Instructional Approach and Mathematics Achievement: 
An Investigation of Traditional, Online, and 
Flipped Classrooms in College Algebra 

by 

Dustin Daniel Files 

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University of Central Florida 
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Applied Mathematics 
Florida Institute of Technology 
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We the undersigned committee hereby approve the attached dissertation

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Dustin Daniel Files

________________________________________  ________________________
Michael A. Gallo, Ph.D.                     Robert Fronk, Ph.D.
Associate Professor                       Professor Emeritus
College of Aeronautics                    Education and
Committee Chair                           Interdisciplinary Studies

________________________________________  ________________________
Kastro Hamed, Ph.D.                        Tom Marcinkowski, Ph.D.
Professor and Head                        Professor
Education and                            Education and
Interdisciplinary Studies                  Interdisciplinary Studies

________________________________________
Cecilia Knoll, Ph.D.
Professor
Mathematical Sciences
ABSTRACT

TITLE: Instructional Approach and Mathematics Achievement: An Investigation of Traditional, Online, and Flipped Classrooms in College Algebra

AUTHOR: Dustin Daniel Files

MAJOR ADVISOR: Michael A. Gallo, Ph.D.

The purpose of this study was to examine the relationship three different instructional models had with students’ mathematics achievement. The research factors included group membership (flipped, online, and traditional), student demographics (gender, age, and race/ethnicity), and students’ affective domain (attitudes toward mathematics, mathematics self-efficacy with respect to algebra, and locus of control). The study used a quasi-experimental, modified nonrandomized pretest-posttest control group, involving intact classes of 117 students during the fall 2015 semester. The data collection instruments consisted of several different assessments: (a) a four-section questionnaire, (b) a test of prerequisite skills (TPRS), (c) three unit examinations, and (d) an end-of-semester comprehensive final examination.

A hierarchical multiple regression strategy was used to analyze the data. Results showed: (a) students in the flipped group scored on average 2.57 and 1.67 units respectively, higher on the final examination, which was the measure of student achievement, than students in the online group and traditional group; (b) student age had a significant and negative effect on student achievement; (c) mathematics self-efficacy had a significant and direct relationship on student
achievement; and (d) there were no significant interactions between group membership and the other research factors relative to student achievement. Stepwise regression analysis confirmed the results of the hierarchical multiple regression analysis. The results were consistent with cognitive and social constructivism, and self-efficacy theory.

The findings inform the mathematics education community about the effect/influence the flipped classroom model has on student achievement in college algebra. Findings also confirm the pronounced role self-efficacy plays with respect to student achievement. Findings also confirm that gender, race/ethnicity, and students’ attitudes toward mathematics make little contribution to explaining the variance in final exam scores.
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Chapter 1

Introduction

Background and Purpose

**Background.** According to Haycock and Huang (2001), the average performance of 17-year-olds on the National Assessment of Educational Progress (NAEP) has gone up between 10 and 13 points in mathematics since the early 1980s. Although there have been gains in mathematics, “only about 1 in 12 of all 17 year-olds can comfortably do multi-step problem-solving and elementary algebra—a finding that may surprise those who know that 91% of those students took at least one algebra course” (Haycock & Huang, 2001, p. 5). Based on NAEP data, students seem to make more growth between Grades 5 and 8 than they do during their high school years (Haycock & Huang, 2001). Haycock and Huang concluded, “Virtually all of the gains in mathematics…during the last decade can be attributed to increased learning prior to high school” (p. 5). These findings beget the question: “What was done in the classroom prior to high school that enabled students to learn more effectively, or alternatively, what was done in high school that slowed the mental growth of students with respect to learning mathematics?”

According to the American College Testing National Report (ACT, 2013), approximately 31% of all 2013 ACT-tested high school graduates met none of the ACT College Readiness Benchmarks. Thus, despite the reported NAEP gains, the ACT’s findings imply that high school graduates “were not prepared academically...
for 1st-year college courses in English composition, college algebra, biology, and social sciences” (p. 24). Nationally, only 44% of high school graduates who took the ACT Assessment achieved scores that would deem them ready (indicating that they would earn a “C” or higher) for their first college algebra course. In Florida, of the 124,131 high school graduates who took the ACT in 2012, only 35% (43,455) were deemed college ready by ACT standards. When juxtaposed against new legislation in Florida, which dictates that students who spend 4 years in a public high school and graduate with a standard diploma are deemed college ready, many Florida high school graduates are entering college academically unprepared.

