2010; Hagedorn, Lester, & Cypers, 2010; P. Jenkins & Cho, 2012; Scott-Clayton, 2011). P. Jenkins and Cho (2012) are among the many researchers affiliated with the Community College Research Center, which is a national organization whose leaders focus on issues and challenges facing community college leaders and students, and found that the longer it takes for students to enter college-level courses, the more likely they were to drop out. However, Bailey et al. (2008) also found that 45% of the students who took the level of remedial mathematics course closest to the college-level course moved on to enroll in the college-level mathematics course. Bailey et al. (2008) reported that only 17% of the students who completed the sequence of remedial mathematics courses enrolled in a college-level mathematics course. These percentages were even lower for men, older students, minorities, part-time students, and students who were in workforce development programs that required these basic skills (Bailey et al., 2008). Other researchers have reported similar findings for students enrolled in remedial English courses (American Association of Community Colleges, 2012; College, 2010; Dowd, 2007; Moss & Yeaton, 2006; Patton, 2012; Zeidenberg & Jenkins, 2012).

Disputes over the efficacy of remedial education. Compounding the problem even further is the fact that researchers disagree about whether remedial education makes a difference in students' readiness to succeed in college-level courses. Many researchers have provided sound evidence that remedial education does little to prepare students for college-level courses (Bailey, Jaggars, & Scott-Clayton, 2013; Bailey et al., 2008; Bailey, 2009; Bettinger, Boatman, & Long, 2013; Bettinger & Long, 2005; Edgecombe, Cormier, Bickerstaff, & Barragan, 2013; Hodara et al., 2012; Hughes & Scott-Clayton, 2011;

Kurlaender & Howell, 2012; Zachry, Rutschow & Schneider, 2012). Leaders of leading organizations concerned with the dismal completion rates of community college students, such as the Education Commission of the States, the National Governors Association, Community College America, Community College Research Center, Achieve, Achieving the Dream, American Association of Community Colleges, and National Center for Policy Research, all agree that most students could enroll in college-level mathematics and English courses and, along with mandatory tutoring, pass them (Adams et al., n.d.; Bailey et al., 2013; Bautsch, 2013; Charles A. Dana Center et al., 2012; Goudas & Boylan, 2012. Community College educators and administrators from many states have joined these organizations and have passed legislation related to reducing or eliminating the need for remedial education at the postsecondary level. Policy makers and state legislators agreed that students should have obtained these skills in high school and contended that taxpayers should not have to pay for the same education twice (Burdman, 2012). These feelings have led legislators in several states such as Indiana, California, and Florida to pass legislation requiring students to bypass remedial courses and enroll in college-level courses (Lu, 2013). Lu (2003) also reported that Colorado, Texas, and Connecticut legislators have passed various pieces of legislation requiring more rigorous preparation of students while they are in high school to prepare them to enroll in college-level courses. For those who needed remediation, this legislation required placement in courses that either combined remedial education with college-level courses or provided additional support of these students while enrolled in college-level courses (Lu, 2013).

On the other side of the debate, some researchers, particularly those associated with the National Association for Developmental Education, maintained that if these reforms were implemented on a wider scale, more students would fail, and the cost would rise to a level even greater than the current $7 billion price tag associated with remedial education (Scott-Clayton, Crosta, & Belfield, 2012). Moreover, as Scott-Clayton et al. (2012) pointed out, putting underprepared students in the same classroom as college-ready students will only water down the content of the courses, thereby compromising the rigor of the courses in general. But going beyond these arguments, Goudas and Boylan (2012) maintained that many researchers who claimed that remedial education was pointless because students in college-level courses who had taken remedial courses did not perform any better than those students who did not complete remedial courses prior to taking college level course, have made these claims using flawed research studies (Bailey et al., 2013; Bailey & Cho, 2010; Goudas & Boylan, 2012; Scott-Clayton et al., 2012). Many of these researchers conveniently ignored research that indicated students who scored significantly below the cut-off scores would have failed these college-level courses if they had not taken remedial courses. The researchers, who made claims that bypassing remedial was a good strategy, had focused primarily on results from studies based on students who scored up to five points below the cut-off scores on the placement tests and were allowed to enroll in college-level courses (Bailey et al., 2013). Goudas and Boylan (2012) cited a research study conducted by Boatman and Long who found that those students who scored far below the cut-off score do benefit from taking remedial courses. Boatman and Long (2010) cautioned that

> remedial and developmental courses help or hinder students differently depending on their levels of academic preparedness. Therefore, states and schools need not treat remediation as a singular policy but instead should consider it as an intervention that might vary in its impact according to students' needs. (p. 21)

Despite the cautionary note, Boatman, and Long, in this same article, suggested community college leaders should reconsider reforming policies and practices related to placement testing. Some of these strategies included using high school GPA and noncognitive assessments to determine readiness for college-level work (Fulton, 2012; Hodara et al., 2012; Hughes & Scott-Clayton, 2010).

In response to the criticisms levied by Goudas and Boylan (2012), Bailey et al. (2013) contended that none of their criticisms could stand up to close scrutiny. Bailey et al. maintained that while some students benefited from remedial education, the results from research involving thousands of students at community colleges across the country showed that students who bypassed remedial education courses and enrolled in college-level courses with support did well and persisted to graduation. Bailey et al. noted that community colleges should continue to find ways to reduce the numbers of students who enroll in remedial courses. Despite these varying and opposing positions, all the researchers agreed that the assessments and processes used to determine which students needed remediation and who did not had serious flaws (Fulton, 2012; Goudas & Boylan, 2012; Morgan, 2010). Because placement tests and practices and policies used to determine which students should be in college-level courses and which students needed remediation had so many flaws, Fulton (2012) noted that "it may be time for a Manhattan Project to redesign assessment and placement practices across the nation" (p. 2).

Effectiveness of placement tests. Placement tests are used to help community colleges determine which students are ready for college-level English and Math, and who must enroll in remedial courses to increase their knowledge, skills, and proficiencies in these subjects. It is necessary to use these tests because most community colleges have an open admissions policy (Bueschel, 2003; Morgan, 2010), which means that community college admissions policies will allow administrators to admit anyone with a high school diploma or GED. The most widely used tests were the computer adaptive tests ACCUPLACER, developed by the College Board; the COMPASS; and the paper-and-pencil ASSET, developed by ACT (Bailey, 2009b; Bailey & Jeong, 2010; Bautsch, 2013; Burdman, 2012; Collins, 2008; Headden, 2011; Lewin, 2012; Merrow, 2007). Nationwide, between 92% and 97% of the almost 1,600 community colleges used at least one of these assessments (Hughes & Scott-Clayton, 2011; Parsad et al., 2003). The ACCUPLACER, used at 62% of colleges, and the COMPASS, used at 46% of colleges, are the two most popular tests used to determine placement (Gerlaugh & Thompson, 2007; Scott-Clayton, 2012). Some colleges and public universities have other measures such as the ACT or the SAT (Belfield, 2012; Fulton, 2012; Headden, 2011; McCormick, 2011; Venezia, Bracco, & Nodine, 2010). Admissions policies at some community colleges allowed administrators to accept SAT and ACT scores in the place of the ACCUPLACER, COMPASS, and ASSET (Austin, Bugler, Finkelstein, & Klarin, 2013). Regardless of the test used, the effectiveness of any of them in determining placement in college-level English and mathematics versus placement in remedial courses is questionable. Discussed below are four areas of criticism often discussed in the literature.

The first criticism was the assessments lacked predictive validity (Barr & Schuetz, 2008; Burdman, 2012; Danenberg, 2011; Edgecombe, 2011; Hodara et al., 2012; Hughes & Scott-Clayton, 2011; Mattern & Packman, 2009; Scott-Clayton, 2012). These researchers maintained that the results of each test did not indicate who would pass the courses they test into based on the results of the placement test (Barr & Schuetz, 2008; Burdman, 2012; Danenberg, 2011; Edgecombe, 2011; Hodara et al., 2012; Hughes & Scott- Clayton, 2011; Mattern & Packman, 2009; Scott-Clayton, 2012). However, some researchers such as Brunk-Chavez and Fredericksen (2008) disagreed and showed a correlation between low placement test scores and final course grades. Brunk-Chavez and Fredericksen reported that students who scored low on the ACCUPLACER test tended to receive low to failing grades. The Pearson correlation was .126 for the scores received on the ACCUPLACER and final grades. According to Brunk-Chavez and Fredricksen, “Correlation is significant at 0.01 level (two-tailed)” (p. 87). A significance of .01 means there is a 99% chance that a relationship exists between the score on the ACCUPLACER test and the grade on the remedial course. Using the G*Power calculation program and a coefficient of determination (r^2) of .016, the effect size was small at .126. This meant that the relationship between the ACCUPLACER test score and successfully completing the remedial course with a minimum grade of C was small and the study’s results yielded little or no statistical significance.

In some editorial comments on the predictive validity of placement tests, Morante (2012) noted that the practice of correlating test results with course grades or GPA was erroneous and inappropriate and that the "validity of related 'findings' was highly questionable" (p. 28). A placement test only measured a person's knowledge and skill at the time of testing and should not be the only measure used to predict how students would perform in a subject, in this case, reading, writing, and mathematics. According to Morante (2012), placement tests "should be used with multiple variables as an integral part of a counseling/advising process to place students in beginning college courses" (p. 28).

The second criticism was researchers were also raising questions about inconsistencies in which community colleges determined the cut scores needed to enroll in college-level or in remedial courses (Danenberg, 2011; Fulton, 2012; Hughes, 2010; Martorell, McFarlin, & Xue, 2014; Safran & Visher, 2010; Sherer & Grunow, 2010; Solomon, 2010). By definition, "a 'cut score' is a benchmark score that determined whether a student must enter remedial education or could be placed directly into a credit-bearing course" (Austin et al., 2013, p. 2). At community colleges across the country, there were variations in the qualifying scores (cut scores) for placement in remedial and college-level courses, even among community colleges within the same state and system (Austin et al., 2013; Collins, 2008; Danenberg, 2011; Hughes, 2010; Solomon, 2010; Venezia et al., 2010). These variations in cut scores have led to variations in course placements and caused students to shop around for the best placement (Morgan, 2010). The variations in the interpretation of the cut scores across community colleges and the variations in placements speak to the poor predictive validity of the ACCUPLACER test related to course outcome performance.

Students shop around to find placements at the levels closest to the college-level courses, which leads to the third criticism of the cut score (Hodara et al., 2012; Venezia et al., 2010). Not only are there variations in cut scores colleges use, but there are also variations in the numbers of remedial course levels. Some institutions have multiple levels of variation, from two to as many as six (Bailey et al., 2008; Bailey, 2009b; Bickerstaff & Monroe-Ellis, 2012; Burdman, 2012; Collins, 2008; Edgecombe, 2011; Kerrigan & Slater, 2010; Safran & Visher, 2010; Sherer & Grunow, 2010).

Fourth, researchers noted that students often did not know about the placement test prior to taking it; were not told to prepare for the test; and were not aware of the seriousness of the test, its impact on course placement, and that it affected time to completion (Bautsch, 2013; Burdman, 2011; Grubb, 2012; Hodara et al., 2012; Rennie Center for Education Research and Policy, 2009; Whitmire & Esch, 2010). In their interviews with incoming freshmen, Venezia et al. (2010) found that students were not aware that they had to take a placement test and therefore did not prepare. Sometimes college advisors told students that they do not have to prepare as there are no pass or fail scores associated with the test, and those told to prepare for the test did not do so (Center for Community College Student Engagement, 2012; Hodara et al., 2012; Martino & Wilson (2009). Other researchers showed that students were not taking the tests as seriously as they did the SAT or the ACT and were not preparing for the placement tests they had to take at community college (Hodara et al., 2012).

In response to these criticisms regarding the placement tests, community college leaders have implemented strategies in the hope that students would take these tests more seriously (Burdman, 2011; Rennie Center for Education Research and Policy, 2009). Some education leaders and researchers recommend that some strategies to improve test scores, should include educating students about how college use these tests to determine placement in remedial and college-level courses after admissions (before taking the test), or while they are still in high school; making students aware of the impact of placement into developmental or remedial courses; encouraging them to study and prepare for these tests; and providing preparation or short-term refresher courses prior to taking the test (Aramburu, Anglin, & Woodcock, 2010; Barnett et al., 2012; Bettinger et al., 2013; Briggs, 2009; Burdman, 2011; Hilliard, 2011; Hodara et al., 2012; Hughes & Scott-Clayton, 2011; Tierney & Garcia, 2008). At the community college where this study took place, students receive letters encouraging them to prepare for the placement test and provide links to sites that would help them prepare for the test prior to taking it. I focused on studying the impact on posttest scores of a mathematics refresher course versus having students study on their own.

Preparing for the placement test. Helping students to prepare for the placement test is becoming a common strategy at community colleges nationwide (Center for Community College Student Engagement, 2012; Barnett et al., 2012; Bettinger et al., 2013; Chao, DeRocco, & Flynn, 2007; Fulton, 2012; Hodara et al., 2012; Sherer & Grunow, 2010; Speckler, 2011; Wathington et al., 2011; Zachry, 2008). These short-term programs help to refresh knowledge and skills in reading, writing, arithmetic, and elementary algebra (Brock, 2010; Edgecombe, 2011; Sherer & Grunow, 2010; Venezia et al., 2010). Although many community colleges have these short-term refresher programs to help students prepare for the placement tests, secondary institutions have tested high school students and, for those students who needed it, have enrolled them in remedial classes while they were still in high school, with proven success (Barnett et al., 2012; Bers, 2007; Bettinger et al., 2013; Burdman, 2012; Bustillos, 2012; Collins, 2008; Cullinane & Treisman, 2010; Goldrick-Rab, 2010; Grubb, 2012; Howell, 2011; Hughes & Scott-Clayton, 2011; Hyslop & Tucker, 2012; Knudson, Zitzer-Comfort, Quirk, & Alexander, 2008; Kurlaender & Howell, 2012; Long, 2011; Martorell et al., 2014; Zachry Rutschow & Schneider, 2012; Solomon, 2010; Spence, 2009; Tierney & Garcia, 2008).

Additionally, there is a growing body of research on the effectiveness of summer bridge programs, which are usually 6 weeks in length and have been successful in equipping high school students with the knowledge and skills needed to bypass remedial courses (Barnett et al., 2012; Bettinger et al., 2013; Bradely, 2012; Kallison & Stader, 2012; Kerrigan & Slater, 2010; Quint et al., 2013). The short-term (2 to 3-week) refresher programs were primarily for working adults who could not attend summer bridge programs. However, research on whether these short-term refresher programs could increase scores on the placement tests is lacking (Bickerstaff & Monroe-Ellis, 2012; Edgecombe, 2011; Sherer & Grunow, 2010; Venezia et al., 2010). Sherer and Grunow (2010) pointed out that, if implemented correctly, boot camps such as Math Boost-Up could have a significant impact on student retention and persistence. If they were successful in moving large numbers of students faster or completely out of the remedial course sequence, then they were worthwhile pursuing (Sherer & Grunow, 2010). I focused on the ACCUPLACER test because that is the placement test used at the community college where this research took place. Further, I focused on the mathematics section of the test because most students fail the mathematics section of both the ACCUPLACER and the COMPASS (Bailey & Cho, 2010; Ewell, 2010).

Studies Related to the Methodology and Methods Consistent With the Scope of the Study

As discussed in Chapter 1, the research method used in this study was a quasi-experimental, pretest–posttest nonequivalent comparison group design. The prefix *quasi* means *sort of* or *resembling* (Shaughnessy, Zechmeister, & Zechmeister, 2009). Therefore, quasi-experiment means sort of an experiment or resembling an experiment. Christensen (1997) defined a quasi-experimental design as “an experimental design that does not meet all the requirements necessary for controlling the influence of extraneous variables” (p. 262), which meant the design was not a true experiment because there was no random assignment of subjects to an intervention or experiment (Campbell & Stanley, 1963; Christensen, 1997). Because of the lack of random assignment, leading experts in the field of research design, such as Campbell and Stanley (1966), Shadish et al. (2002), and Christensen (1997), have cautioned that the design poses many threats to internal and external validity. The threats to internal validity are history, maturation, testing, instrumentation, statistical regression, mortality, different selection of participants or selection bias, mortality, and selection maturation interaction (Campbell & Stanley, 1963; Huck & Chuang, 1977; Oakes & Feldman, 2001; Shadish et al., 2002). Shadish et al.

(2002) noted that of the threats that plague quasi-experimental designs, five could link directly to the nonequivalent comparison group design: selection bias, selection-maturation, selection-instrumentation, selection-regression, and selection history. Additionally, Campbell and Stanley (1963) warned that the main threats to external validity were the effect of pretest on the posttest, the effects of selection biases on the experimental variable, effects of prior experiments, generalization of results across time, population, various settings, and dependent variables.

Despite the threats to internal and external validity, the quasi-experimental design is a feasible alternative to the true experimental design when true experiments are not possible (Brock, 2010; Campbell & Stanley, n.d.; Christensen, 1997; Shadish et al., 2002), which was the case in this study. The results of two literature reviews conducted in 2010 of these types of transition-to-college programs, and researchers at the U.S. Department of Education Office of Vocational and Adult Education, confirmed that quasi-experimental research methods were among the rigorous methods that could provide evidence of a programs' efficacy (U.S. Department of Education Office of Vocational and Adult Education, 2010). The researchers of the report concluded, "Such research can begin to provide practitioners with information about useful strategies and enable program administrators and policymakers to make sound decisions about how best to deploy resources to support postsecondary education transitions" (p. 7). I used a quasi-experimental design to assess the efficacy of the Math Boost-Up program to increase students' mathematics ACCUPLACER numeric scores compared to the students who decided not to participate in the program. Additionally, I provided empirical evidence of the program's efficacy, which was lacking in the literature (Levin & Calcagno, 2008).

A number of researchers have used quasi-experimental research design methods at community colleges to investigate the effectiveness and impact of various interventions, initiatives, and programs on student achievement, retention, and program completion with favorable results (Bettinger et al., 2013; Hughes & Scott-Clayton, 2010; Sherer & Grunow, 2010). I used the strongest and most commonly used of the quasi-experimental research methods: a pretest–posttest nonequivalent comparison group design (Campbell & Stanley, 1963; Kenny, 1975; Shadish et al., 2002).

As noted earlier, research on short-term refresher programs designed to help students increase their scores on placement exams was lacking. A number of researchers have used a similar methodology involving computer-assisted instruction (CAI) such as Pearson's MyFoundationsLab to increase the mathematics knowledge and skills of students as measured by placement tests such as the ACCUPLACER (Cullinane & Treisman, 2010; Edgecombe, 2011; Edgecombe et al., 2013; Sherer & Grunow, 2010; Vassiliou, 2011; Vassiliou & Mcdonald, 2009; Venezia et al., 2010). At the Miami Dade College in Florida, Vassiliou (2011) used the CAI A^{+}dvancer to help students avoid remediation altogether or at least one level of remedial courses. Vassiliou pretested 180 students using the ACCUPLACER and then retested them using A^{+}dvancer. Using multivariate analysis of variance, Vassiliou (2011) found significant increases in the mean posttest scores of students in all areas. The results of the study indicated that the CAI A^{+}dvancer helped to increase the scores of the students who participated. The study took place across seven semesters, summer, spring, and fall, and involved 180 students. Vassiliou used a one-group pretest–posttest design, and students self-selected to participate in the study. Overall, students increased their scores on the ACCUPLACER test in arithmetic by 57% and in elementary algebra by 45% from pre- to posttest. Students were also able to increase their scores in reading by 17% and in sentence skill by 12% (Vassiliou, 2011). The results confirmed the efficacy of CAI and "further strengthened the argument that CAI does achieve the goal of improving student college readiness skills to the point where they are ready for more advanced College level coursework" (p. 198). Vassiliou (2011) cautioned that he could not prove causality due to the lack of random assignment and nonexistence of a control group. The use of the one-group pretest–posttest design was by far the weakest of the quasi-experimental research designs, even though its use was frequent in social science research (Campbell & Stanley, 1963). Research studies using this design lack internal and external validity, and therefore readers should not put much stake in the results from these studies (Cook & Campbell, 1979). Claims about the increase in ACCUPLACER test scores using the A$^+$dvancer only show probable cause and not causation (Cook & Campbell, 1979). Despite these shortcomings in the research design, researchers concluded that the short-term refresher programs with CAI worked well with students who needed to refresh forgotten knowledge and skills, thereby decreasing the numbers of students who needed remediation and increasing retention and graduation rates (Perin, 2004; Vassiliou & Mcdonald, 2009; Vassiliou, 2011).

Similar results using Pearson's MyFoundationsLab occurred at California State University—Bakersfield, Florence Darlington Technical College, Jackson State Community College, Marion Technical College, Merced College, Northeast State Technical Community College, Odessa College, Rock Valley College, and Sussex County Community College, just to name a few (Speckler, 2011). Data reported by Pearson (2011) indicated that of the more than 120,000 students using the program at Ivy Tech Community College from 2007 to 2008, 91% of students retested in reading improved at least one course level, 70% of students retested in writing improved at least one course level, and 43% of students retested in math improved at least one course level (Speckler, 2011). Despite these results showing improvement in test scores resulting from using these CAI programs, Speckler did not include in the report on how community colleges used Pearson's MyFoundationsLab to increase test scores, important details such as information regarding research design used, statistical power, and detailed results of the study. I provide another example of the lack of empirically designed studies making claims of success but backed by poor evidence and not following American Psychological Association research reporting guidelines.

The methodology in this study involved providing CAI through the MyFoundationsLab online intervention program to students in both the experimental and the comparison groups. Students in the experimental group received 10 days of in-class instruction, supplemented by work in Pearson's MyFoundationsLab in the computer lab. Students in the experiment group had the opportunity to attend other sessions to make up for absences. However, the mathematics faculty running the Math Boost-Up program stipulated that any student who missed three or more face-to-face sessions and had not attempted to make up these sessions would not be able to retest. Students in the experiment group retested within 2.5 weeks of the date of the pretest.

Students in the comparison group received access to MyFoundationsLab after a review of how to use the program and the modules related to their areas of weakness identified by the ACCUPLACER Diagnostics program. Faculty monitored student activity in MyFoundationsLab to ensure the students in the control group were logging in and completing the exercises. If there was no activity, the faculty members contacted the students to determine the reasons for inactivity and provided technical support if needed. The students in the comparison group also had 2 weeks to complete the modules on their own and retested within 1 week after the intervention ended.

To optimize the use of andragogy as the framework, Knowles (2011) encouraged programs to follow the steps listed below. A description of each step along with its use in the study appears in Chapter 3. The steps were as follows:

1. Preparing the learner.
2. Establishing a climate conducive to learning.
3. Creating a mechanism for mutual planning.
4. Diagnosing the needs for learning.
5. Formulating program objectives (which is content) that will satisfy these needs.
6. Designing a pattern of learning experiences.
7. Conducting the learning experiences with suitable techniques and materials.

8. Evaluating the learning outcomes and rediagnosing learning needs (Knowles et al., 2011).

Studies in which the methodology included these steps, which included an online teacher education program for student teachers and a program designed to improve the English reading ability of students, had positive results for their participants (Blondy, 2007; Wichadee, 2011).

Approaches to the Study of Short-Term Refresher Programs

In trying to determine whether these short-term refresher programs were successful in increasing the mathematics knowledge and skills of students enough to test into a higher level remedial course or avoid remediation, I found that faculty and administrators who were leading interventions at community colleges such as at Miami Dade College in Florida, Northampton Community College, and North Central State College in North Carolina, had used a quasi-experimental one-group pretest–posttest design and made claims that the programs contributed to some students being able to increase their test scores and bypass remedial courses altogether or test into higher level remedial courses (Levin & Calcagno, 2008; North Central State College, n.d.; Sherer & Grunow, 2010; Vassiliou, 2011). However, no one empirically validated any of these claims. Even though these types of short-term intensive refresher programs were successful in helping students increase their test scores on placement tests, no research studies included empirically validated evidence comparing the results of one group to that of another group that did not participate in the short-term refresher program. Although randomized assignment is the gold standard in evaluating the effectiveness of programs

(Burholt et al., 2010; Epper & Baker, 2009; Levin & Calcagno, 2008; Moore, 2008; Nora, 2009; Shadish, et al., 2011), quasi-experiments without a random assignment of participants to groups are becoming more prevalent in studying the effectiveness of interventions, programs, and initiatives implemented at community colleges (Burdman, 2012; Calcagno & Long, 2008; Hodara, 2011; Levin & Calcagno, 2008; Martorell & McFarlin, 2011). Brock (2010) indicated that to evaluate the effectiveness of a program, a "counterfactual — that is, some means of determining what would have happened if the policy or program did not exist" was essential. Through randomized experiments, researchers can prove causal relationships between the intervention and the results, but researchers do not often use randomized experiments in higher education research (Brock, 2010). Whenever randomized experiments are not possible, quasi-experiments are a viable alternative (Bettinger et al., 2013; Campbell & Stanley, n.d., 1963; Christensen, 1997; Fife-Schaw, (2006); Hong, 2010; Hughes & Scott- Clayton, 2011; Kirk, 2012; Oakes & Feldman, 2001; Salkind, 2010; Shadish et al., 2002). Moreover, the quasi-experimental nonequivalent control group pretest–posttest design is closer to a true experiment than the quasi-experimental one-group pretest–posttest design that is weak in comparison to randomized experiments and even weaker in comparison to the quasi-experimental two-group pretest–posttest designs (Campbell & Stanley, 1963; Hong, 2010; Salkind, 2012; Shadish et al., 2002).

Rationale for the Selection of the Variables

The variables studied were the independent variable Math Boost-Up and the dependent variable mathematics knowledge and skills as measured by the

ACCUPLACER test. The rationale for selecting the variables for this study was the need to provide evidence that short-term refresher programs such as Math Boost-Up can help students bypass remediation or test into a higher level remedial or developmental course, thereby reducing the need for remedial education. The variables served as a framework for studying the impact of Math Boost-Up on ACCUPLACER posttest results. In the research literature related to placement test preparation, researchers often manipulated the intervention, in this case the mathematics refresher program Math Boost-Up and the mathematics knowledge and skill as measured by the ACCUPLACER, as variables (Burdman, 2012; Fulton, 2012; D. Jenkins, 2011; Plan, Barron, & Foutz, 2009; Quint et al., 2013; Schneider, 2010; Sherer & Grunow, 2010; Wathington et al., 2011; Zachry Rutschow & Schneider, 2012). These studies supported the rationale for selecting the two variables.

Studies Related to the Independent, Dependent, and Moderator Variables

The independent variable was the short-term refresher program, Math Boost-Up. The dependent variable was the mathematics knowledge and skill as measured by the ACCUPLACER. The moderator variables appeared in Table 1: age, the pretest scores participants received on the mathematics section of the ACCUPLACER test, high school GPA, time spent completing the modules in MyFoundationsLab, number of Math Boost-Up sessions attended, and the time difference between high school graduation and taking the ACCUPLACER test.

Administrators at community colleges across the country have struggled with determining which of the many strategies available, such as math boot camps, brush-up programs, and summer bridge programs, succeeded in reducing the numbers of students who tested into remedial or developmental courses. Enrollment in remedial or developmental courses, which is costly to students, taxpayers, and the colleges and has a negative effect on retention and completion rates, is not the preferred option, yet it is where many underprepared students end up. To combat the negative effects associated with having to take remedial courses before enrolling in credit-bearing courses, administrators, staff and faculty have studied the effects of a number of possible fixes.

The first fix is early assessment (Bettinger et al., 2013; Grubb, 2012; Howell, 2011; Hughes & Scott-Clayton, 2010; Knudson et al., 2008; Spence, 2009; Tierney & Garcia, 2008) while students are still in high school and remediate there where it is cheaper and more cost effective. At many high schools, teachers and counselors have administered the placement test to 11th-grade students, and if the results showed that the students were not college ready, they administered a diagnostic assessment that accompanied some of the computer programs such as those in MyFoundationsLab and A^{+}dvancer (Sherer & Grunow, 2010; Speckler, 2011; Vassiliou & Mcdonald, 2008, 2009). The results of the diagnostic assessment showed the areas in which the students were weak. The diagnostics program then mapped these areas to exercises or modules in the program that students could either complete on their own or with the support of a tutor or teacher.

The second fix was to provide a refresher program to students who scored below the cut score on the placement test so they could refresh the knowledge and skills in math and English that they had forgotten and then retake the test (Burdman, 2012; Chao et al., 2007; Fulton, 2012; D. Jenkins, 2011; Plan et al., 2009; Quint et al., 2013; Zachry Rutschow & Schneider, 2012; Sherer & Grunow, 2010; Wathington et al., 2011; Zachry, 2008). One example of these refresher programs was the summer bridge program often implemented with recently graduated high school students (Bailey & Cho, 2010; Barnett et al., 2012; Bettinger et al., 2013; Burdman, 2011; Garcia & Paz, 2009; Jones, 2009; Kallison & Stader, 2012; Sherer & Grunow, 2010; Stedron, Shah, Bautsch, & Martin, 2010). Summer bridge programs lasted anywhere from 4 to 10 weeks and usually meet 5 days a week, from 3 to 6 hours a day. Another type of placement test preparation program was the short-term refresher programs or boot camps (Bickerstaff & Monroe-Ellis, 2012; Brock, 2010; Edgecombe, 2011; Edgecombe et al., 2013; Freedberg, 2010; Sherer & Grunow, 2010; Venezia et al., 2010; Whitmire & Esch, 2010). These short-term refresher programs lasted anywhere from 1 to 2 weeks and ran for 3 to 4 hours for 2 to 4 days a week. The short-term refresher programs were specifically for older students who were not able to commit to the time involved with summer bridge programs due to family and work obligations (Sherer & Grunow, 2010).

The third fix in making correct placements in remedial or college-level courses was to use, in addition to placement tests, other measures such as high school transcripts to determine academic readiness (Belfield & Crosta, 2012; Bettinger et al., 2013; Edgecombe, 2011; Edgecombe et al., 2013; Fields & Parsad, 2012; Hughes & Scott-Clayton, 2011; Levin & Calcagno, 2008; Lewin, 2012; Long, 2011; Scott-Clayton & Rodriguez, 2012). Studies supporting this strategy have maintained that using high school transcripts along with placement tests offered a more balanced and accurate approach to determining readiness for college-level work or placement in remedial courses (Belfield & Crosta, 2012).

Given community colleges' open admissions policy, researchers have agreed that the colleges should have measures to determine who is ready for college-level work and who needs to enroll in remedial or developmental courses. However, much controversy has erupted over the validity of the commonly used placement tests and their capacity to predict placement. Researchers have questioned not only the efficacy of these tests but also the interpretation of the scores and using them to make placement decisions. As Belfield and Crosta (2012) noted, researchers did not need to study the test itself but needed to study the use of the test to determine placement in college-level or remedial courses. With all the controversy surrounding placement tests and their use, Scott-Clayton (2012) maintained that the best strategy for preventing students from enrolling in remedial education was a strategy to examine what administrators at community colleges could do to help students score better on these placement tests. In light of this controversy, researchers at Complete College America recommended that policies should be implemented at community colleges that would allow administrators and staff to administer a diagnostic assessment to incoming students, enroll them in credit-bearing courses, and use the results of the diagnostics to provide tutoring or supplemental instruction (Charles A. Dana Center et al., 2012).

Studies related to the moderating variables. The moderating variables listed in Table 1 could play a role in how individuals performed on the placement test (Bailey et al., 2013; Bettinger et al., 2013; Horn & McCoy, 2009; Kirst, 2003; Levin & Calcagno, 2008; Zachry, 2008). Vassiliou and McDonald (2009) confirmed that more researchers should disaggregate data by various demographics to determine the extent of the mediating effects of certain demographics such as age, race or ethnicity, and socioeconomic status. In this study, I asked whether these short-term refresher programs can increase mathematics knowledge and skills, as measured by the ACCUPLACER test. I considered but did not include the dichotomous variable gender or the nominal variables race or ethnicity as factors in the interpretation of the results of the study. The Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square nonparametric tests were suitable for evaluating the effect of each variable, time spent working on the modules in MyFoundationsLab, length of time spent in the face-to-face sessions in the Math Boost-Up program, high school GPA, and length of time between graduating from high school and taking ACCUPLACER test, on the pre- and posttest scores of students in each group. I also used the Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square nonparametric tests to determine the extent of the impact of each variable on the pre- and posttest results. The results of two studies conducted by researchers at the Montgomery County Public School System that implemented an ACCUPLACER preparation program using MyFoundationsLab indicated that time spent working on the modules was a major factor related to the increase in posttest scores (Cooper-Martin & Wade, 2012; Liu & Wade, 2012).

Studies Related to the Research Questions

I conducted this study in an effort to determine whether short-term refresher programs such as Math Boost-Up could increase the mathematics knowledge and skills to a level where community college students can avoid remedial or development courses altogether or enroll in a higher level course. I explored the answer to this question in the context of the moderator variables contained in Table 1, which included the impact of age, length of time between graduating from high school and taking the ACCUPLACER test, time spent completing modules in MyFoundationsLab, and time spent attending the face-to-face sessions in Math Boost-Up. As mentioned earlier, the researchers who conducted studies in community colleges and universities provided information on the overall results of the studies. Evidence from the studies reviewed showed that the interventions worked for the students in the group but the researchers did not compare the results to students who did not participate in the program. Randomized and nonrandomized experiments on the short-term refresher or brush-up programs were lacking in the literature and were necessary to provide empirically derived evidence of the relationship between the short-term refresher programs and increased scores on the placement tests.

Summary and Conclusion

A major theme in all the studies on placement test preparation was how best to help students avoid remediation and still do well in college-level courses. Based on the results from a number of studies involving students enrolled in summer bridge programs, these short-term refresher courses could help students accomplish this goal. However, most of these studies had a one-group-only design. A gap existed in the research literature related to the short-term refresher test preparation programs, as many of them did not have empirically validated approaches to determine their efficacy (Hughes & Ritze, 2010; Sherer & Grunow, 2010).

Lack of adherence to research protocol. Sections 2.06 and 2.07 of the sixth edition of the *Publication Manual of the American Psychological Association* (American Psychological Association, 2010) include the elements needed when reporting on the method and results sections of a study. The researchers for most of the studies referenced in this study did not follow this protocol for reporting the results of their research studies. This failure by the researchers was a limitation to this study, as the researchers did not follow the established protocol reporting on determining sample size, the effect size, power, and precision, along with the procedures used to handle missing data.

In an analysis of studies on the effectiveness of short-term refresher or summer bridge programs in increasing the college-level English and mathematics readiness of incoming freshmen, Kallison and Stader (2012) and Hodara (2013) noted that statistical evidence that these types of programs were effective in increasing college readiness was lacking. Kallison and Stader's analysis of the results from the mathematics section revealed a number or negative effects related to regression to the mean and in student drop-out rates or mortality. Hodara (2013) indicated that the limited studies on short-term refresher programs did not provide strong evidence of the efficacy of these programs because the researcher lacked equivalent comparison groups and failed to discuss what statistical power analyses they used to interpret their results. Moreover, the researchers failed to report the effect sizes used to measure meaningful changes in test scores. I followed the guidelines on the results and methods described in Sections 2.06 and 2.07 of the *Publication Manual of the American Psychological Association* (American Psychological Association, 2010). A discussion on the methodology used to study the efficacy of short-term refresher programs and to help fill the gap in the literature is in Chapter 3. Chapter 3 also includes the research design and rationale, participant recruitment, the intervention used, data gathering, and data analysis.

Chapter 3: Research Method

Introduction

The purpose of this study was to provide sound and empirically derived evidence that short-term intensive mathematics refresher programs, often called boot camps, are effective in increasing the mathematics knowledge and skills of entering freshmen at a community college. I measured the mathematics knowledge and skills of students using the ACCUPLACER test developed by the College Board. I investigated the hypothesis that the Math Boost-Up intervention would increase the ACCUPLACER mathematics scores of incoming students. Increasing the test scores on the ACCUPLACER test in basic arithmetic and elementary algebra would result in students either testing out of remedial math courses or into a higher level mathematics remedial course to help relieve the bottleneck of students in remedial or developmental mathematics courses. I focused on the mathematics section of the ACCUPLACER test because most students perform poorly on this section of the placement tests (Bailey & Cho, 2010; Ewell, 2010). Nationally 59% of students entering community colleges score below the cutoff score needed to enter a college-level mathematics course, compared to 33% of students who have to take remedial courses in English (Hodara, 2013).

Chapter 3 has five additional sections. In the second section, I use the research design to study the independent and dependent variables, as well as the rationale for choosing the design. The third section is on the methodology and includes a description of the target population, the type of sampling and sampling procedures employed, participant recruitment, and the nature of the intervention. Because this study was an intervention study, I also discuss details regarding the data analysis plan and how I measured each variable. The fourth section includes the various threats to internal and external validity and an explanation of how I handled each in the study. This section also has an outline of the ethical procedures used to select participants and to handle confidential data. The fifth and final section of this chapter includes a summary of the design and methodology used and an introduction to Chapter 4.

Research Design and Rationale

The independent variable for the study was the mathematics refresher program Math Boost-Up. The dependent variable was the gains in the mathematics knowledge and skills as measured by the ACCUPLACER test. To study the independent and dependent variables, I used a quasi-experimental nonequivalent group pretest–posttest design. The students who participated in the intervention program, Math Boost-Up, were members of the experimental group. The students who did not participate in intervention program were members of the comparison group. The research question that I addressed in this study was as follows: Did participation in the Math Boost-Up program increase the ACCUPLACER posttest scores of incoming community college students in the experimental group more than the scores of students in the comparison group who did not participate in the program but studied on their own? The relationship between the research design and the research question was comparative. Using a quasi-experiment design, the study involved comparing the ACCUPLACER test results of students in the experimental group who participated in the intervention with those of students in the comparison group who did not.