One possible way to improve this situation is to revise the instructional model, and one such alternative to the traditional classroom is the flipped classroom. In a traditional classroom, students attend class and listen to lectures, and then outside of class they try to interpret what they were presented in class and apply this knowledge to assigned homework problems. In a flipped classroom, students receive instructional videos of the lectures and review these videos at home, or more generally, outside the classroom. During class students receive guidance in interpreting and applying what they learned from the lectures and complete their assignments under the tutelage of their instructor. The underlying premise of this approach is that by being present at the time students are trying to bridge the gap between lecture and interpretation-application, a teacher can be more effective helping students understand content than delivering content.
The concept of the flipped classroom is grounded in scaffolding theory, which was first introduced in the late 1950s by Jerome Bruner in the context of how children learn to speak. Bruner subsequently generalized this theory to the concept of instructional scaffolding (Wood, Bruner, & Ross, 1976), which posits that for students to mature into independent thinkers and problem solvers, they require active guidance from their teachers and parents. Thus, scaffolding represents the helpful interactions between adult and child, and it enables the child to do something beyond his or her independent efforts. It is a temporary framework erected for support and access to meaning, and it is then removed when the child secures control of or success with a task. The scaffolds provided by the adult do not change the nature or difficulty level of the task; instead, the scaffolds allow the child to successfully complete the task.

Vygotsky (1978) also introduced the concept of scaffolding in his sociocultural theory where he described the practice of an expert guiding a novice. A construct that Vygotsky introduced in this context was the zone of proximal development (ZPD). The ZPD is a cognitive state that consists of what learners can do with the support of a competent peer or instructor. The ZPD lies between two other cognitive states that consist of (a) what learners can do by themselves independent of any guidance, and (b) what learners cannot do by themselves even with guidance (Ellis & Worthington, 2002). Vygotsky was convinced that a child
could be taught any subject efficiently using scaffolding practices by implementing the scaffolds within the child’s ZPD.

When applied to the flipped classroom concept, students are escorted and monitored through learning activities that function as interactive conduits to get them to the next stage of development. Thus, learners may add new understanding to their prior knowledge through the support delivered by more capable individuals (Raymond, 2000). Several peer-reviewed studies have shown that when there is a deficiency in guided learning experiences and social interaction, learning and development are obstructed (Bransford, Brown, & Cocking, 2000), which is often the case with the traditional classroom.

Foertsch, Moses, Strikwerda, and Litzkow (2002) used eTEACH, an online streaming video and multi-media application to teach a computer science course using the flipped classroom. Through their review of the literature they concluded that lectures are being portrayed as ineffective ways of teaching; that they are a passive one-way flow of information from professor to student. Foertsch et al. argued that lectures are not really the problem; it is more the timing of the lecture that is the real problem. The most important time for students and professors to spend together is when students have questions and the professors can act as a source of knowledge or guidance. From this notion, the time that students and professors spend together is essentially wasted by a one-sided conversation (lecture).
The benefits that students mentioned most frequently from Foertsch et al.’s (2002) study were: the ability to learn from lectures at one’s own pace, the convenience of watching lectures on their own time, and watching lectures at times that were the most conducive to learning. The drawbacks most frequently mentioned were: not having the opportunity to ask questions in the middle of a lecture, having printed course notes and the ability to replay lectures discouraged some students from taking notes, and some students felt the more formal and more focused setting of a live lecture would have encouraged them to pay fuller attention to the lectures. In all, 59% of the students felt that the flipped classroom had a positive effect on their learning while 25% felt it did not make a difference.

Fulton (2012) reported on the success of the flipped classroom at Byron High School (BHS) in Minnesota. Beginning with the 2010-2011 school year, teachers created their own videos for their courses and uploaded the videos to YouTube. Students were allowed to access any teacher’s videos they wanted. Fulton reported that in doing this (p. 14),

Some like to watch a different teacher’s video lesson for review or to see a new angle for understanding a difficult concept. It gives the kids great freedom, and the teachers are benefiting…they learn new approaches for their own teaching when viewing each other’s videos.
At the end of the 1st year of using the flipped classroom, Fulton reported that the percentage of students who scored 80% or above on unit assessments increased 9.8% in calculus and 6.1% in precalculus.