This study included two resource constraints. The first was the time constraint and second was funding. The time constraint associated with this study was that I could only conduct the study from May to August and it must end before the beginning of the fall 2014 semester. After students received their letters of acceptance to the community college, the Office of Admissions staff notified the students of the need to schedule a time to take the ACCUPLACER test. Advisors in the Department of Student Success also contacted the students to ensure they understood what was necessary to complete the admissions process for the college. The time frame, May to August, was optimal because there would be a large pool of students from which to recruit. The other resource constraint was funding. The program had a budget of $20,000, but the actual cost was $30,000. The study went over budget because staff added another session.

The quasi-experiment research design was suitable for two reasons. The first reason was that random experiments related to the topic of this study were not permissible at the college where the study took place. Collins (2010) and Levin and Calcagno (2008) noted that the quasi-experimental nonequivalent comparison group design serves as a good compromise when researchers cannot use random assignments. Even though I could not prove causality, I could still infer it (Bailey, 2009a; Martorell & McFarlin, 2011). The second reason was that self-selection was key to ensuring the chance was good that the students who decided to participate in the study would be self-directed and motivated to complete the study plan designed by the ACCUPLACER Diagnostics program. Chapter 2 included a detailed description of this aspect of the self-directed nature of adults. According to Knowles et al. (2005), a self-directed learner is more likely to feel motivated to persist at any task.

Quasi-experimental designs have been used to shed light on the efficacy of interventions and remedial or developmental education (Bailey et al., 2008, 2010b; Bettinger & Long, 2005; Burdman, 2012; Goldrick-Rab, 2010; Romano, 2011; Scott-Clayton, 2012). Levin and Calcagno (2008) contended that even though the preferred assignment of participants to comparison and experimental groups is random, rigorous quasi-experimental designs are effective if researchers address controls for internal and external threats to validity in the design and implementation of the study. I discuss how I handled these threats to validity in the Threats to Validity section. Participants in both groups used Pearson's MyFoundationsLab to help refresh the mathematics knowledge and skills of students who had not met the cut scores on the ACCUPLACER test in basic arithmetic and elementary algebra. The use of MyFoundationsLab capitalized on the benefits derived from CAI and discussed in Chapter 2.

Methodology

Population

The target population for the study was incoming students admitted to an open admissions community college in the Washington, DC, metropolitan area for the fall 2014 semester and who had not achieved the cutoff scores on the ACCUPLACER test needed to enroll in college-level mathematics courses. Based on 2013 fall data, the students who enrolled at the community college were mostly African Americans. Hispanics comprised approximately 15% of the student population. The average age of the students who attended the college was 28.5 years and most were female. Data I obtained from the Office of Institutional Research indicated that for the fall 2013 semester 68% of students received some financial aid or government assistance. Based on ACCUPLACER test scores, of the 881 incoming students taking the test for entry into the college for the fall 2013 semester, 96% (n = 846) tested into at least one remedial course, and 4% (n = 35) were college ready. Incoming students' scores on the mathematics sections of the ACCUPLACER test indicated that the majority of the students tested into one or more developmental course. A breakdown of the students' overall performance is in Figure 2. Information regarding the students' performance on all sections of the ACCUPLACER test is in Figure 3.

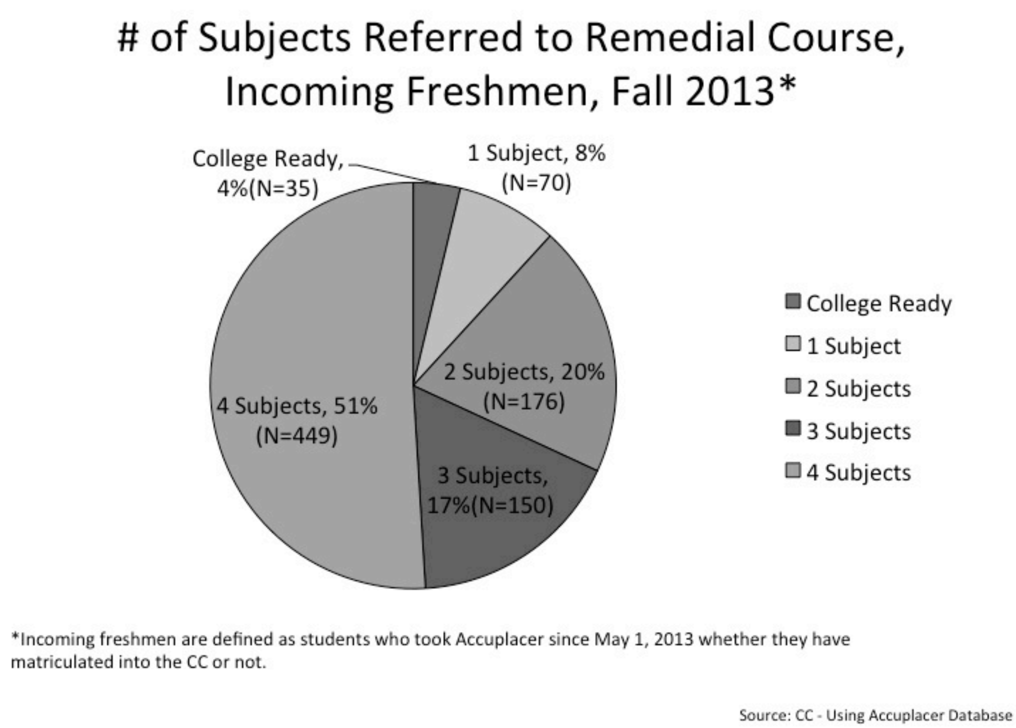

Figure 2. Number of students who tested into remedial courses. Report presented to Board of Trustees, June 10, 2014.

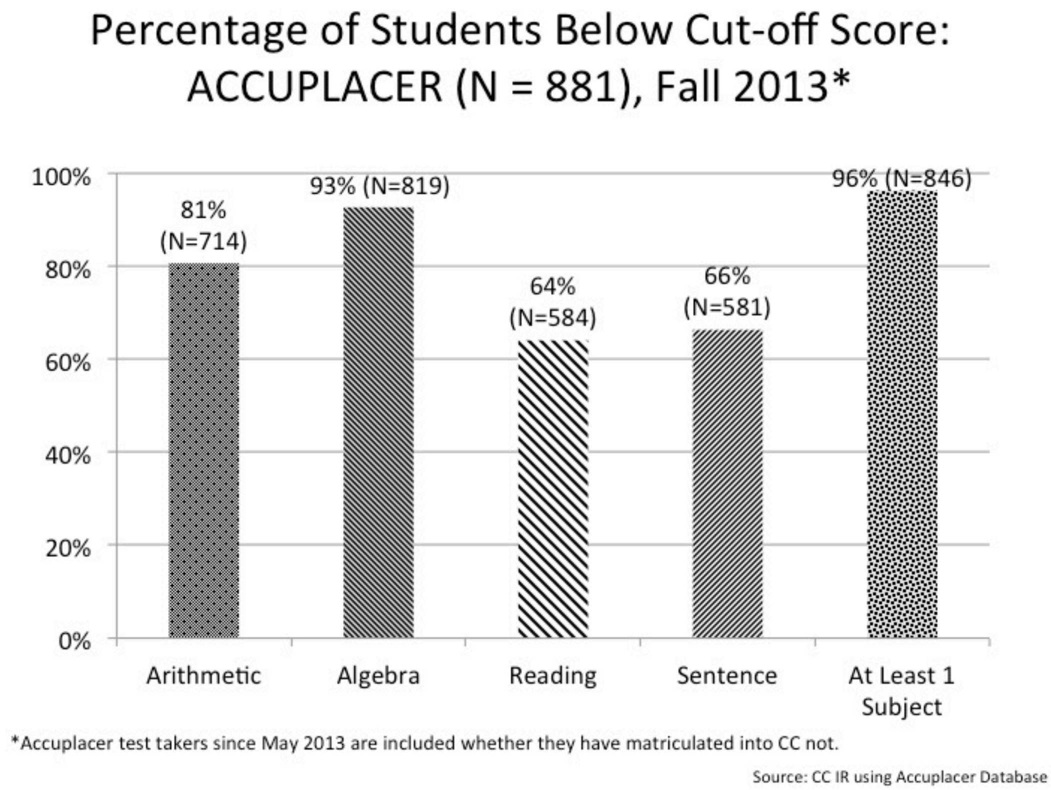

Figure 3. Student performance on ACCUPLACER test. Report presented to Board of Trustees, June 10, 2014.

Information related to the students' performance on the mathematics tests in arithmetic and elementary algebra appears in Figure 4. Of the 881 students tested, 67% (*n* = 590) of these students scored 40 points or more below the cut-off score in arithmetic, and 38% (*n* = 335) of these students scored 40 points and more below the cut-off score in algebra. Students did better in English than in mathematics. Eight-eight students (10%) scored 40 points or more below the cut-off score in reading, and 53 students (6%) scored 40 or more points below the cut-off score in sentence structure.

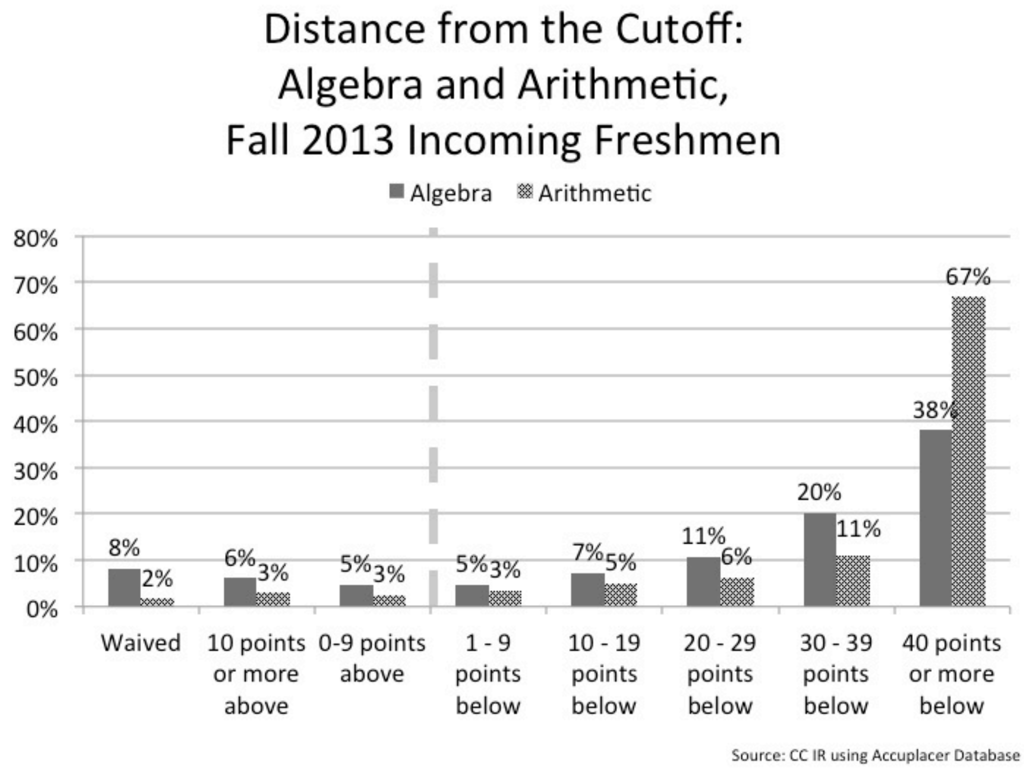

Figure 4. Students' scores below ACCUPLACER cut-off levels.

Every fall semester, approximately 2,000 students apply for admission into the community college where this study resides. However, approximately 1,000 students are admitted into the college. Upon entry to the college, all first-time-in-college (FTIC) students must take the ACCUPLACER test. Using the statistical power analysis program, G*Power Version 3.1, I anticipated that the sample size should be at least 152 to detect a small to medium effect size of .20. This effect size was in keeping with those reported in similar studies in the Montgomery County Public School System (Cooper-Martin & Wade, 2012; Liu & Wade, 2012). A summary of the study's major activities and an outline of the efforts to achieve the anticipated sample size appear in Table 3.

Table 3

Implementation Summary

Activities	Week 1: Testing	Week 2: Assessment of mathematics knowledge and skills	Weeks 3-4: Preparing to retake ACCUPLACER test (face-to-face and online-only)	Week 5: Retake ACCUPLACER posttest
• ACCUPLACER assessment • Review results of ACCUPLACER test with advisor • Invitation extended to students to retake the ACCUPLACER test	• Students take the ACCUPLACER pretest • After completing the test, students met with an advisor to review test results. Students who met the cut scores enrolled in the college-level mathematics course or in remedial education. Students who took the test prior to June 2 also received invitations to participate in the program. • Arithmetic: 69 or lower meant the student placed into the remedial course Basic Mathematics. • Elementary Algebra: 70-84 meant the student placed into the remedial course Introduction to Algebra. • College-level math course: 85 and above on elementary algebra meant the student tested into college-level mathematics course. • Students who received the cut scores on the arithmetic and elementary sections of the ACCUPLACER test received an invitation to retake the test. • A condition of retaking the test, was agreeing to participate in Math Boost-Up or study on their own. • Students who did not wish to retake the test had to enroll in remedial mathematics. • Students in both groups had access to the MyFoundationsLab intervention	• ACCUPLACER Diagnostic assessment: students will be scheduled to take this test. • Students who wanted to retake the test had to choose to participate in Math Boost-Up (experiment group) or study on their own (comparison group). • ACCUPLACER Diagnostics was administered to each student in the experiment and comparison group. • Faculty members reviewed assessment results with each student and reviewed the modules students needed to complete. • Students who decided to study on their own received additional training in how to access the modules in MyFoundationsLab that were mapped to their areas of weakness.	• Refreshing mathematics knowledge and skills (2 weeks). • Students refreshed their mathematics knowledge and skills by participating in Math Boost-Up or by studying on their own. • Students in both groups had access to MyFoundationsLab • Students were encouraged to make arrangements to make up missed sessions.	• Students retake the ACCUPLACER test. • The students retook the ACCUPLACER test within 3 weeks of the end of the initial test date. • Modification: Students retook the ACCUPLACER test within 1 week after the end of each session. • The modification is being made because students who took the test from January 1 to June 2 received an invitation to participate in the program.

Research Design

The research design for the study was a quasi-experimental nonequivalent comparison group pretest–posttest design. The study did not include any random assignments of students to the experiment or the comparison group, as the college's administration did not allow experiments involving random assignments.

Sampling and Sampling Procedures

Sampling strategy and justification. The convenience sample consisted of students who self-selected to participate in the program. Self-selection kept with the andragogical framework of this study. According to Knowles (1980), having adults self-select would capitalize on the self-directed nature of adult learners and their motivation to learn. The approach of allowing students to determine whether to participate in the program resulted in recruiting only students who would feel committed to completing all activities. Further, I felt after students understood the benefits of participating in Math Boost-Up, they would choose to enroll in the program. Knowles (1996) noted that other strategies such as making participation mandatory and dictating to learners what they needed to learn and how and when they needed to learn it, which he and other adult learning theorists categorized as pedagogy, which ignored the need for adults to be self-directed, ended up with "high drop-out rates, low-motivation, and poor performance" (pp. 256-257).

Sampling procedures. Students who received scores of 69 and below on the arithmetic section or 84 and below on the elementary algebra section of the ACCUPLACER test received an invitation to participate in this program. College leaders dictated the cut scores that corresponded to the courses in which students could enroll. The students who were ineligible to enroll in college-level mathematics courses self-selected to participate in the intervention program. Students who did not wish to participate in the study went on to enroll in remedial courses. Limiting participation to those students who self-selected to participate in the program posed a threat to internal as well as external validity. Inviting all students who did not meet the cut scores to participate in the study minimized the threat to selection bias related to the restriction of range in test scores. The community college leader set the qualifying test scores for participation in the Math Boost-Up program.

Sample size. I used the G*Power statistical power program to conduct an a priori power analysis to compute sample size *N* that would yield the statistical power needed to reject the null hypothesis and avoid a Type I error and to accept the alternate hypothesis and avoid making a Type II error. Sample size *N* was a function of the required power level $(1 - \beta)$, the prespecified significance level α, and the population effect size detected with probability $(1 - \beta)$. In determining the effect size for the study, I followed the guidelines outlined by Cohen (1992), in which small, medium, and large effect sizes are .10, .30, and .50, respectively. I anticipated that the study would achieve a small effect size of .20, in keeping with the effect sizes reported by the Montgomery County Public School System (Cooper-Martin & Wade, 2012; Liu & Wade, 2012).

Based on the anticipated population effect size of .20, to gain detection with the prespecified probability $1 - \beta$ (.80); the prespecified significance level α of .05, which is the standard used in research studies; and the required power level $1 - \beta$ of .80, which is also the standard used in research studies, the G*Power indicated that a total sample size of 152 (76 in each group) was necessary (Cohen, 1992; Dong & Maynard, 2013; Faul, Erdfelder, Lang, & Buchner, 2007). However, as reported in Chapter 4, after I conducted the study, the total sample size was 136 FTIC students. An equal distribution between the two groups, the experimental group that attended face-to-face Math Boost-Up sessions and the comparison group who studied online on their own, did not occur. Forty-four students were in the experimental group, and 92 students were in the comparison group.

Procedures for Recruitment, Participation, and Data Collection of the Intervention

After taking the ACCUPLACER test, a student success specialist reviewed the results with the students who did not achieve the cut-off scores and therefore had to enroll in remedial courses. The student success specialist met with each student and discussed the implications of taking remedial courses as opposed to college-level courses. The student success specialist then encouraged the students to refresh their mathematics knowledge and skills and retake the test. As a condition of retaking the test, the specialist explained to the students that they would need to take the ACCUPLACER Diagnostics assessment and prepare either by participating in the Math Boost-Up program or by using the MyFoundationsLab on their own.

The developers of Math Boost-Up designed the program to increase the mathematics knowledge and skills of incoming students as measured by the ACCUPLACER test for students who have not met the cut scores in basic arithmetic and elementary algebra that are necessary to enroll in a college-level mathematics course. At the community college where this study took place, to enroll in a college-level mathematics course, the college's policy dictates that students must obtain the scores listed in Table 4. Faculty in the mathematics department developed the cut scores and the related course in which students will be eligible to enroll.

Table 4

ACCUPLACER Cut Scores Required by the College

Course	Score
Elementary algebra	85 or above means a student has placed into several college-level courses 84 or lower means a student has placed into Basic Mathematics
Arithmetic	69 or lower means a student has placed into Basic Mathematics

Students had the option of participating in a 2-week intensive face-to-face session of Math Boost-Up or studying on their own for the same time period. The students who attended the face-to-face session were in the experimental group. Students who chose not to participate in the face-to-face session were in the comparison group. Both groups had access to MyFoundationsLab.

The ACCUPLACER Diagnostics assessment is an instrument that measures students' strengths and weaknesses in the areas of reading comprehension, sentence skills, arithmetic, and elementary algebra (College Board & Pearson, 2011). The aim of the computerized program MyFoundationsLab is to "Assess quickly, Remediate thoroughly, Place accurately, and Advance successfully" (College Board & Pearson, 2011). The focus in this study was only on the mathematics section of the diagnostics assessment. The assessment identified the students' strengths and weaknesses in arithmetic and elementary algebra. Based on an analysis of these results, the program created an individualized study plan for each student that mapped to intervention modules in Pearson's MyFoundationsLab.

MyFoundationsLab is a computerized program that engages each student in activities based on each student's particular strengths and weaknesses. The student then follows this plan, completes the activities, and receives feedback along the way that are both computer generated and provided by the facilitator. The faculty members assigned to the experimental group facilitated the process by working with individual students and sometimes with small groups of students who were experiencing difficulties with similar topics. I intentionally linked this aspect of the intervention to Knowles's six assumptions or principles of adult learning, confirmed by an andragogical framework (Knowles et al. 2005). The strategy of beginning with an assessment of what participants know, understand, and are able to do, and using these results to advise them of next steps, gives them, and not the teachers, the responsibility for their learning (Knowles, 1980). In a study on improving safety in a science lab, Galbraith and Fouch (2007) found that letting participants know where the gaps were in their knowledge and skills and what they needed to learn at the beginning of any learning situation engaged the learners from the beginning and motivated them to want to learn. The strategy of letting learners know where they stand is in line with Assumptions 1, 2, and 6 of Knowles's theoretical framework (Knowles, 1980, 1981, 2005). From the results of the study, I able to confirm that if learners were going to succeed in learning, they needed to know what they needed to learn to be successful.

The students who participated in the Math Boost-Up program (the experimental group) attended the face-to-face sessions for 2 weeks, from Monday to Friday. Students chose to attend either the morning or the evening session. Each session lasted 4 hours. The faculty designed the sessions based on students' needs and balanced the each sessions between time in the classroom and time in the lab. At the end of 2 weeks, students retook the ACCUPLACER test. Chapter 4 includes a discussion of the results of the intervention.

The students in the comparison group who decided not to participate in the Math Boost-Up program also took the ACCUPLACER Diagnostic assessment. These students had the same amount of time as the experimental group to prepare on their own using MyFoundationsLab. They also retook the ACCUPLACER test within 1 week after the intervention ended. Chapter 4 also includes information about their performance.

Informed consent. The study included archival data. Therefore, the study was project exempt, and informed consent forms were not necessary. The data report that I received from the faculty contained no demographic data.

Data collection. I collected data using various assessment instruments. I used the ACCUPLACER test to collect pretest and posttest data regarding the mathematics knowledge and skills of participants in the study before and after the intervention. The ACCUPLACER Diagnostics collected data regarding what students knew, understood, and could do related to arithmetic and elementary algebra. I obtained related moderator variables identified in Table 1, high school GPA, date of high school graduation, and date of birth from the Banner student management system. The variables such as the date that the students took the ACCUPLACER pre- and posttests and the scores they earned were available from the ACCUPLACER database. Faculty extracted the additional moderator variable, length of time each group spent working on the modules in MyFoundationsLab, from the MyFoundationsLab program. Instructors maintained a daily attendance log, and participants had to sign in each day as well. The faculty running the intervention also extracted data from Banner and the ACCUPLACER database. They collected data related to name, student identification number, GPA, and age in the beginning when students received invitations to participate in the program. The original plan for handling missing data follows. In Chapter 4, I provide detailed information about how I actually handled missing data.

Age (date of birth): I planned to calculate age from the date of birth extracted for each student from Banner. If this information was missing, I would cross-reference the ACCUPLACER database and input the data manually.

GPA: I planned to capture GPA at admission by reviewing a scanned copy of the student's original high school transcript and capturing the data from the transcript. If the data were missing from these sources, I would enter the mean GPA for the group.

ACCUPLACER pre- and posttest scores: I planned to extract ACCUPLACER scores from the ACCUPLACER database. If they were missing, I planned to perform a manual check of the ACCUPLACER database and input the scores manually. If any of the scores were missing from the database, I planned to enter the mean scores of the participants.

Attendance at the face-to-face sessions: The faculty leading the sessions would complete attendance logs for the students in each session. In addition, students would have to sign in at each session. I planned to cross-reference the two logs for missing information at the end of each session.

Time spent on the MyFoundationsLab intervention: I planned to extract this information from MyFoundationsLab. If any information were missing, I would perform a manual check of the MyFoundationsLab report and enter the times manually. Faculty would perform regular checks of the time participants spent completing the exercise in MyFoundationsLab.

Posttest score: If students participated in the intervention but did not retest, I would manually input the mean score of the group they were in: experiment or comparison.

Exiting the study and debriefing procedures. Faculty and the student success specialists assured participants they could leave the study at any time without fear of repercussion. After the posttest, an advisor met with each student to review results and discussed placement in the mathematics course based on the results.

Instrumentation and Operationalization of Constructs Related to the Intervention

The ACCUPLACER test instrument assessed each student's knowledge and skills in reading comprehension, sentence skills, arithmetic, elementary algebra and college level mathematics upon entry to the college. The ACCUPLACER is a computer-adaptive test developed by the College Board to determine which course students should begin taking in English and Mathematics. Administrators and advisors in 62% of the community colleges in the United States have administered the test to incoming students since 1985 (Gerlaugh & Thompson, 2007; Scott-Clayton, 2012). The ACCUPLACER test returns a score to determine the course-level placement in English and mathematics.

ACCUPLACER Diagnostics was another assessment instrument used in this study. Testing coordinators at the College Board developed the diagnostics test to determine the weak areas that students need to work on to improve their scores on the ACCUPLACER. The ACCUPLACER Diagnostics provided students with detailed information regarding these weak areas. The ACCUPLACER Diagnostics mapped the results from this assessment to Pearson's MyFoundationsLab, which provided each student with an individualized learning plan. The ACCUPLACER Diagnostics program automatically mapped this plan to self-paced modules in MyFoundationsLab that students could complete on their own or with the support of a math teacher or facilitator (Speckler, 2011). According to their advertisement literature, "ACCUPLACER//MyFoundationsLab enabled learners to build and master the requisite skills needed to pursue postsecondary degree pathways successfully and accelerate time to completion" (College Board & Pearson, 2011, p. 4).

Operationalization of the Variables

The independent variable of the study was the Math Boost-Up program. In the Math Boost-Up program, participants worked to increase their mathematics knowledge and skills by using Pearson's MyFoundationsLab and attending face-to-face sessions. The students who attended Math Boost-Up were in the experimental group. Students who chose not to participate in the Math Boost-Up program were in the comparison group.

Students in the comparison group chose not to participate the face-to-face sessions but agreed to study on their own using Pearson's MyFoundationsLab. The dependent variable was the mathematics knowledge and skills as measured by the ACCUPLACER test. I used the Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square nonparametric tests to evaluate the impact of the ordinal variables age, pretest scores, high school GPA, length of time between graduating from high school and taking the ACCUPLACER test, length of time spent working on the modules in MyFoundationsLab, and time spent attending the face-to-face modules in Math Boost-Up on the mathematics knowledge and skills of students in both the experimental and the comparison groups.

Admissions' counselors use the ACCUPLACER test, which is a computer-adaptive test, to measure the mathematics knowledge and skills at the time of admission into the community college. According to the *ACCUPLACER Program Manual* (College Board, 2012), the ACCUPLACER tailors test questions to each student "using an item selection algorithm based on a weighted deviations model and algorithm for item selection" (p. 8). This means that the program chooses test questions based on the test taker's knowledge, skills, and abilities. Because of the adaptive nature of the test, no two test takers will receive the same test; therefore, the results provide an accurate assessment of the students' knowledge and skills in each content area (College Board, 2012).

The score on the pretest determined eligibility to participate in the study. Those students who did not meet the cut scores needed to enroll in college-level mathematics received an invitation to participate in the study and as a condition of being able to retake the ACCUPLACER test. The test results are an indication of what students know and can do related to arithmetic and elementary algebra. Students who receive a minimum score of 70 in arithmetic possess the knowledge and skills needed to enroll in the Introduction to Algebra course. Students who score 85 and above in elementary algebra, as well as 70 and above in arithmetic, possess the knowledge and skills needed to enroll in the General College Mathematics course at the college.

Data Analysis Plan for the Intervention

I analyzed the data using the Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square nonparametric tests that were in the Statistical Package for the Social Sciences (SPSS) Version 21. I had originally planned to use a stepwise multiple linear regression method with forward and backward procedures. These procedures could help to determine which predictor variable or variables have a strong correlation (variables will be removed when $p \geq .10$) between the independent and the dependent variables and can explain the variances between the two groups in the study (George & Mallery, 2014). However, I had to substitute nonparametric tests because there were an unequal number of participants in each group, and there were considerable differences in the amounts of missing data between the variables. I also could not use the logistic regression model because the dependent variable, the measure (the ACCUPLACER test) of mathematical knowledge and skills, yielded results that were continuous and not dichotomous. Additionally, the hierarchical linear model was not appropriate for this study because I was not conducting a multilevel analysis of the variables similar to how schools are nested in districts, classes are nested within schools, and students are nested within classes (Enders & Tofighi, 2007). Further, there was no established theoretical scheme for establishing the variables within a hierarchical structure (Raundenbush, 1993).

In summary, nonparametric procedures were the most appropriate alternative to the stepwise multiple regression analyses previously proposed. Nonparametric procedures were more appropriate because of the amount of missing data, the uneven distribution of participants between the two groups, and the number of outliers. Researchers can use nonparametric procedures when the distribution of data is not normal, as was the case in this study (Corder & Foreman, 2014; Siegel, 1957).

The data for the study were from the ACCUPLACER test results database and from Banner. Scores from the ACCUPLACER test were from the test's own database. Information related to age, entering GPA, and high school graduation date was from the student information system, Banner. Data related to the length of time each group spent in completing the modules in MyFoundationsLab were from the program itself and exported to an Excel spreadsheet. I did not need to enter any data by hand, so data cleaning and screening procedures were not necessary. However, there was a considerable amount of missing data. Because of the amount of missing data, I used nonparametric tests. In Chapter 4, I provides additional information regarding how I handled the issues related to missing data.

The goal of the study was to determine whether the mathematics refresher program Math Boost-Up could increase the mathematics knowledge and skills of incoming community college students in the experimental group compared to students in the comparison group who did not participate in the program, as reflected in gains in the ACCUPLACER posttest scores. The related hypotheses were as follows:

H_0: Students' gains in the ACCUPLACER posttest scores would essentially be the same for those in the experimental group who participated in Math Boost-Up (independent variable) and those in the comparison group who studied on their own.

H_A: Students' gains in ACCUPLACER posttest scores would be different for those in the experimental group who participated in the Math Boost-Up program (independent variable) and those in the comparison group who studied on their own.

Statistical tests. The statistical methods used to test the hypotheses were the Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square nonparametric tests. I used the nonparametric tests to account for the differences between the ACCUPLACER pretest and posttest score of both groups that were attributable to the moderator variables addressed in Table 1, namely age, high school GPA, length of time between graduating from high school and taking the ACCUPLACER test, length of time each group spent working on the modules in MyFoundationsLab, and time spent attending the face-to-face modules in Math Boost-Up. I also used these nonparametric tests to determine the degree of correlation between the moderator variables and posttest scores. I had planned to use the *t* test on the pretest scores to determine equivalency between the experiment and comparison groups and to compare the mean pretest and posttest scores of the two groups. However, I had to use Spearman correlations instead of Pearson correlations because I found 24 outliers and because of the unevenness in the make-up of the groups. In addition, I used Mann-Whitney tests (Best & Kahn, 2006; Field, 2009) instead of *t* tests for independent means and Kruskal-Wallis tests instead of one-way analysis of variance tests. Table 1 included a listing of the moderator variables and the data analysis methods used to determine the effect of each variable on the pretest and posttest scores of participants in each group. Chapter 4 includes a more detailed discussion of the statistical tests and their related results.

Procedures used to account for multiple statistical tests. I used nonparametric procedures, specifically Kruskal-Wallis and Mann-Whitney (Corder & Foreman, 2014), along with the Bonferroni adjustment modified by Sture Holm (1979), to control for the family-wise Type I error rate, which has been set to α error probability = .05.

> In Holm's sequential version, the tests need first to be performed in order to obtain their "p-values." The tests are then ordered from the one with the smallest p-value to the one with the largest p-value. The test with the lowest probability is tested first with a Bonferroni correction involving all tests. The second test is tested with a Bonferroni correction involving one less test and so on for the remaining tests. (Abdi, 2010, pp. 1-2)

Using the Holm-Bonferroni adjustment, a researcher will reject H_0 for each test if $\alpha \leq$ .05/the number of comparisons (g) or .008 (.05/6). This procedure increases "the critical value necessary for a difference to be statistically significant" (Parsad, Lewis, & Greene, 2003, p. A-9).

Rationale for inclusion of covariates and confounding variables. I included the moderator variables age, high school GPA, years since graduating from high school and taking the ACCUPLACER test, and the covariate pretest scores in the test because of their potential threats to internal validity, primarily to selection maturation.

How results were interpreted. Because of the results of the test, I was able to make inferences regarding whether the Math Boost-Up program could change the mathematics knowledge and skills of students. I could not show causal relationship because of the nonrandom assignment of participants to the experimental and comparison groups. Despite these shortcomings, I was able to make claims of association after discussing the efforts made to minimize the threats to validity discussed below.

Threats to Validity

The study had a quasi-experimental design as opposed to a true experimental design. Studies with a quasi-experimental design do not have randomly assigned participants, whereas studies with a true experimental design have randomly assigned participants. According to Christensen (1997) and Shadish et al. (2002), a quasi-experimental design will cause difficulty in controlling for the influence of variables that can pose threats to internal and external validity. Although the threats to internal and external validity might cause some researchers not to consider quasi-experimental designs as valid as true experiments, Shadish et al. contended that "in the best of quasi-experiments, internal validity is not much worse than with the randomized experiment" (p. 484). Using a design that matched the requirements of a true experiment as closely as possible would minimize the threats to internal and external validity (Christensen, 1997;

Shadish et al., 2002). Shadish et al. (2011) found that while randomized experiments were more preferable than nonrandomized experiments, researchers could still conclude with confidence that the results yielded from these types of experiments were accurate. Because quasi-experimental designs are not strong in controlling for internal validity, researchers can resolve some threats to external validity due to the research study taking place in a natural setting (Shadish et al., 2002). Careful monitoring of these elements helped to ensure they did not affect the integrity of the study.

In quantitative research studies, the threats to internal validity are history, maturation, testing, instrumentation, statistical regression, mortality, different selection of participants or selection bias, mortality, and selection maturation interaction (Campbell & Stanley, 1963; Huck & Chuang, 1977; Oakes & Feldman, 2001; Shadish et al., 2002). Campbell and Stanley (1963) warned that the main threats to external validity are the effect of the pretest on the posttest, the effects of selection biases on the experimental variable, effects of prior experiments, generalization of results across time, population, various settings, and dependent variables. A discussion follows of how I handled threats to external and internal validity and the precautions I took in this study to minimize these threats.

Threats to External Validity

According to Cook and Campbell (1979), external validity is the degree to which the results of any study are generalizable to the larger population, setting, and times. As it related to this study, external validity had to do with whether the results of the study were generalizable to similar target populations and community colleges. First, external validity of this study was a limitation of the study because students self-selected to participate. Self-selection was a threat to population validity because it indicated that only self-directed and motivated persons would participate in the study. Motivation is not generalizable to all incoming students at this or any other community college. Second, the study took place at a community college in an urban setting. Third, cut-scores (see Table 4) at the college where I conducted this study, may not be the same at other colleges. Fourth, I had to limit external validity of this study to those community colleges that used similar cut scores to determine the course levels in which students could enroll. Last, the extent of the impact of temporal validity relating to whether the moderator variables, identified in Table 1, would vary depending on which semester (fall, spring, and summer) students took the ACCUPLACER test was difficult to determine as the optimal time to provide this program was during May, June, July, and August.

Threats to Internal Validity

Shadish et al. (2002) described five threats with direct links to the nonequivalent comparison-group design. The threats were selection bias, selection-maturation, selection-instrumentation, selection-regression, and selection-history (Shadish et al., 2002). I provide a description of each of these threats below.

Selection bias. Selection bias was inherent in the nonequivalent group design mainly because the assignment of participants to the experimental and comparison groups was not random (Shadish et al., 2011). The fact that participants self-selected to participate in the study further compounded this threat. This was a recognized limitation of the study.

Selection-maturation. In the context of this study, selection-maturation was likely to occur when the mathematics knowledge and skills of the members of one group would grow faster than those of the participants in the other group because the participants' abilities in this area differed greatly as indicated by the pretest scores. To minimize this threat, all students in the study had to retest within 1 week after the intervention ended. Faculty scheduled the tests to accommodate students' schedules.

Selection-instrumentation. Selection instrumentation occurs when administrators use different instruments to assess students' performance. The impact of the intervention on student performance would not be clear because of the use of different assessment instruments. Using the same instrument, the ACCUPLACER test, to measure mathematics knowledge and skills pre- and posttest prevented this threat.

Selection-regression. Selection-regression would likely occur when students in one group have lower or higher scores on the pretest than the students in the other group. The use of the ACCUPLACER, a computer-adaptive test, minimized this threat to internal validity.

Selection-history. Selection-history is a threat when an event occurs between the pretest and posttest that affects the performance of one group over the other group on the posttest. To minimize the impact of this bias, faculty administered ACCUPLACER Diagnostics to each student in the experimental and comparison groups. An advisor reviewed the results of the diagnostic assessment with each student and reviewed the individualized intervention and study plan identified by the assessment. Students gained access to MyFoundationsLab after receiving an orientation on how to complete the modules in the program.

Threats to Construct Validity

To minimize the threat to construct validity, the computer adaptive ACCUPLACER test was suitable to measure the construct: mathematics knowledge and skills related to arithmetic and elementary algebra (independent variable). The ACCUPLACER Diagnostics was also suitable to determine what students knew and understood (mathematics knowledge and skills) in relation to arithmetic and elementary algebra. The ACCUPLACER test in conjunction with the ACCUPLACER Diagnostics assessment ensured the assessment of mathematics knowledge and skills only and no other variables. However, even though the goal of the study was not to focus on which elements of the design of the Math Boost-Up program affected posttest scores, face-to-face sessions or extra practice in class with MyFoundationsLab, this was a confound that was inherent in the design of the study.

Threats to Statistical Conclusion Validity

Shadish et al. (2002) identified seven threats to statistical conclusion validity. The threats were

> low statistical power, violated assumptions of statistical tests, fishing and the error rate problem, the unreliability of measures, restriction of range, the unreliability of treatment implementation, extraneous variance in the experimental setting, the heterogeneity of units (respondents) and inaccurate effect size estimation. (Shadish et al., 2002, p. 45)

Answers to how the study addressed each of these threats follow.

Low statistical power. As discussed in the section on sample size, I used the G*Power statistical power program to conduct an a priori power analysis to compute sample size *N* that would yield the statistical power needed to reject the null hypothesis and avoid a Type I error and to accept the alternate hypothesis and avoid making a Type II error. An effect size of .20 based on Cohen's *d* was necessary. To gain detection with the prespecified probability $1 - \beta$ (.80); the prespecified significance level α of .05, which is the standard used in research studies; and the required power level $1 - \beta$ of .80, which is also the standard used in research studies, G*Power indicated that a total sample size of 152 (76 in each group) was necessary (Cohen, 1992; Dong & Maynard, 2013; Faul et al., 2007). Information pertaining to sample size and effect size is in Chapter 4.