In addition to the increase in course proficiency, Fulton (2012) also reported that students’ mathematics scores on the Minnesota Comprehensive Assessment (MCA) dramatically increased from a mastery level of 29.9% in 2006 to 65.6% in 2010. After the implementation of the flipped classroom model, mastery rose to 73.8% in 2011. Student feedback from the study included (p. 14): (a) “…when I do the homework in class, I can have help right away, which means I ask more questions.”; (b) “I liked this approach a lot because when we work on homework in class, [the teacher is] here to help us. Otherwise, I would be lost at home…”; (c) “I liked how I could rewind and pause lectures in case I didn’t understand something.”; and (d) “I liked how we watched the concept at home, but then mastered the concept in class.”

Gannod, Burge, and Helmick (2008) believed that the most successful education initiatives are those that benefit both teacher and student, and that the flipped classroom does just this. In their endeavor to build motivation for the use of the flipped classroom, Gannod et al. sought to identify benefits and common characteristics between today’s students (referred to as millennials) and the flipped classroom. Gannod et al. elaborated on 4 of the 10 characteristics identified by Frand (2000) that are common to millennials and addressed by the flipped
classroom: (a) doing is more important than knowing, (b) learning more closely resembles Nintendo than logic, (c) multitasking is a way of life, and (d) there is zero tolerance for delays. That is, the flipped classroom takes the focus away from lecture and puts it on active learning; it provides more opportunity for iteration; content is delivered when and where the student chooses; and feedback is instant as activities are completed in class.

Augmenting these characteristics, Foreman (2003) provided several elements of learning theory that are essential for the flipped classroom: it is customized, constructive, motivating, enduring, and it provides immediate feedback. The flipped classroom model enables instructors to tailor instruction to students based on the feedback they receive when reviewing their homework assignments. There is no need to wait to see how they did on an assignment as students get immediate feedback during in-class activities because the instructor is physically present working with students. More hands-on activities provide students with a constructive environment filled with active discovery. This provides a lasting experience that affords students the opportunity to link knowing and doing.

Although not directly related to the flipped classroom model, Kay and Kletskin (2012) examined the aspect of using technology outside of the classroom to convey lecture material to students. Their study involved the use of podcasts to teach mathematics in higher education where a podcast was defined as audio-visual
files that are distributed in a digital format through the Internet using personal or mobile devices (McGarr, 2009). In particular, Kay and Kletskin used podcasts to fill in any gaps that might exist in prerequisite knowledge that introductory calculus students had with respect to precalculus.

Approximately two-thirds of the 288 students enrolled in the courses used the podcasts. Those who chose not to use them felt they did not need a refresher or did not have time to view them. For those students who did view the podcasts, 87% rated them as useful or very useful on a follow-up survey. This finding suggests that the use of podcasts as a medium for delivering lectures outside of the traditional classroom is effective. If podcasts were to be used within the flipped classroom model, Kay and Kletskin’s (2012) study has shown that students have a better chance of using them if they are easy to follow, contain high quality explanations, and can be viewed when needed.

Strayer (2007) employed a mixed-methods comparative study using two college-level introductory statistics courses to compare the flipped classroom to the traditional classroom. His research made use of the College and University Classroom Environment Inventory (CUCEI) developed by Fraser and Treagust (1986). This inventory was developed to assess students’ actual and preferred perceptions of the learning environment. The seven scales on the CUCEI are personalization, innovation, student cohesion, task orientation, cooperation, individualization, and equity. Strayer reported that 64.2% of the overall variation in
data was explained by the version of the CUCEI (actual or preferred), and instructional method explained 44.5% of the overall variation in data. Both of these reported effects were statistically significant \( (p < .001) \), and the interaction effect also was significant \( (p = .02) \) explaining 32.5% of the overall variation in the data. Of the seven scales on the CUCEI, only cooperation, innovation, and task orientation were significant. With regards to cooperation, Strayer reported that a significantly greater number of students in the flipped classroom were more open to cooperation than those in the traditional classroom. With regards to innovation, the flipped classroom students again reported experiencing/preferring more innovation in the classroom even though at times they reported being frustrated by some of the learning activities.