Violated assumptions of statistical tests. The study included nonparametric tests, primarily Mann-Whitney and Kruskal-Wallis, to determine the effect of the moderator variables, listed in Table 1, on the independent and dependent variables. The nonparametric procedures helped determine the extent to which each and then all of the independent and moderator variables could explain the changes in the dependent variable (Brace & Kemp, 2012; Garson, 2012). Using nonparametric procedures involves checking to ensure the data pass certain assumptions. I performed these checks using SPSS. Described below are the tests to ensure I did not violate any of these assumptions. Further, if I did violate any of these assumptions, I also discuss the steps recommended in the literature to correct them.

Because the study did not meet the major assumptions required to use multiple linear regression analysis procedures, which were that the independent, dependent, and moderator variables were continuous and measurable on an interval scale and that the distribution of data was normal (Brace & Kemp, 2012; Garson, 2012), I used the Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square nonparametric procedures instead (Corder & Foreman, 2014; Siegel, 1957). Because I used nonparametric procedures, tests for the assumptions of linear relationship, homoscedasticity, and multicollinearity were no longer necessary. However, the following tests remained as a part of the study. I used SPSS to check for the normality of data and to identify the outliers. A detailed discussion of how I handled the results appears in Chapter 4.

Fishing and the error rate problem. Cook, Campbell, and Peracchio (1990) also referred to the fishing and error rate problem as alpha inflation. To reduce the threat, I anticipated using an effect size (.20) and a sample size (152 students) that would have made Type I and Type II errors unlikely. The various effect sizes and the ways I resolved the issue are in Chapter 4.

Unreliability of measures. The ACCUPLACER test is a computer adaptive test that reduced the threat to the study related to unreliability of measures. Because the test was a computer adaptive test, it was unlikely that students would receive the same test the second time that they took the first time. The discussion of the impact of how this threat related to performance on the pre- and posttest and how I handled it was in the sections on history, maturation, and regression.

Restriction of range. To help minimize the restriction of range threat, all students who scored below the cut scores in arithmetic and elementary algebra on the ACCUPLACER test, as indicated in Table 4, received an invitation to retake the test. However, I could not eliminate this threat completely because the college policy dictated that administrators and advisors consider the students who score above the cut score in both arithmetic and elementary algebra to have passed the test and could enroll in college level mathematics courses. Therefore, I did not extend an invitation to these students to participate in the study. I anticipated there might be students in the group who achieved the cut scores in arithmetic and not in elementary algebra or vice versa. The possibility that students who received very low scores would have withdrawn from the study also confounded the restriction of range. I made every effort to work with these students, as with all students in the study, to prevent them from dropping out. A detailed discussion of this situation appears in Chapters 4 and 5. These issues further added to the fact that I could not make any claims of causality between the independent and the dependent variable. The restriction of range threat that resulted in the sample size not being representative of the population of incoming students taking the ACCUPLACER test was a limitation of the study.

Unreliability of treatment implementation. To reduce the effect of this threat on the study, I developed implementation procedures that addressed items such as students recruitment, the information that was necessary to share with them related to the requirements for retesting, the ACCUPLACER Diagnostics program, the logistics regarding the use of Pearson's MyFoundationsLab, the details pertaining to the Math

Boost-Up program, and the attendance requirements. I met with the advisors in the Department of Student Success to review these requirements. I also met with faculty leading the Math Boost-Up program to review the core principles of andragogy and its relationship to the ACCUPLACER Diagnostics and MyFoundationsLab. I also met several times with the faculty to review how the program would operate after students enrolled and provided information regarding how students could exit the program, attendance policies, and monitoring of students in the control group. I conducted two (beginning and middle) observations of each face-to-face session to ensure the faculty members were conducting the sessions in accordance with the theoretical framework for andragogy. I reviewed the notes from these observations with faculty in the context of the six core principles of Knowles's theory of andragogy discussed in Table 2. I implemented the aforementioned strategies to "make the treatment and its implementation as standard as possible across occasions of implementation" (Cook & Campbell, 1979, p. 43).

Extraneous variables in the experimental setting. I anticipated that variables were likely to affect the dependent variable, mathematics knowledge and skills. These variables are in Table 1. Because this was a small-scale study in a community college (social setting) and not in a laboratory, it was not possible to control for extraneous variables that arose from the setting (environment) itself (Cook et al., 1990). According to Cook et al. (1990), not being able to control the impact of these extraneous variables on the dependent variable, mathematics knowledge and skills, may cause an inflation of the error variance leading to the researcher not being able to reject the null hypothesis.

To minimize this threat, the study took place in a single community college in an urban setting and the analysis of the results took place in one time period. Therefore, the results were "representative of the situational, organizational, and administrative, as well as sociopolitical conditions" (Albrecht, 1991, p. 409) of this urban setting. This factor may have strengthened the external validity of the study in relation to similar settings.

Heterogeneity of units (respondents). The heterogeneity of respondents was another methodological dilemma in the study. Cook et al. (1990) suggested researchers use three strategies in a study to control for this threat. Cook et al. suggested "(a) selecting homogenous respondent populations (at some cost in external validity), (b) blocking on respondent characteristics most highly correlated with the dependent variable, or (c) choosing within-subject error terms as in pretest-posttest designs" (p. 500). The first suggestion would result in compromising external validity. Because the study included nonparametric procedures, the other variables that may affect the dependent variable such as motivation, race, or gender are in a sense blocked, as noted in Cook et al.'s second suggestion. Because this study included pretest-posttest measures, the third suggestion provided a plausible solution to the problem. According to Cook et al., "In designs with both pretest and posttest measures, the extent to which within-subject error terms reduce the error terms depends on the correlation between scores over time: The higher it is, the greater the reduction in error" (p. 500). Following their suggestions, I used nonparametric procedures to compare the within-subject mean difference between the pretest and posttest scores for the experiment and control groups and then compared the result with the between-subject mean scores for the experimental and control groups.

Inaccurate effect-size estimation. I used the statistical power analysis program G*Power Version 3.1 to conduct an a priori analysis to estimate the effect size of the study based on a minimum sample size of 152 and "the required power level (1 - β), the pre-specified significance level α, and the population effect size to be detected with probability (1 - β)" (Faul, Erdfelder, Lang, & Buchner, 2007, p. 5) that should help to detect a small to medium effect size. Based on these calculations, the effect size was small at .20 (Cohen's *d*). However, the eta coefficients, Cramer's *V*, and correlation coefficients were the measures of effect size used in this study. Using Cramer's *V* and correlation coefficients, I noted the magnitude of the association between the moderator variables for students both in the online and face-to-face groups. According to Rea and Parker (1992), Hinkle, Wiersma, and Jurs (1979), Davis (1971), and Hopkins (1997), the effect size ranges from .00 to 1.00 and from a negligible association to very strong or high. Based on these guidelines, the resulting measures showed that the effect size was in the little or negligible association or correlation to low to moderate correlation or association. A discussion on the details and magnitude of these relationships is in Chapter 4.

Ethical Procedures

The study followed the ethical procedures outlined by the Institutional Review Boards (IRB) at Walden University and at the host college where this study took place. The policies and procedures followed at each institution served to secure the safety and confidentiality of participants. I made every effort to be transparent in the recruitment and implementation processes associated with this study. I submitted an application to the community college's IRB to obtain permission to conduct the study at the community college.

Given my role as researcher and administrator at the college, I was not involved in the recruitment and selection of the participants or in the delivery of the intervention. Further, I did not supervise its implementation or the instructors who delivered the content. A faculty member supervised the implementation of the program and monitored activities related to the comparison group. Any data related to the participants was encoded, so that I was not be able to associate results with any of the participants' names or demographic information, beyond what was necessary for the study. All data and any information divulged to any of the advisors and faculty were confidential.

Summary

The study included a quantitative quasi-experimental nonequivalent comparison group research design to determine whether a short-term intensive program, Math Boost-Up, could refresh the mathematics knowledge and skills of incoming students to a level where they could bypass remedial courses and test into a college-level mathematics course or test into a higher level remedial course. Incoming students who did not receive the scores needed to enroll in college-level mathematics courses received an invitation to participate in the study. To participate, participants agreed to retake the ACCUPLACER test. The faculty reviewed the results of the diagnostics test with each student, and the students decided to either participate in the Math Boost-Up program or study on their own. Each student received access to Pearson's MyFoundationLab. The ACCUPLACER Diagnostics program determined the areas in which each student needed help. The ACCUPLACER Diagnostics program mapped these results to practice modules in MyFoundationsLab. After the faculty reviewed the results of the diagnostics test with each student and the modules the student had to complete, the student decided whether to participate in the Math Boost-Up program or study on his or her own. The students understood that they had to complete the exercises and retake the ACCUPLACER test within 1 week after the intervention ended. I used nonparametric tests to evaluate the impact of the moderating variables: pretest scores, age, length of time between graduating from high school and taking the ACCUPLACER test, high school GPA, length of time completing the modules in MyFoundationsLab, and length of time spent in the face-to-face sessions of the Math Boost-Up program. A detailed discussion of the findings and results of the study, along with data collection and manipulation, appears in Chapter 4. Also addressed in Chapter 4 is the demographics of the participants, how the participants were representative of the larger population, and whether there were any variations in the administration of the experiment from the original plan. The chapter concludes with a discussion of the answers to the research question.

Chapter 4: Results

Introduction

The purpose of this quantitative study was to provide sound and empirically derived evidence (Christensen, 1997) that short-term intensive mathematics refresher programs, often called boot camps, are effective in increasing the placement test scores of incoming students on arithmetic and algebra so they can either test into a higher level remedial mathematics course or into a college-level credit-bearing math course. I used archival data from 136 students who self-selected to either enroll in the Math Boost-Up program (face-to-face instruction with Pearson's MyFoundationsLab) or study on their own with MyFoundationsLab. The aim of the two programs was to determine which of the two strategies was successful in increasing the ACCUPLACER test scores of students in basic arithmetic and elementary algebra.

I hypothesized that the short-term refresher program Math Boost-Up would increase the mathematics knowledge and skills of participating students more than the self-study plan would. The computer adaptive ACCUPLACER test measured the mathematics knowledge and skills in basic arithmetic and elementary algebra of incoming community college students.

The research question for the study and related hypotheses was as follows:

RQ: Did participation in the Math Boost-Up program increase the ACCUPLACER posttest scores of incoming community college students in the experimental group more than the scores of students in the comparison group who did not participate in the program but studied on their own?

H_0: Students' gains in the ACCUPLACER posttest scores would essentially be the same for those in the experimental group who participated in Math Boost-Up (independent variable) and those in the comparison group who studied on their own.

H_A: Students' gains in ACCUPLACER posttest scores would be different for those in the experimental group who participated in the Math Boost-Up program (independent variable) and those in the comparison group who studied on their own.

The independent variable of the study was the ACCUPLACER refresher program Math Boost-Up, and the dependent variable was mathematics knowledge and skills as measured by the ACCUPLACER.

In addition to the brief overview of the purpose, research question, and hypotheses, the chapter includes a brief description of the intervention and a discussion on whether I implemented the intervention according to the plan outlined in Chapter 3. In subsequent sections of this chapter, I address whether data collection proceeded according to plan and the impact of the moderator variables on the dependent and independent variables. Tables and figures share the data results and analyses. The chapter ends with a summary of the findings from the research study.

Data Collection

Time Frame

After I received IRB approval (07-07-14-0102588) from Walden University on July 7, 2014, I held meetings with the faculty who would lead the intervention and the student success specialists who would be responsible for recruiting the participants. Archival data were reflective of individuals who took the test from January to June, who were going to enter the college for the fall term, and who received an invitation to participate in the program. In addition to the student success specialists' recruitment efforts, I sent invitations via e-mail to approximately 1,500 students. Two hundred fifty students volunteered to participate in the intervention but only 136 students attended the orientation session and completed the ACCUPLACER Diagnostics assessment. Of the 136 students who completed the ACCUPLACER Diagnostics, 44 participated in the face-to-face session with Pearson's MyFoundationsLab (Math Boost-Up) and 92 chose to study online on their own using Pearson's MyFoundationsLab.

I collected the data according to the plan I discussed in Chapter 3. The two faculty members involved in the study extracted, from the ACCUPLACER database, the pretest and posttest scores of the 136 students and the dates they took the tests. Faculty leading the intervention extracted data related to the moderator variables date of birth, school graduation date, and GPA from Banner. Banner is the student information system used at the college. The faculty extracted the data related to the moderator variable, length of time each group spent working on the modules in MyFoundationsLab, from the MyFoundationsLab program. Faculty also provided the number of days that each student attended the face-to-face sessions.

Data Analysis

As I outlined in the methodology section of Chapter 3, I used a quantitative quasi-experimental, nonequivalent comparison group research design with cutoff assignments, to determine whether a mathematics refresher program that included Pearson's MyFoundationsLab with face-to-face instruction, Math Boost-Up, could increase the mathematics knowledge and skills of students, as measured by the ACCUPLACER test, compared to students who used MyFoundationsLab to study on their own. I used a quasi-experimental design because the college administrators did not approve random assignment of students to the experiment and control groups. According to Christensen (1997), it is acceptable to use a quasi-experiment design when it is not possible to use random assignment. The study's design appears in Figure 1.

The original plan that I outlined in Chapter 3 was to use a stepwise multiple linear regression analysis to determine whether gains in the mathematics knowledge and skills of students (the dependent variable) were greater for those students in the experimental group who participated in the Math Boost-Up program (independent variable) compared to students in the comparison group who studied on their own. Because there were an unequal number of participants in each group, and there were considerable differences in the amounts of missing data between the variables, I made the decision to use nonparametric statistical procedures instead.

Baseline Descriptive and Demographic Characteristics of the Sample

The study included archival data from 136 students. The frequency counts for selected variables appear in Table 5. There were more than twice as many students in the online group (n = 92) as in the face-to-face group (n = 44), and younger (under 25 years old, n = 87) than older (25 years and older, n = 49) students. After combining the research group and age group, the smallest student category was the face-to-face older students (14.7%) and the largest student category was the online younger students (46.3%).

Table 5

Frequency Counts for Selected Variables

Variable and category	*N*	%
Research group		
Face-to-face	44	32.4
Online	92	67.6
Age Group		
Younger (under 25)	87	64.0
Older (25+)	49	36.0
Student		
Face-to-face younger	24	17.6
Face-to-face older	20	14.7
Online younger	63	46.3
Online older	29	21.3

The descriptive statistics for selected variables are in Table 6. The average age for the sample was $M = 25.27$ years. For those who took the posttest in arithmetic ($n = 113$), the average gain (posttest minus pretest) was $M = 11.36$. For those who took the posttest in algebra ($n = 122$), the average gain was $M = 10.80$. The amount of online instructional minutes by students ranged from 0 to 2,800 (46.67 hours). In addition, the average number of days that students ($n = 44$) attended face-to-face sessions was 6.32. The number of face-to-face days ranged from 0 to 14. Considerable differences existed in the amount of missing data among the variables (see Table 6). For the 82 participants for which GPA was available, the average GPA was 2.35.

Discrepancies in Data Collection

I collected the data as planned, although there were some challenges. First, there were twice as many students in the online than in the face-to-face groups. Second, the amount of missing data among the variables, primarily high school GPA, was considerable. Considerable differences also existed in the amount of missing data among the variables. Data related to GPA were only available for the 82 of the 136 participants. In addition, of the 250 students who expressed interest in participating in the refresher program, only 136 actually participated.

Table 6

Descriptive Statistics for Selected Variables

Variable	*N*	*M*	*SD*	Low	High
Pretest age	136	25.27	9.75	15.00	61.00
High school grade point average	82	2.35	0.66	0.00	4.00
Pretest arithmetic	133	45.72	21.73	20.00	118.00
Posttest arithmetic	113	56.95	23.75	20.00	125.00
Gain in arithmetic [a]	113	11.36	16.86	-23.00	55.00
Pretest algebra	136	43.57	19.26	21.00	112.00
Posttest algebra	122	54.93	24.95	20.00	150.00
Gain in algebra [a]	122	10.80	15.20	-21.00	48.00
Lab online minutes	136	683.47	678.60	0.00	2,800.00
Face-to-face days	44	6.32	2.79	0.00	14.00

[a] Gain score = posttest – pretest.

Relationship Between Representative Sample and Population of Interest

The population of interest was the 1,442 students who applied for entry in the fall 2014 semester and who had taken the ACCUPLACER test from January 2014 through August 2014. The average age of students in the population of interest (N = 1,442) was 22.63. The average age of students in the sample was 25.27. The average age of students in the sample was representative of students in the population of interest.

The average pretest score of students in the sample (n = 136) on the arithmetic section of the ACCUPLACER test was 45.76, which was representative of the population (N = 1,307) of interest whose average pretest score on the arithmetic test was 41.36. Of the 1,307 students who took the arithmetic test, 155 students (11.9%) tested out of basic arithmetic, which was representative of the sample wherein 20 of the 136 students (14.7%) tested out of basic arithmetic. Pretest arithmetic scores were missing for 37 students in the population of interest. Performance on the elementary algebra test of students in the sample (*n* = 136) was also representative of students in the population of interest (*N* = 1,442). On the algebra test, the average test score of students in the sample population was 43.57 compared with 44.61 for students in the total population of interest.

Of the total population of students taking the pretest algebra test (*N* = 1,442), 99 students (6.9%) tested into a college-level math course. Of the total 1,442 students who took the test, 36 students did not take the arithmetic test. Based on the 1,307 students who took both tests, 155 students tested out of arithmetic, leaving 1,152 (79.9%) students who tested into both sections of mathematics remedial courses. In conclusion, the sample was representative of the population of interest at the community college where this study took place. I did not examine representativeness of the sample for larger populations.

Treatment and Intervention Fidelity

The outline of the intervention implemented is in Chapter 3. Three sessions took place from June 2 to August 22, 2014. Despite the challenges encountered in recruiting students to participate in the program, 250 students expressed interest in the program. However, a little more than half, 136 students (54.5%) attended and completed the ACCUPLACER Diagnostics assessment. Of the 136 students who completed the ACCUPLACER Diagnostics, 44 participated in the face-to-face (Pearson's

MyFoundationsLab) session, and 92 chose the online option of studying on their own using Pearson's MyFoundationsLab.

I initially planned two face-to-face classes for the first and second sessions, one in the morning and one in the evening. However, the faculty canceled the evening classes for Sessions 1 and 2 due to low enrollment. Morning and afternoon classes took place during the third session. See Table 3 for a summary description of the implementation.

Results

Evaluation of Statistical Assumptions

I used boxplots to test the normality of the data. The 10 boxplots for the 10 variables in Table 6 appear in the Appendix. An inspection of the boxplots revealed seven of the 10 variables had between one and nine outliers, for a total of 24 outliers. Given the considerable differences in the amount of missing data between the variables (see Table 6), I chose to keep the 24 outliers in the sample and use the Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square nonparametric tests. Deleting those cases with one or more outliers would have further reduced the sample size. In addition, if I had removed the outliers, I would have needed a second series of boxplots, which in turn could have resulted in further case removals. As reported in Table 5, there were more than twice as many students in the online group (n = 92) as in the face-to-face group (n = 44). Following the recommendations of Bolboaca and Jäntschi (2006) and Spearman (1904), and the fact that Cooper-Martin and Wade (2012) used this test in a similar study, I used Spearman correlations instead of Pearson correlations. In addition, I used Mann-

Whitney tests (Best & Kahn, 2006; Field, 2009) instead of *t* tests for independent means and Kruskal-Wallis tests instead of one-way analysis of variance tests.