Traphagan, Kucsera, and Kishi (2009) studied the impact class-lecture webcast availability had on student attendance and learning. Webcasting refers to streaming audio or video broadcasts over the Web, requiring a connection to the Internet throughout the broadcast. The study was conceived through the notion that having accessible class-lecture recordings excuses students from attending class. Previous studies by Harley et al. (2003) and Brotherton and Abowd (2004) supported this notion noting that 25% and 33% of students, respectively, felt that webcasts are a substitute replacement for attending lecture. Even though a majority of students did not feel this way and still preferred live lectures over webcasts, Traphagan et al. noted that lectures, by a 2 to 1 margin, are what students miss most
often when compared to seminars, and by a 5 to 1 margin when compared to workshops and laboratory sessions (Woodfield, Jessop, & McMillan, 2002). Using a quasi-experimental design Traphagan et al. conducted their study using 364 students split between two sections. Their study showed that students used online resources outside of class, which is a key element of making the flipped classroom work. Traphagan et al. also found that online resources (beyond webcasting) posted by an instructor could possibly suppress class attendance further. This finding suggests it is important for students in the flipped classroom to understand that (a) class attendance is mandatory and not optional, and (b) the online material is taking place of the normal lecture material, and (c) assignments that would have been completed outside of class are now being completed inside of class.

A concern many instructors have about implementing a flipped classroom model is that students might not take the initiative to properly prepare for class by watching the videos. Findings from Zappe, Leicht, Messner, Litzinger, and Lee (2009) indicated there is merit to this concern. As part of their study, Zappe et al. required students to complete short pre-class assessments on the material presented in the assigned videos. Zappe et al. reported that although 92% of students reported watching the assigned videos at least one time before class, only 33.8% of students indicated they might/would have viewed the videos had they not had to take a quiz on the material covered in the video. As a result of this finding, Zappe et al. concluded that pre-class assessments of the video material (a) should increase the
likelihood of students watching videos and (b) will give flipped classroom
instructors a snap shot of what should be the focus of the in-class activities. Zappe
et al. also reported that students preferred “shorter” videos (between 20 to 30
minutes), which suggests that the flipped classroom might be a better setting for
students with short attention spans.

Ogden (2014) used a multiple-case study approach to describe the design
and development of a flipped classroom model over 3 semesters of college algebra.
The first case study involved implementing a modified flipped classroom in which
she did not prepare videos for all sections ahead of time. In this first attempt at
flipping the classroom, Ogden taught the experimental group from a hybrid
approach (part face-to-face, part online), and assigned videos as homework once or
twice a week. In her second case study Ogden used a more common flipped
classroom model by assigning videos four to five times a week. In her third case
study Ogden went back to assigning videos once or twice a week. She did this
because student feedback from the second case study indicated they had trouble
watching four to five videos a week. To measure the appeal and receive feedback
as to how students felt about the design of the course, Ogden administered surveys
and held meetings with her students. Ogden used the results from these surveys and
meetings to improve the instructional model in each subsequent case study. Based
on student feedback, Ogden concluded that students more likely would embrace a
flipped classroom if they were required to watch no more than one or two videos
per week because this would give them sufficient time to complete all assignments for the week.

The current literature on flipped classrooms has demonstrated that this model can be an effective instructional approach. In summary, some of the benefits that have been reported include: it enables students to learn at their own pace, it provides students with immediate feedback when completing problems, and it involves accessing online resources, which is appealing to today’s generation of students. However, as inferred by Zappe et al.’s (2009) findings, students in a flipped classroom must have a certain level of self-discipline to meet the challenges inherent in executing their responsibilities outside of the classroom. Nevertheless, when contrasting the workload between doing practice problems or watching videos and taking notes, it seems that students are much more inclined to do the latter rather than the former on their own. By this notion, the flipped classroom model should promote higher student achievement than the traditional classroom model.

The current literature also has demonstrated the efficacy of the flipped classroom concept across various mathematics related courses, including computer science, high school precalculus, college-level introductory statistics, college algebra, and as a tool for helping 1st-year calculus students reinforce or strengthen their prerequisite mathematics knowledge. One plausible explanation for the success of the flipped classroom in these courses is they all require a certain level
of mathematical maturity, which is generally achieved via college algebra. For example, college algebra is a prerequisite course for precalculus and statistics, and commonly is a requirement for a 1st-year course in computer science. With the exception of Ogden (2014), who used a case study approach to investigate the effect of the flipped classroom in college algebra, there is a dearth of published quantitative studies involving the flipped classroom in college algebra. Furthermore, there have been no published studies that also examined the relationship of students’ affective domain such as attitudes, self-efficacy, and locus of control relative to the flipped classroom model. As a result, the current study endeavored to help fill this gap in the literature.

**Purpose.** The purpose of this study was to determine the relationship each of the three different instructional models—flipped, online, and traditional—had with students’ mathematics achievement, student attributes, and students’ affective domain. In the context of the current study, the traditional instructional model—also referred to as the traditional classroom—was defined as one in which students met in a face-to-face classroom setting for 2.5 hours per week and the class followed a conventional protocol of a procedural lecture with students completing homework assignments outside of and independent of the classroom. The online instructional model—also referred to as the online classroom—was defined as one in which students were presented lectures via online instructional videos, which were viewed independent of and outside the classroom at their leisure. Students
also completed their homework assignments completely outside the classroom. The flipped instructional model, which is sometimes referred to as the “flipped classroom” or the “inside-outside classroom,” was defined as one in which students viewed lectures outside of the classroom via online instructional videos, but they completed their homework assignments in a face-to-face classroom setting guided by the teacher. The online instructional videos used were the videos provided by the textbook author and used in conjunction with preprinted notes and PowerPoint handouts. In all three models, students were presented with the same mathematical subject matter and completed exactly the same homework assignments. Unit and final exams for the traditional and flipped classroom models were administered in class. Unit and final exams for the online model were administered by one of the following: (a) any of Eastern Florida State College’s (EFSC) five testing labs, (b) Proctor-U (an online test proctoring service), or (c) an instructor-approved outside proctor (for students living outside of the county).

Student attributes were defined as age, gender, and race/ethnicity. The affective domain variables included students’ attitudes toward mathematics, mathematics self-efficacy with respect to algebra, and locus of control. Attitudes toward mathematics were measured using Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory (ATMI), mathematics self-efficacy was measured using Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale-Revised (MSES-R), and locus of control was measured using Rotter’s (1966) Locus of Control
Personality Test (LCPT). Lake’s (2008) comprehensive college algebra final exam was used to measure mathematics achievement.

**Definition of Terms**

Key terms pertinent to this study were operationally defined as follows:

1. *Achievement* was defined as scores on Lake’s (2008) comprehensive end-of-semester college algebra final exam. Student achievement also was defined from a formative perspective and included students’ scores on textbook-based homework assignments and researcher-developed unit exams.

2. *Affective domain* was defined as students’ emotions toward a learning experience and included their feelings, values, enthusiasm, motivation, and attitudes. In the context of the current study, students’ affective domain was examined from three perspectives: attitudes toward mathematics, mathematics self-efficacy related to algebra, and locus of control, each of which is defined separately.

3. *Attitudes toward mathematics* were defined as students’ level of self-confidence, value, enjoyment, and motivation relative to mathematics. In the current study, students’ attitudes toward mathematics were measured using Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory (ATMI).

4. *College algebra* was defined as the 3-credit-hour, 48-contact-hour course MAC 1105, which refers to a specific set of instructional objectives and content defined by Florida’s Division of Community College’s college algebra
curriculum. The major topics of the course includes functions and function notation; domain, range, and graphs of functions and relations; operations on functions; inverse functions; linear, quadratic, rational, radical, exponential and logarithmic equations and functions; piecewise and higher degree monomial functions; systems of equations and inequalities; applications. A description of the course is provided in Chapter 3.

5. *Flipped classroom* was defined as the inverse of the traditional classroom. In the current study, this instructional model involved (a) students viewing lessons via videos and/or online resources and taking notes of the lessons outside of class prior to the beginning of each class session, and (b) completing and reviewing corresponding homework assignments during class with the assistance/guidance of the instructor and/or other students. At the end of each class session, the instructor assigned a new lecture video with notes to be watched and completed outside of class.

6. *Learning management system (LMS)* was defined as an online software application for the administration, tracking, reporting, and delivery of course materials in a face-to-face or virtual environment. For the current study, Canvas, which is EFSC’s LMS was used.

7. *Locus of control* was defined as a theoretical construct that assesses the extent to which people believe they are in control over the events and circumstances affecting their lives. Rotter (1966) differentiated between two extreme beliefs
of control: *internal locus*, which refers to individuals who believe that rewards are contingent upon their own behavior and as such, they believe they are in control of and responsible for events that affect their life; and *external locus*, which refers to individuals who believe that events in their life are not under their control but under the control of outside forces. In the current study, Rotter’s Locus of Control Personality Test (LCPT) was used to measure students’ locus of control.