Statistical Analysis Findings for the Research Questions and Hypotheses

The primary research question was as follows: Did participation in the Math Boost-Up program increase the ACCUPLACER posttest scores of incoming community college students in the experimental group more than the scores of students in the comparison group who did not participate in the program but studied on their own? The related null hypothesis was as follows: Students' gains in the ACCUPLACER posttest scores would essentially be the same for those in the experimental group who participated in Math Boost-Up (independent variable) and those in the comparison group who studied on their own. The Mann-Whitney tests in Table 7 indicate a comparison of the two groups.

In arithmetic, face-to-face students (M = 17.51) had significantly larger gains (p = .004) than did the online students (M = 8.12). In addition, in algebra, face-to-face students (M = 14.38) tended to have larger gains (p = .07) than did the online students (M = 9.06). These findings provided support to accept the alternate hypothesis $H1_a$, because the students' gains in ACCUPLACER posttest scores were different for students in the experimental group who participated in the Math Boost-Up program (independent variable) than for those students in the comparison group who studied on their own. The results provided sufficient evidence to reject the null hypothesis $H1_0$, which predicted that the gains in the ACCUPLACER posttest scores would essentially be the same for students in the experimental group who participated in Math Boost-Up (independent variable) and students in the comparison group who studied on their own.

Table 7

Mann-Whitney Comparisons for Selected Variables Based on Research Group

Variable and group	*n*	*M*	*SD*	r_s	*z*	*p*
Pretest age				.18	2.14	.03
Face-to-face	44	26.05	8.25			
Online	92	24.90	10.42			
High school grade point average				.00	0.02	.99
Face-to-face	27	2.36	0.59			
Online	55	2.35	0.70			
Pretest arithmetic				.07	0.75	.45
Face-to-face	44	43.95	21.73			
Online	89	46.60	21.80			
Posttest arithmetic				.13	1.32	.19
Face-to-face	39	62.00	26.87			
Online	74	54.28	21.65			
Gain in arithmetic [a] (gain more)				.27	2.88	.004
Face-to-face	39	17.51	16.05			
Online	74	8.12	16.47			
Pretest algebra				.11	1.24	.22
Face-to-face	44	41.52	20.17			
Online	92	44.55	18.85			
Posttest algebra				.01	0.05	.96
Face-to-face	40	55.78	28.54			
Online	82	54.52	23.18			
Gain in algebra [a]				.17	1.84	.07
Face-to-face	40	14.38	15.16			
Online	82	9.06	15.00			
Lab online minutes				.35	4.08	.001
Face-to-face	44	395.05	593.08			
Online	92	821.41	676.38			

[a] Gain score = posttest – pretest.

Other significant differences in Table 7 were that face-to-face students were significantly older ($p = .03$). The mean difference in age between the two groups was a little over 1 year. The students in the face-to-face group had significantly fewer minutes of online study time (p = .001).

The eta coefficients, Cramer's *V*, and correlation coefficients were the measures of effect size used in this study. I used Cramer's *V* and correlation coefficients to determine the magnitude of the association between the moderator variables for students in the online and face-to-face groups. According to Rea and Parker (1992), Hinkle et al. (1979), Davis (1971), and Hopkins (1997), the effect size ranges from .00 to 1.00 and can range from a negligible association to a very strong or high association. Using these guidelines, the resulting measures showed that the effect size was in the little or negligible association or correlation to low to moderate correlation or association. A discussion of the details of and magnitude of these relationships follows.

The goal of the study was to determine which of the variables had the most impact on the posttest scores of the students in the experiment and comparison groups. The Spearman rank-ordered correlations for the six arithmetic and algebra outcome variables with the four moderator variables are in Table 8. The variables were high school GPA; category of age groups, where younger was age < 25 and older was age ≥ 25; length of time spent working on the modules in MyFoundationsLab; and time spent attending the face-to-face modules in Math Boost-Up. For the resulting 30 correlations, eight were significant at the $p < .05$ level.

Table 8

Spearman's Rho Correlations for Outcome Variables with Demographics

Outcome variable	Group	Pretest age	High school grade point average	Online lab minutes	Face-to-face days
Pretest arithmetic	.07	-.17*	.13	.11	-.04
Posttest arithmetic	-.13	-.07	.10	.16	.18
Gain in arithmetic [a]	-.27***	.12	.01	.17	.19
Pretest algebra	.11	-.42****	.14	.29***	.20
Posttest algebra	.00	-.37****	.26*	.36****	.17
Gain in algebra [a]	-.17	-.12	.17	.18*	.17

* $p < .05$. ** $p < .01$. *** $p < .005$. **** $p < .001$.

[a.] Gain score = posttest – pretest.

As reported in Table 8, face-to-face students had greater gains in arithmetic ($r_s = -.27$, $p < .005$). Younger students had better pretest arithmetic scores ($r_s = -.17$, $p < .05$), better pretest algebra scores ($r_s = -.42$, $p < .001$), and better posttest algebra scores ($r_s = -.37$, $p < .001$). Those with higher high school GPAs had higher posttest algebra scores ($r_s = .26$, $p < .05$). Those students who had more minutes working in the online lab had better pretest algebra scores ($r_s = .29$, $p < .005$), better posttest algebra scores ($r_s = .36$, $p < .001$), and larger gains in algebra ($r_s = .18$, $p < .05$). These results provided evidence that the moderator variables high school GPA, category of age groups, length of time spent working on the modules in MyFoundationsLab, and time spent attending the face-to-face modules in Math Boost-Up affected the pre- and posttest scores of students.

The results of the Kruskal-Wallis tests comparing the four student categories (research group × age group) for the six outcomes (pretest, posttest, and gain scores for both arithmetic and algebra). Three of the six tests were significant at the $p < .05$ level. Specifically, both groups of face-to-face students (younger and older) had greater gains in arithmetic than did the two online groups ($p = .04$). In addition, the two groups of younger students (face-to-face and online) had higher algebra pretest (p = .001) and posttest scores (p = .001) than did the two groups of older students.

Based on the results provided in Table 9, the answer to the research question is that both age groups who participated in the Math Boost-Up program (face-to-face session) were able to increase the posttest scores compared to the students in the online-only program. The chi-square test for whether the student completed the posttest arithmetic test based on the four categories of students is in Table 10. No differences in completion rate emerged among the four categories of students (p = .55).

Table 9

Kruskal-Wallis Tests for Selected Variables Based on Student Category

Variable and category	*N*	*M*	*SD*	η	χ^2	*p*
Pretest arithmetic [a]				.19	2.43	.22
1. Face-to-face younger	24	48.83	25.35			
2. Face-to-face older	20	38.10	14.99			
3. Online younger	61	48.59	22.18			
4. Online older	28	42.25	20.66			
Posttest arithmetic [a]				.22	3.48	.32
1. Face-to-face younger	21	66.76	30.21			
2. Face-to-face older	18	56.44	21.90			
3. Online younger	52	55.75	22.86			
4. Online older	22	50.82	18.50			
Gain arithmetic [a]				.27	8.52	.04
1. Face-to-face younger	21	17.86	16.53			
2. Face-to-face older	18	17.11	15.94			
3. Online younger	52	7.90	16.83			
4. Online older	22	8.64	15.96			

[a] Gain score = posttest – pretest.

Table 10

Student Category Based on Whether the Student Did the Posttest in Arithmetic

	Did posttest in arithmetic [a]			
	Yes		No	
	n	%	*n*	%
1. Face-to-face younger	21	87.5	3	12.5
2. Face-to-face older	18	90.0	2	10.0
3. Online younger	52	82.5	11	17.5
4. Online older	22	75.9	7	24.1

[a] χ^2 (3, N = 136) = 2.10, p = .55. Cramer's V = .12.

Table 11 displays the chi-square test for whether the student completed the posttest algebra test based on the four categories of students. No differences in completion rate were found among the four categories of students (p = .21).

Table 11

Student Category Based on Whether the Student Did the Posttest in Algebra

	Did posttest in algebra [a]			
	Yes		No	
	n	%	*n*	%
1. Face-to-face younger	22	91.7	2	8.3
2. Face-to-face older	18	90.0	2	10.0
3. Online younger	59	93.7	4	6.3
4. Online older	23	79.3	6	20.7

[a] χ^2 (3, N = 136) = 4.56, p = .21, Cramer's V = .18.

Summary

In summary, I used archival data for 136 students to provide sound and empirically derived evidence (Christensen, 1997) that short-term intensive mathematics refresher programs, often called boot camps, were effective in increasing the placement test scores of incoming students on arithmetic and algebra, so that they could test either into a higher level of remedial mathematics course or into a college-level credit-bearing math course. The results of the data analysis supported the primary hypothesis that experimental students would gain more (see Table 7).

I initially examined the moderator variables using Spearman correlations in Table 8. Face-to-face students had greater gains in arithmetic ($r_s = -.27$, $p < .005$). Younger students had better pretest arithmetic scores ($r_s = -.17$, $p < .05$), better pretest algebra scores ($r_s = -.42$, $p < .001$), and better posttest algebra scores ($r_s = -.37$, $p < .001$). Those with higher high school GPAs had higher posttest algebra scores ($r_s = .26$, $p < .05$). Those students who had more minutes working in the online lab had better pretest algebra scores ($r_s = .29$, $p < .005$), better posttest algebra scores ($r_s = .36$, $p < .001$) and larger gains in algebra ($r_s = .18$, $p < .05$). I used multivariate techniques such as multiple regression or analysis of variance to control for moderating variables due to the wide variations in sample sizes across the different variables (see Table 6).

A major threat to validity encountered in the execution of the study related to statistical conclusion validity, was violated assumptions of statistical tests. Violated assumptions of statistical tests became a major threat because of missing data and attrition. Given the considerable differences in the amount of missing data between the variables (see Table 6) and attrition, I made the decision to keep the 24 outliers in the sample and use nonparametric tests (Spearman, Kruskal-Wallis, Mann-Whitney, and chi-square) instead of the stepwise multiple linear regression analysis proposed originally. The results of the tests revealed that both groups of face-to-face students (younger and older) had greater gains in arithmetic than did the two online groups ($p = .04$, $\eta = .27$). In addition, the two groups of younger students (face-to-face and online) had higher algebra pretest ($p = .001$, $\eta = .40$) and posttest scores ($p = .001$, $\eta = .34$) than did the two groups of older students. I examined the strength of evidence using Spearman correlations, eta coefficients, and Cramer's V tests. Using the Cohen (1988) size of correlation criteria (see Tables 7 through 9), gains in either arithmetic or algebra were weak $|r = .10|$. Additionally, the results provided evidence that the short-term refresher program, Math Boost-Up, can increase the mathematics knowledge and skills of students more than students who choose to study on their own. However, I found that the online-only program was more effective in increasing the mathematics knowledge and skills of students than the face-to-face group, particularly in the area of algebra and especially for younger (< 25) students.

I made every effort to ensure participant recruitment was in accordance with the implementation plan outlined in Table 3. In addition, I conducted the intervention and carried out the data-gathering protocols as described in Chapter 3. However, despite these efforts, there were missing data. Despite the missing data, the sample was representative of the larger population of students who had taken the ACCUPLACER test for fall 2014 entry into the college.

Chapter 5 includes a comparison of the findings and an assessment of the strength of the evidence in relation to the literature review and in the context of the theoretical framework discussed in Chapter 2. I will address the limitations of the study as they related to generalizability and reliability. Additionally, I draw and discuss methodological, theoretical, and empirical conclusions and implications, as they relate to social change. Finally, I provide a series of recommendations for future research and practice.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

In Chapter 1, I stated that the purpose of the study was to answer the following question: Did participation in the Math Boost-Up program increase the ACCUPLACER posttest scores of incoming community college students in the experimental group more than the scores of students in the comparison group who did not participate in the program but studied on their own? To answer this question, I used a quantitative quasi-experimental, nonequivalent comparison group research design with cutoff assignments. This was mainly a pretest–posttest design without random assignment. Students received invitations to participate in the program and chose whether to participate in the face-to-face session, Math Boost-Up (experiment group), or study on their own, the online-only method (comparison group).

I conducted the study to fill the gap in the research literature by using a quantitative quasi-experimental design and to determine whether short-term mathematics refresher programs could increase the ACCUPLACER posttest scores of students. The research design provided the community college where this study took place with sound and empirically derived evidence as to whether short-term mathematics refresher programs can successfully increase the mathematics knowledge and skills of incoming students who failed to meet the cut scores on the mathematics section of the ACCUPLACER assessment. In addition, the study served as a model for future studies that will involve an attempt to show the effectiveness of one intervention over another approach (Shadish et al., 2002).

The key findings of the study were that (a) the Math Boost-Up program worked to increase the mathematics knowledge and skills of students and as a result the posttest scores of students; (b) the four moderator variables affected the gains in posttest scores of students; (c) I disproved the andragogical premise that students would be self-directed and self-select to participate in the Math Boost-Up program; (d) the self-paced online modules helped students to increase their posttest scores on the ACCUPLACER test; (e) I was able to provide empirically derived evidence that the Math Boost-Up program can increase the mathematics knowledge and skills of FTIC students; and (f) even though most students preferred to study on their own, both younger and older students in the face-to-face program experienced higher gains in arithmetic and elementary algebra than the students in the online-only program.

In this chapter, I summarize the key findings of the study and interpret these findings in the context of the theoretical framework and related research literature, both of which I discussed in Chapter 2. Recommendations for future studies precede a discussion of the limitations of the study in relation to the limitations discussed in Chapter 1. A review of the implications of the study related to social change, the methodological design, and the empirically based findings of the study follow the discussion. The chapter concludes with a discussion regarding the key takeaways from the study related to the use of boot camps as a strategy for increasing the ACCUPLACER test scores of incoming freshmen.

Interpretation of the Findings

The results of study that included 136 students, as discussed in Chapter 4, indicated that short-term intensive mathematics refresher programs, often called boot camps, were effective in increasing the mathematics knowledge and skills of students. For those who took the posttest in arithmetic ($n = 113$), the average gain (posttest minus pretest) was $M = 11.36$. For those who took the posttest in algebra ($n = 122$), the average gain was $M = 10.80$. These results were in keeping with similar studies conducted at Miami Dade Community College in Florida, Northampton Community College in Pennsylvania, North Central State College in North Carolina, and Maricopa Community Colleges in Arizona, where researchers found that short-term refresher programs could increase the posttest scores of students on the placement exams (Hodara, 2013; Sherer & Grunow, 2010; Vassiliou, 2011). However, based on the amount of money and time invested in this particular study, the number of students who were able to bypass one or both remedial education courses was dismal.

Of the 113 students who took the posttest in arithmetic, 27 students (23.9%) tested into a higher level remedial course. Of the 122 students who retested in algebra, 10 students (8.2%) tested into a college-level mathematics course. According to Hodara (2013), similar studies conducted at other community colleges and universities did not yield strong findings in favor of bridges, boot camps, and brush-ups. The effect sizes of the studies ranged from trivially negative to moderately positive (Hodara, 2013, p. 13).

Moderator variables. Exploring the relationship between and among the various variables that affected posttest results was key to understanding the impact of the intervention on the students in the experiment and comparisons groups. Vassiliou and McDonald (2009) confirmed that more researchers should disaggregate data by various demographics to determine the extent the mediating effects of certain demographics such as age, race or ethnicity, and socioeconomic status can have on pre- and posttest performance. The findings of this study expand knowledge in this area.

The independent variable of the study was the short-term refresher program Math Boost-Up. The dependent variable was mathematics knowledge and skill, as measured by the ACCUPLACER. The four moderator variables were high school GPA, category of age groups for students younger than 25 and for students 25 and older, length of time spent working on the modules in MyFoundationsLab, and time spent attending the face-to-face modules in Math Boost-Up.

The results of the study revealed that each of the four moderator variables affected pre- and posttest scores. Data reported in Table 7 showed that students in the face-to-face sessions had greater gains in arithmetic and algebra than the online students did. As reported in Table 6, face-to-face students had greater gains in arithmetic ($r_s = -.27$, $p < .005$). Younger students had better pretest arithmetic scores ($r_s = -.17$, $p < .05$), better pretest algebra scores ($r_s = -.42$, $p < .001$), and better posttest algebra scores ($r_s = -.37$, $p < .001$). Those with higher high school GPAs had higher posttest algebra scores ($r_s = .26$, $p < .05$). Students who had more minutes working in the online lab had better pretest algebra scores ($r_s = .29$, $p < .005$), better posttest algebra scores ($r_s = .36$, $p < .001$) and larger gains in algebra ($r_s = .18$, $p < .05$).

As shown in Table 6, the average number of days that students (*n* = 44) attended face-to-face sessions was 6.32. The number of face-to-face days ranged from 0 to 14. Based on the data shown in Table 8, there was no significant correlation between the number of days attending face-to-face sessions and posttest scores in both subject areas.

Theoretical framework: andragogy. Knowles's theory of adult learning, andragogy, served as the theoretical framework for the study. The core principles and assumptions associated with andragogy helped to shape the design, development, and implementation of the study. I developed the student recruitment process, the design of the face-to-face sessions, and the independent computer-assisted learning sessions based on the learners' weaknesses in math based on the premise that adults learn best when they can develop their own plan for learning rather than having one imposed upon them (Knowles et al., 2011). Choosing andragogy to be the theoretical framework for the study allowed me to map each of andragogy's core principles to the theoretical propositions or hypotheses related to the study's approach and design.

Knowles et al. (2011) posited that adults are self-directed and therefore more likely to participate in an activity if participation is voluntary and not mandatory. Knowles (1996) indicated that other strategies, such as making participation mandatory and dictating to learners what they needed to learn and how and when they needed to learn it, which Knowles and other adult learning theorists categorized as pedagogy, ignored the need for adults to be self-directed, which resulted in "high drop-out rates, low-motivation, and poor performance" (Knowles, 1996, p. 44). I expected that the approach of allowing students to be self-directed in determining whether to participate in the program or not would result in many students wanting to participate in the program. After students understood the benefits of participating in the Math Boost-Up, I expected them to enroll in the program. However, the results of this study indicated that the strategy of self-selection yielded fewer students and higher drop-out rates than anticipated.

Using technology to helping students increase their scores. In Chapter 2, I cited research that indicated boot camps that included technology to refresh the knowledge and skills of students were able to increase test scores of students on placement tests. For example, at the Miami Dade College in Florida, Vassiliou (2011) used the CAI A^{+}dvancer to help students avoid remediation altogether or at least one level of remedial courses.