8. *Mathematics self-efficacy* was defined as students’ perceptions of their ability to perform various mathematics related tasks and behaviors independent their actual ability. In the current study, Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale-Revised (MSES-R), which is focused on algebra, was used to measure students’ mathematics self-efficacy.

9. *Online classroom* was defined as an instructional model that was similar to the traditional classroom except students watched all lectures via video outside of class rather than coming to campus to receive a face-to-face lecture. Similar to the traditional instructional model, students completed homework assignments outside of class.

10. *Student attributes* were defined as students’ age, gender, and race/ethnicity.

11. *Traditional classroom* was defined as an instructional model in which students met in a face-to-face setting in class and followed a traditional protocol that involved (a) reviewing homework from the previous class session, (b)
presenting a new lesson, and (c) assigning homework to be completed outside of class relative to the new lesson.

Research Questions and Hypotheses

Research questions. The overall research question that guided this study was “What is the relationship between group membership (flipped, online, traditional) and student achievement?” As part of this overall question, answers to the following research questions were examined:

1. What is the relationship between group membership and student achievement?
2. What is the relationship between student attributes and student achievement?
3. What is the relationship between students’ affective domain and student achievement?
4. What interaction (if any) does group membership have with student attributes and with students’ affective domain, respectively, relative to student achievement?

Research hypotheses. The research hypotheses that corresponded to the research questions were as follows:

Hypothesis 1. Students in the flipped classroom will have higher achievement than students in either the online or traditional classrooms.
Hypothesis 2. The relationship between student attributes and student achievement was posited as follows: (a) There will be a relationship between age and achievement. (b) There will be a relationship between gender and achievement with male students having higher achievement than female students. (c) There will be a relationship between race/ethnicity and achievement: At least one race/ethnic group will have higher achievement than any of the other race/ethnic groups.

Hypothesis 3. The relationship between students’ affective domain and student achievement was posited as follows: (a) There will be a direct relationship between students’ attitudes toward mathematics and achievement: As students’ ATMI scores increase, so too will their achievement. (b) There will be a direct relationship between students’ mathematics self-efficacy and achievement: As students’ MSES-R scores increase, so too will their achievement. (c) There will be an inverse relationship between students’ locus of control and achievement: As students’ LCPT scores decrease, their achievement will increase.

Hypothesis 4. The interaction between group membership and the respective factors of student attributes and students’ affective domain relative to student achievement was posited as follows: (a) There will be a disordinal interaction between group membership and age (nominal-by-continuous interaction). (b) There will be a disordinal interaction between group membership and gender (nominal-by-nominal interaction). (c) There will be a disordinal interaction between group membership and race/ethnicity (nominal-by-nominal interaction).
(d) There will be a disordinal interaction between group membership and students’ attitudes toward mathematics (nominal-by-continuous interaction). (e) There will be a disordinal interaction between group membership and students’ mathematics self-efficacy (nominal-by-continuous interaction). (f) There will be a disordinal interaction between group membership and students’ locus of control (nominal-by-continuous interaction).

**Study Design**

This study used a quasiexperimental, nonrandomized, modified pretest-posttest control group design involving intact classes. The target population was all students in Florida public colleges who enrolled in college algebra (MAC 1105) during the fall 2015, 16-week semester. This population was delimited to a smaller accessible population that consisted of students who enrolled in MAC 1105 at Eastern Florida State College (EFSC). From this accessible population I used a convenient sample ($N = 149$), which consisted of six sections of intact classes of MAC 1105 offered during the 16-week fall 2015 semester: four face-to-face sections from the Palm Bay campus and two online sections from e-Learning. The four face-to-face classes were purposively assigned so that either traditional or flipped met on different days and times: The flipped group met Monday/Wednesday from 10:50 a.m. to 12:05 p.m. and Tuesday/Thursday from 1:40 p.m. to 2:55 p.m.; and the traditional group met Monday/Wednesday from 1:40 p.m. to 2:55 p.m. and Tuesday/Thursday from 10:50 a.m. to 12:05 p.m. The
eLearning department chair assigned me the online classes. As a result, I had no control over the selection of these students.