This study yielded similar results. Students who spent more time in MyFoundationsLab were able to increase their scores in arithmetic and algebra. The older students did not spend as much time online as the younger students and as a result were not able to increase their scores as much as the younger students. The results of the study indicated that MyFoundationsLab had a positive impact on posttest scores. Students who had more minutes working in the online lab had better posttest algebra scores ($r_s = .36$, $p < .001$) and larger gains in algebra ($r_s = .18$, $p < .05$). The effect size for these scores was in the moderate range (Rea & Parker, 1992). The correlation criteria reflected in Tables 7 through 9 indicated that the effect size for the results of the study overall was $|r = .10|$, which indicated that the gains in either arithmetic or algebra were weak $|r = .10|$ (Cohen, 1988).

Empirically derived evidence. As I shared in Chapter 1, a review of the current research literature on short-term intensive refresher programs at community colleges such as Miami Dade Community College in Florida, Northampton Community College in Pennsylvania, and North Central State College in North Carolina revealed that the programs contributed to students being able to increase their test scores to bypass remedial courses altogether or test into higher level remedial courses (North Central State College, n.d.; Sherer & Grunow, 2010; Vassiliou, 2011). However, none of the researchers empirically validated the claims. Further research did not reveal any studies that provided empirically validated evidence that these types of short-term intensive refresher programs were successful in helping students increase their test scores on placement tests (Levin & Calcagno, 2008). There was no experiment or comparison group. This research study is among the first studies that involved analyzing data from an empirically valid research design and determined whether refresher courses are effective in reducing the number of students who tested into remedial courses.

In conducting the study, I used a quantitative quasi-experimental, nonequivalent comparison group pretest–posttest research design with cutoff assignments because random assignment was not possible. One hundred thirty-six students participated in the study, with 44 students (experiment group) in the face-to-face session and 92 students (comparison group) in the online-only session. The study proceeded as planned, which indicated that it is possible to develop and implement studies of this type using empirically validated methodologies involving experiment and comparison groups. The nonequivalent, comparison group methodology was a good fit for the study, as it allowed for dissimilarities between the two groups.

Hughes and Scott-Clayton (2011) and Collins (2010) concluded that the best remedial education program is one that works with incoming students to help them avoid having to take remedial education courses altogether by testing into college-level courses upon entry into college. According to Sherer and Grunow (2010), focusing on these short, intensive programs is important. Boot camps can have a significant impact on student retention and persistence, and if they are successful, boot camps can move large numbers of students faster along or completely out of the remedial course sequence. They are worth pursuing for these reasons (Sherer & Grunow, 2010).

Face-to-face versus online-only students. I sent invitations to approximately 1,500 students. Of this number, 250 students indicated an interest in participating in the program. However, only 136 students attended and completed the ACCUPLACER Diagnostics assessment. Of the 136 students who completed the ACCUPLACER Diagnostics, 44 students participated in the face-to-face session with Pearson's MyFoundationsLab (Math Boost-Up) and 92 chose the online option to study on their own using Pearson's MyFoundationsLab. Because no follow-up participant survey to indicate why more students did not participate in the program, I can only speculate that if the program were mandatory with clearly defined penalties for nonparticipation, more students would have completed and participated. Nevertheless, it is noteworthy that the refresher program was more of a favorite among younger (n = 87) than older (n = 49) students, which showed that younger students are more likely to volunteer to participate in these short-term refresher programs than older students are. The reason for this could be that younger students had fewer family responsibilities than the older students did.

Despite the popularity of the online-only program over the face-to-face program, both younger and older students in the face-to-face program experienced higher gains in arithmetic and elementary algebra than those students in the online-only program. As shown in Table 7, face-to-face students ($M = 17.51$) had significantly larger gains ($p = .004$) in arithmetic than did the online students ($M = 8.12$). In addition, face-to-face students ($M = 14.38$) in algebra tended to have larger gains ($p = .07$) than did the online students ($M = 9.06$). I interpreted the findings to mean that short intensive mathematics refresher programs, such as the Math Boost-Up program (i.e., the face-to-face sessions), have the capacity to increase the mathematics scores of students on the ACCUPLACER test.

Students who attended all or most of the sessions and spent time working on the online modules in Pearson's MyFoundationsLab were able to increase their scores on the posttest. The results of the study also showed that compared to the older students, the younger students had a better chance of increasing their posttest scores as a result of refresher programs such as Math Boost-Up. Therefore, college administrators should target younger students to participate in these refresher programs. Further, as was expected, the higher the students' GPA, the higher their ACCUPLACER test scores, pre and posttest, for students in both groups. The overall impact of the program was minimal as the program was not mandatory.

Limitations of the Study

I addressed the limitations of the study discussed in Chapter 1 in the design and implementation of the study. A discussion of the limitations follows:

Sample. The sample consisted of FTIC freshmen who had not met the cut scores on the mathematics sections of the ACCUPLACER placement test. The sample consisted of those FTIC students who, by invitation, had self-selected to participate in the study because they wanted to retake the test. Students were able to select whether they wanted to attend the face-to-face sessions with the supplement, Pearson's MyFoundationsLab and Math Boost-Up, or study on their own using Pearson's MyFoundationsLab. This was a limitation of the study because the assignment of students to each group was not random, and I was not able to select participants in the study. However, despite this limitation, 250 of the 1,443 students invited to participate in the study self-selected to participate. One hundred thirty-six of the 250 students showed up to take the diagnostic test, which was 16 short of the 152 students needed to achieve an effect size of .20 (Cohen, 1992). Further, only 113 students retook the arithmetic test, and only 122 students retook the algebra test. Only 44 students participated in the face-to-face sessions, and 92 participated in the online-only sessions. Based on Cohen's (1988) size of correlation criteria (Tables 7-9), the gains in arithmetic and algebra were weak $|r = .10|$.

Generalizability. I was limited in the generalizability of the study's results to the larger population for three reasons. First, the ACCUPLACER was the only placement test; second, only FTIC students could participate in the program and retake the test; invited students had to self-select to participate in the program; and third, students had to select whether they would participate in the experiment or the comparison group. Because of these aforementioned limitations, the results only apply to those community colleges where administrators have approved the use of the ACCUPLACER test and a similar research design. Therefore, I cannot make inferences to the larger population. This is a major limitation in the study's external validity.

Research methodology. In the research study, I used a quantitative quasi-experimental pretest–posttest design with nonequivalent comparison groups. The methodology was a limitation to the study because the assignment of students to the experiment or comparison groups was not random. Another limitation was that any differences in outcomes could be due to the preexisting differences between the experiment and comparison groups, rather than the intervention (Hodara, 2011b). To this end, I focused on the moderator variables high school GPA, category of age groups, length of time spent working on the modules in MyFoundationsLab, and time spent attending the face-to-face modules in Math Boost-Up. The results showed that these moderator variables affected the pre- and posttest scores of the participants (see Table 8). The younger students performed better on the pre- and posttest, as did the students with high GPAs. Students who spent more time in face-to-face sessions and in the self-paced online modules performed better on the posttest as well.

According to Christensen (1997), despite these limitations, it is acceptable to use a quasi-experimental design when it is not possible to use random assignment. The quasi-experimental design is a feasible alternative to the true experimental design when true experiments are not possible, which was the case in this study (Brock, 2010; Campbell &

Stanley, n.d.; Christensen, 1997; Shadish et al., 2002). In the results of two literature reviews conducted in 2010 of these types of transition-to-college programs, researchers for the U.S. Department of Education Office of Vocational and Adult Education confirmed that quasi-experimental research methods were a rigorous method that researchers can used to provide evidence of a programs' efficacy (U.S. Department of Education Office of Vocational and Adult Education, 2010). The researchers at the U.S. Department of Education Office of Vocational and Adult Education concluded, that even though quasi-experimental research methods were not the gold standard for research design, studies using this design method could provide empirical results that can be used to make sound program decisions. Therefore, because I used a quasi-experimental design, I was able to assess the efficacy of the Math Boost-Up program to increase students' mathematics ACCUPLACER numeric scores compared to students who decided not to participate in the program. Additionally, the study included empirical evidence of the program's efficacy, which was lacking in the literature (Levin & Calcagno, 2008).

A number of researchers of studies at community colleges have used quasi-experimental research design methods to investigate the effectiveness and impact of various interventions, initiatives, and programs on student achievement, retention, and program completion with favorable results (Bettinger et al., 2013; Hughes & Scott-Clayton, 2010; Sherer & Grunow, 2010). The strongest and most commonly used of the quasi-experimental research methods, a pretest–posttest nonequivalent comparison group design was suitable for this study (Campbell & Stanley, 1963; Kenny, 1975; Shadish et al., 2002). Further, the nonequivalent group design allowed for the differences in the make-up and nature of the participants in the experiment and comparison groups reflected in the study.

Threats to internal and external validity. Leading experts in the field of research design, such as Campbell and Stanley (1966), Shadish et al. (2002), and Christensen (1997), cautioned that the design poses many threats to internal and external validity. The threats to internal validity are history, maturation, testing, instrumentation, statistical regression, mortality, different selection of participants or selection bias, mortality, and selection maturation interaction (Campbell & Stanley, 1963; Huck & Chuang, 1977; Oakes & Feldman, 2001; Shadish et al., 2002). Shadish et al. pointed out that of the threats that plague quasi-experimental designs mentioned before, five have a direct link to the nonequivalent comparison group design. The five threats are selection bias, selection-maturation, selection-instrumentation, selection-regression, and selection history. Additionally, Campbell and Stanley (1963) warned that the main threats to external validity are the effect of the pretest on the posttest, the effects of selection biases on the experimental variable, effects of prior experiments, generalization of results across time, population, various settings, and dependent variables. These threats were limitations to the study that I addressed during the design and implementation of the study. I discussed the specific strategies used and precautions taken to minimize each of these threats in Chapter 3 in the Threats to Validity section. I implemented the study design as described in Table 3. Table 1 included a summary of the data collection and analyses methods used to address these threats.

Time spent by students online. Forty-four students participated in the face-to-face sessions, and 92 participated in the online-only session. The number of online instructional minutes by students ranged from 0 to 2,800 (46.67 hours). Another limitation of the study was the inability to control the amount of time that the comparison group would spend completing the modules on MyFoundationsLab. After the faculty reviewed the results of the diagnostics test with each student, each faculty member strongly encouraged both groups to spend as much time as possible completing the online modules assigned to them. Students in the online-only group logged more minutes than those in the face-to-face sessions.

Results from the Mann-Whitney tests comparing the two groups are in Table 7. In arithmetic, face-to-face students ($M = 17.51$) had significantly larger gains ($p = .004$) than did the online students ($M = 8.12$). In algebra, face-to-face students ($M = 14.38$) tended to have larger gains ($p = .07$) than did the online students ($M = 9.06$). Despite the fact that the students in the face-to-face group had significantly fewer minutes of online study time ($p = .001$), those students who had more minutes working in the online lab had better pretest algebra scores ($r_s = .29$, $p < .005$), better posttest algebra scores ($r_s = .36$, $p < .001$), and larger gains in algebra ($r_s = .18$, $p < .05$), which showed that a positive relationship existed between length of time spent online and gains in posttest scores.

The results of the study also showed that a negative linear relationship existed between length of time students spent online and their ages. Results outlined in Table 7 showed that face-to-face students were significantly older ($p = .03$). The mean difference in age between the two groups was a little over 1 year. The younger age students spent more time online than the older students did.

Recommendations

The results of the study indicated that while participation in the short-term refresher mathematics program Math Boost-Up resulted in students being able to increase the mathematics knowledge and skills of participating students, the number of students who self-selected to participate in the intervention and those who were able to test into a higher level or college-level course was dismal. Of the 113 students who took the posttest in arithmetic, 27 students (23.9%) tested into a higher level remedial course. Of the 122 students who retested in algebra, 10 students (8.2%) tested into a college-level mathematics course. According to Hodara (2013), similar studies conducted at other community colleges and universities did not yield strong findings in favor of bridges, boot camps, and brush-ups. The effect sizes of the studies range from trivially negative to moderately positive (Hodara, 2013, p. 13). In the context of the results, key findings, and limitations discussed in the previous two sections, I recommend that future researchers on short-term refresher programs focus on the elements discussed below.

Mandatory Student Participation

In future studies, researchers should explore the effects of the Math Boost-Up program on posttest scores if student participation in intervention programs is mandatory and not optional. Fain (2012) discussed the need to make refresher programs mandatory. Center for Community College Student Engagement (2012) proposed that "Colleges should create opportunities for students to participate in review or brush-up experiences before placement tests to minimize the amount of remediation students need" (p. 8). However, very few students took advantage of placement test preparation programs. According to McClenney, the director of the Center for Community College Student Engagement, "Students Do Not Do Optional" (Fain, 2012, p. 1); if participation were mandatory and students had to complete all elements of the program, the number of program students would have increased, attendance in the face-to-face sessions would have increased, more students would have completed the posttest, and students would have spent more time completing the modules in MyFoundationsLab.

If college leaders make participation mandatory, more students will engage in the intervention, and the college leaders would be able to make data-driven decisions regarding whether the short-term refresher programs are successful in helping students bypass remedial education courses altogether or test into a higher level remedial course. The basis of these decisions will be results gleaned from a wide-scale implementation of the intervention as opposed to having students self-select to participate in the program.

Self-Paced Online Tutorials

In future studies, researchers should explore the effects of self-paced online modules, such as MyFoundationsLab, on student performance on the placement test either pre- or post assessment. Researchers should compare the results to those of students enrolled in face-to-face programs. In this way, college leaders would be able to determine which of the two approaches, computer-assisted programs such as MyFoundationsLab or face-to-face instruction, was successful in increasing the mathematics knowledge and skills of students to levels where they can bypass remedial courses.

If the program repeats, more emphasis would be necessary on assessing the technological competency of each student prior to participating in the program and on providing support to students who have low skills or exhibit low proficiency with the program. In addition, a faculty member would be responsible for managing the online aspect of the program and would reach out to students who are not fully using the MyFoundationsLab. In this way, more students would benefit from tutorials in the MyFoundationsLab and, as a result, be able to increase their test scores.

Implications for Social Change

The study has many implications for community colleges, incoming students, and the design of future research studies related to studying short-term refresher programs or boot camps. In Chapter 1, I indicated that this study would contribute to the social change mission by providing evidence regarding whether short-term refresher programs could help reduce the need for remedial courses. Decreasing the numbers of students taking remedial courses could help community college leaders increase the numbers of students who persist in the programs and earn a degree or certificate. Moreover, completing a degree program would provide opportunities for students to create a better quality of life for them and their families (Bautsch, 2013; Hodara et al., 2012; Levin & Calcagno, 2008; Long, 2011). Furthermore, labor market statistics indicate that between 2008 and 2018, 63% of jobs will require a postsecondary education (Albright, 2008).

Based on the information shared in the previous paragraph, the implication of the study as it relates to students is that it provided a model for engaging students in these types of programs. Students must persist and complete their degree or certificate programs and get jobs that pay a sustainable income. Otherwise they would remain in poverty and in the underclass. The lessons learned from this study may help in the design of future programs that can result in success for many students and help them to bypass remedial education courses.

For community colleges whose staff use placement tests, specifically the ACCUPLACER, to make decisions regarding the readiness of students to succeed in college level mathematics courses, the implications are that college leaders should develop policies that make participation in these refresher programs mandatory rather than voluntary. In this way, more students could benefit from these programs, hence leading to increases in retention and completion rates. When more students graduate with associate degrees, community college leaders would have a better chance of meeting President Obama’s mandate of adding 5,000,000 graduates to the existing number of Americans possessing a college degree by 2020 (White House, 2009, n.d.). In addition, the increase in degree and certificate completion rates would help to accomplish another of President Obama’s goals, which is to reposition the United States as number one in the world of having the most citizens with postsecondary degrees and certificates by 2025 (Aud et al., 2011; Bustillos, 2012; Lee, Edwards, Menson, & Rawls, 2011; Vandal, 2010; White House, n.d.).

Another implication of the study as it related to the theoretical framework of andragogy is that participation in these short-term refresher programs should be mandatory and not voluntary. Knowles et al. (2011) posited that adults were self-directed and after advisors explained the benefits of participation, adults would self-select to participate in the study. However, this premise did not hold true for this study. Only 250 of the almost 1,500 students who received invitations self-selected to participate in the program, and only 44 of the 136 students who showed up to take the diagnostic test opted to participate in the Math Boost-Up program. The remaining students ($N = 92$) opted to study on their own. If another researcher repeats the study, participation should be mandatory.

The implication related to the research design of the study was that it provided a model for researching these types of intervention programs using an empirically validated approach with experiment and comparison groups. Researchers did not use this approach in similar studies, which emerged as a major flaw in the research literature (Hodara, 2013b). Levin and Calcagno (2008) noted that the absence of a comparison group and random assignment threatens the validity of the study and provides little or no evidence of the causal relationship between the intervention and the changes in test scores. This study, which had a quantitative quasi-experimental pretest–posttest design with a nonequivalent comparison group may serve as a model for future studies that involve an attempt to show the effectiveness of one intervention over another approach (Shadish et al., 2002).

Conclusion

The results, key findings, recommendations, and implications of the study shed light on the capacity of short-term refresher programs, often referred to as boot camps, to help first-time incoming college students increase their mathematics knowledge and skills. The goal of this study was to answer the following question:

> RQ: Did participation in the Math Boost-Up program increase the ACCUPLACER posttest scores of incoming community college students in the experimental group more than the scores of students in the comparison group who did not participate in the program but studied on their own?
>
> > H_0: Students' gains in the ACCUPLACER posttest scores would essentially be the same for those in the experimental group who participated in Math Boost-Up (independent variable) and those in the comparison group who studied on their own.
> >
> > H_A: Students' gains in ACCUPLACER posttest scores would be different for those in the experimental group who participated in the Math Boost-Up program (independent variable) and those in the comparison group who studied on their own.

The results indicated that although students in the Math Boost-Up program were successful in increasing their mathematics knowledge and skills, however these results were dismal given the investment of time and money. The investment of money, time, and effort yielded little return on investment. College leaders could make participation in the refresher program mandatory for all incoming FTIC students in the hopes that more students would test out of remedial courses. However, more studies and more empirically derived evidence would be necessary to show that these short-term refresher programs could help students meet the cut scores on the placement tests.

In this study, I examined one strategy for helping incoming freshmen students increase their scores on the ACCUPLACER placement test. Other strategies discussed in Chapter 2 centered on the growing controversy surrounding using placement tests to determine readiness for college-level work. The focus of some strategies was on using a combination of placement test scores and high school GPA or on having students prepare for the test prior to taking it or testing and remediating students while they were still in high school (Bettinger et al., 2013; Grubb, 2012; Howell, 2011; Hughes & Scott-Clayton, 2010; Knudson et al., 2008; Spence, 2009; Tierney & Garcia, 2008). More controversy has emerged over the validity of the tests and their capacity to predict placement. Community college education leaders and researchers are questioning the reliability and validity of these tests, as well as the interpretation of the scores and their use for making placement decisions. As Belfield and Crosta (2012) noted, it is not the test itself that researchers should study but their use to determine placement in college-level or remedial courses. Placement tests were not strong predictors of success in college-level courses, and, therefore, college administrators should revisit their widespread use (Belfield & Crosta, 2012; Hughes & Scott-Clayton, 2011; Scott-Clayton, 2012).

To settle this controversy, education leaders at Complete College America recommended that college leaders follow three strategies related to course taking. The three strategies are among the five game changers the leaders of Complete College

America promote as a way of helping students complete their degree or certificate programs. First, community college staff should administer a diagnostic assessment, enroll the students in credit-bearing courses, and use the results of the diagnostics to provide tutoring or supplemental instruction (Charles A. Dana Center et al., 2012). Second, to align with the work of Uri Treisman and other leading experts in the field of mathematics, encourage faculty who teach mathematics, to work with administrators to align those mathematics courses that would best fit the program of study. For example, leading educators in the mathematics maintain that the study of algebra is only necessary to learn calculus; “statistics or quantitative literacy would be more appropriate for many programs of study” (Complete College America, 2013, p. 10). Third, mathematics faculty and college administrators should implement corequisite remediation, wherein students enroll in both remedial and college-level courses with supplemental instruction (Complete College America, 2013, p.10).

Despite the numerous approaches to teaching remedial courses or intervention programs that will help students bypass these courses, all educators must join forces to ensure students leave school with the knowledge and skills needed to succeed in and achieve a postsecondary education. This achievement is critical because researchers at the Georgetown University Center for Workforce Development (2010) predicted that by 2018, 63% of the jobs will require some college education. If citizens are not ready to fill this demand, they run the risk of joining the ranks of the underclass, which means a vicious cycle of poverty. Whatever the strategy that college leaders employ, those who work to increase the numbers of students who persist to college-level courses and ultimately complete a degree program in a timely manner should take center stage.

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Appendix: Boxplots for the Primary Study Variables

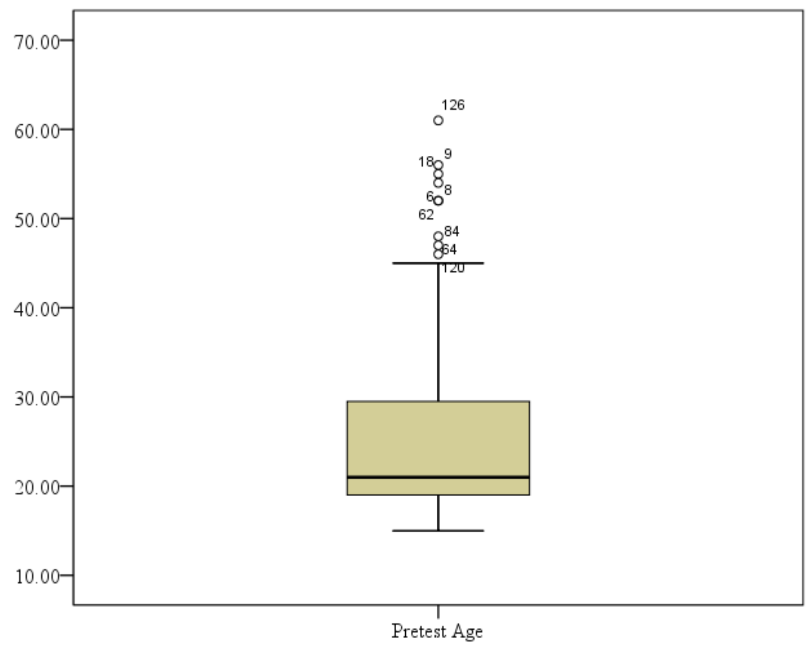

Figure A1. Pretest age.

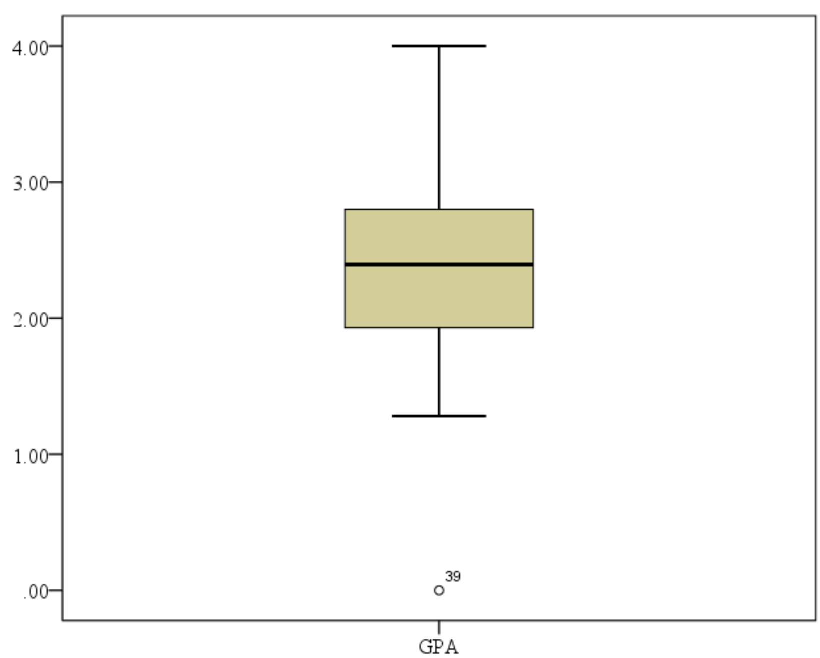

Figure A2. GPA.

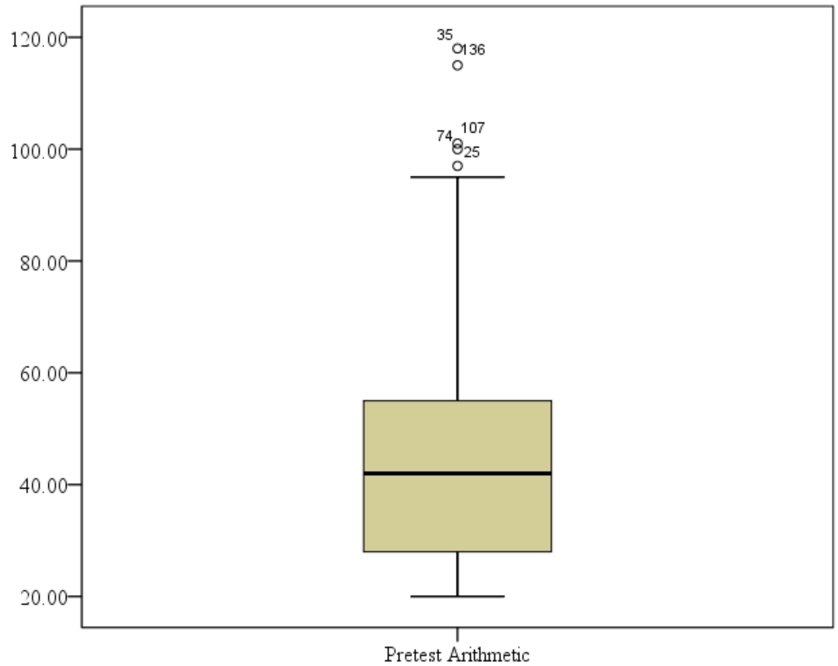

Figure A3. Pretest arithmetic.

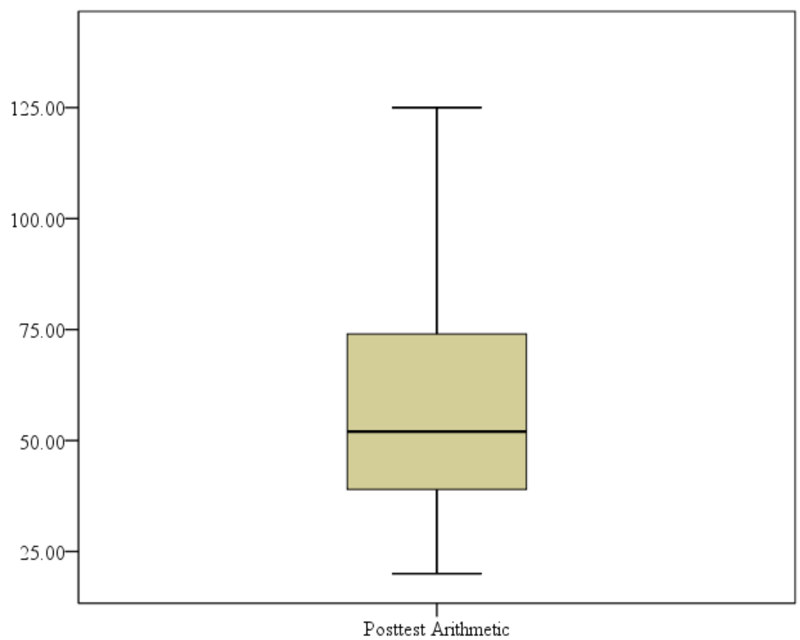

Figure A4. Posttest arithmetic.

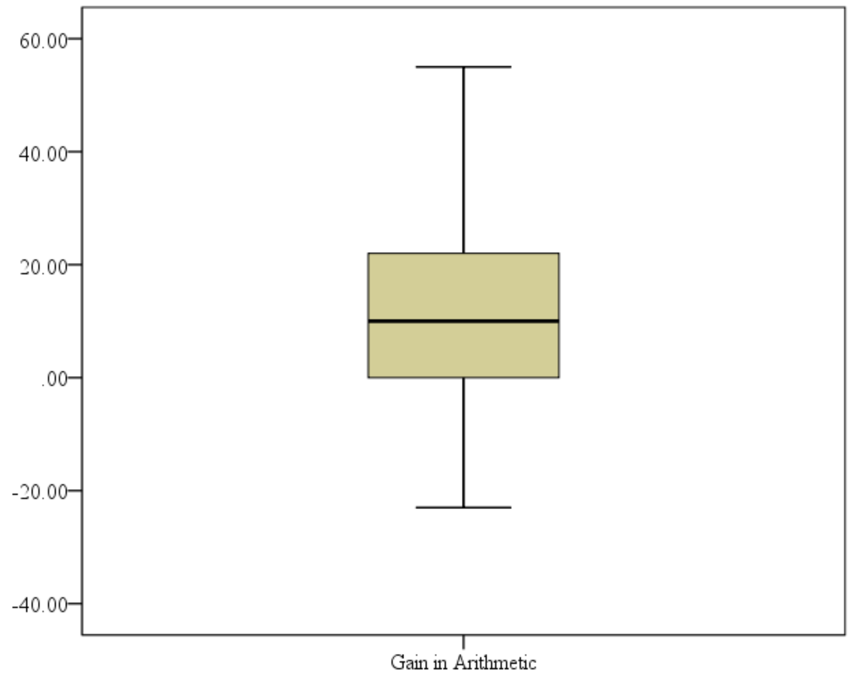

Figure A5. Gain in arithmetic.

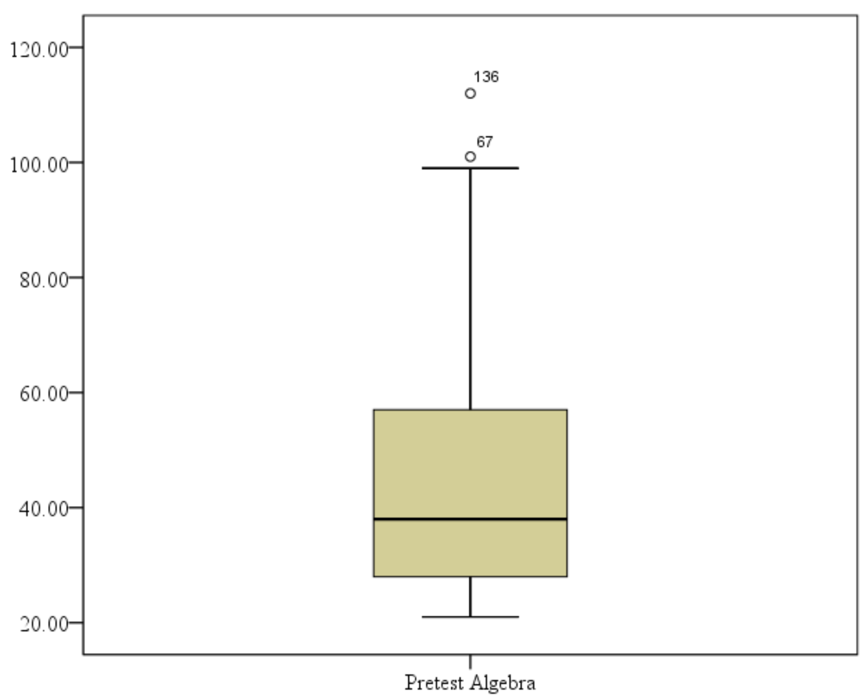

Figure A6. Pretest algebra.

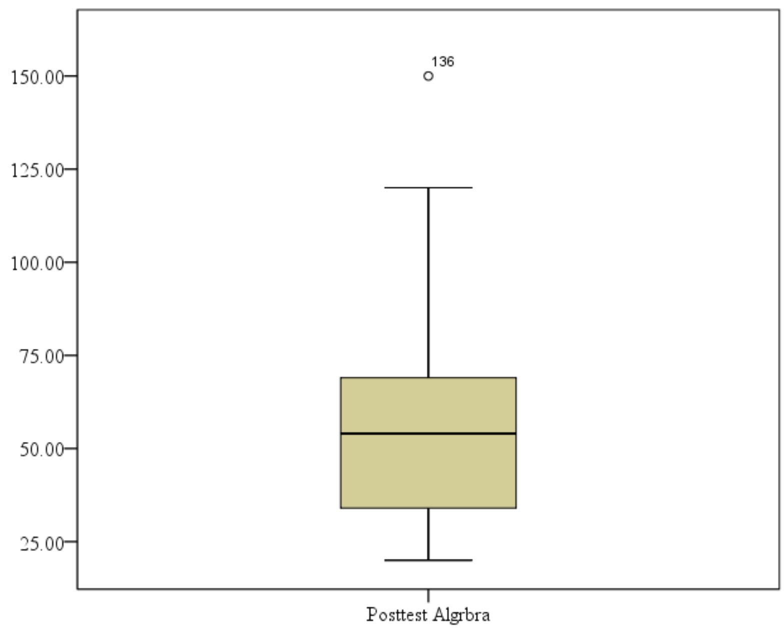

Figure A7. Posttest algebra.

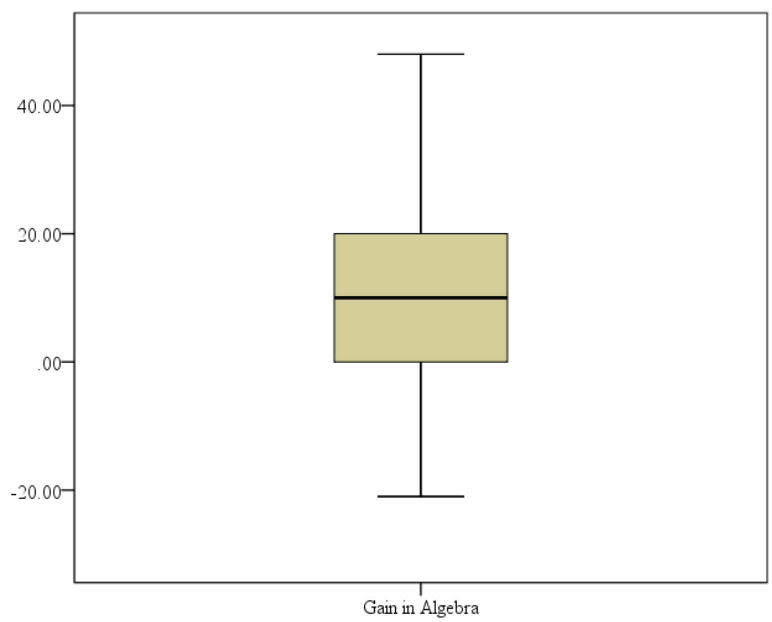

Figure A8. Gain in algebra.

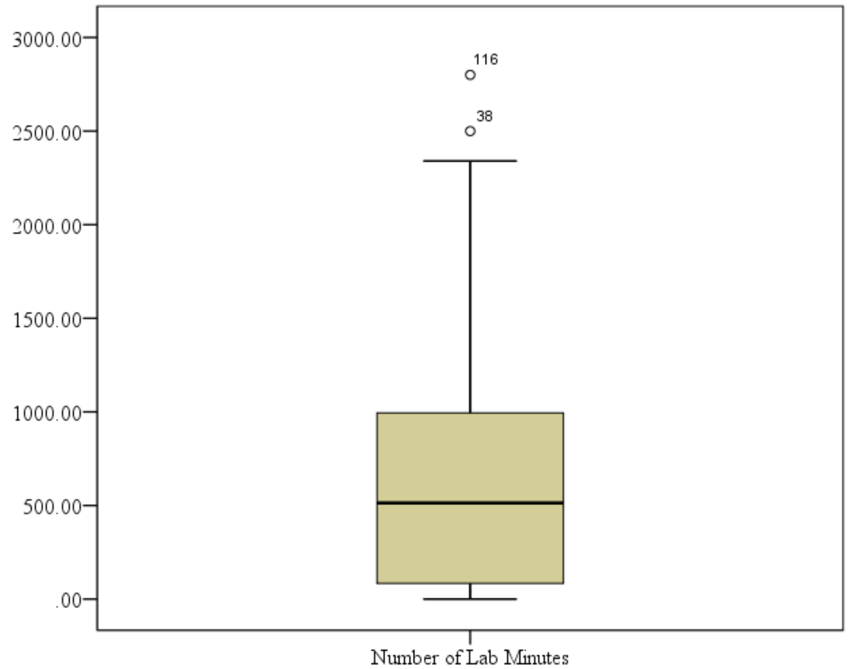

Figure A9. Number of lab minutes.

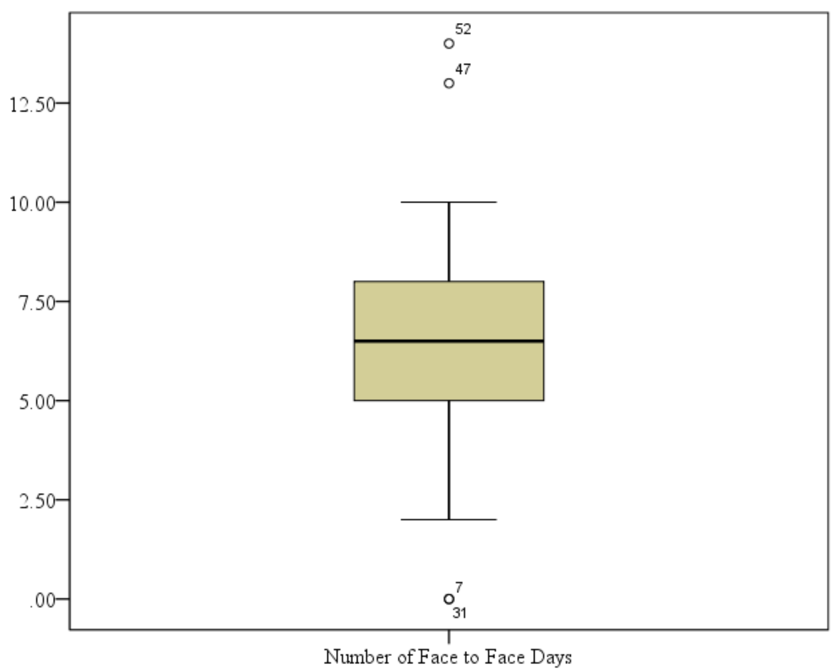

Figure A10. Number of face-to-face days.