**Significance of the Study**

As noted earlier, there is a dearth of systematic quantitative studies that examined the relationship between flipped classrooms and student achievement in college algebra. There were, however, many results using just the key word “flipped classroom.” However, many of these results, were anecdotal reports. This lack of systematic research on the flipped classroom, particularly with respect to teaching college algebra, suggests there is a gap in the research that needs to be filled. As a result, a key significance of the current study was that it adds to the current body of knowledge and informs the mathematics research community about the effect the flipped classroom model has in college algebra.

The research and theoretical significance of the current study is that it also examined the various interactions the three instructional models had with student attributes and students’ affective domain relative to achievement. This was critical because the findings help inform which type of student is better suited for what type of instructional model and could be used to develop a profile of what student attributes and affective domain characteristics are more appropriate for a flipped classroom with respect to student achievement. This is discussed in Chapter 5.
Study Limitations and Delimitations

Limitations. Limitations of a study are events, conditions, or circumstances outside the control of the researcher that limit population and ecological generalizations of a study’s results. Therefore, any interpretations, explanations, or generalizations of the results of the current study should take the following limitations into consideration:

1. Textbook. A college-wide college algebra textbook selection committee selected the textbook that was used in the current study. This textbook also contained a set of instructional videos that were used for the flipped and online classrooms. As a result, similar studies that use a different textbook and/or videos might not yield the same results.

2. Course curriculum. College algebra is a common course, MAC 1105, offered throughout Florida’s colleges and universities and as such has a well-defined curriculum. As a result, similar studies that use a different college algebra curriculum might not yield the same results.

3. Instructional schedule. The instructional schedule for the targeted course will vary among universities and colleges. For example, some schools might offer the course 1, 2, or 3 days per week for a conventional 16-week semester, others might offer it during a 10-week quarter system, and still others might offer it on a nonconventional schedule (e.g., 3 days per week at 4 hours per day for 4 weeks).
This means that studies involving an instructional schedule different than that used in the current study might yield different results.

4. **Sample demographics.** The demographics of the participants of any study influence the results of the study because of the different attributes that define the participants. As a result, similar studies with different sample demographics will not necessarily yield similar outcomes as the current study. Information on the current study’s sample demographics is provided in both Chapters 3 and 4 to aid the reader in making comparisons for generalizability purposes.

5. **Add-drop period.** During the 1st week of classes, students were free to add or drop any course. This means it is conceivable that students who initially enrolled into one of the targeted sections of MAC 1105 might have dropped or changed sections during this period, which has the potential of altering the complexion of the sections (e.g., all low achieving students might opt for the flipped model). As a result, similar studies that do not include an add-drop period, or studies in which the add-drop period is longer than 1-week, might yield different results.

**Delimitations.** Delimitations of a study are conditions, events, or circumstances a researcher imposes to make a study feasible to implement but might further limit the generalizability of the results. As a result, any interpretations, explanations, or generalizations of the results of the current study should take the following delimitations into consideration:
1. **Campus location.** The current study was conducted using the Palm Bay and eLearning campuses of EFSC. Because student demographics are specific to these two campuses, it is possible the results of other studies using different locations could be different.

2. **Participating instructors.** The current study was implemented using a single instructor who also was the researcher. As a result, similar studies that employ different instructors for each instructional model, or include a single instructor with different personological and professional characteristics than mine, might not yield the same results.

3. **Semester.** The current study was conducted during the fall semester. The student population characteristics such as age and full-time status are different between the fall and spring semesters. For example, in the fall semester, the MAC 1105 students mainly consist of freshmen whereas students who take MAC 1105 in the spring semester might include sophomores, juniors, and seniors who for some reason failed to take the course during their freshman year. As a result, studies conducted during the spring or summer semesters may not yield the same findings.

4. **Students’ attitudes toward mathematics.** The current study measured students’ attitudes toward mathematics using Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory. Thus, similar studies that use a different attitudes scale might yield different results.
5. **Students’ mathematics self-efficacy.** The current study measured students’ mathematics self-efficacy using Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale-Revised which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale. Thus, similar studies that use a different efficacy scale might yield different results.

6. **Students’ locus of control.** This study measured students’ mathematics locus of control using Rotter’s (1966) Locus of Control Personality Test. Thus, similar studies that use a different personality test might get different results.

7. **Lecture videos.** The current study used textbook specific videos developed by the publisher. Thus, similar studies that use different videos might yield different results.

8. **Student achievement.** Student achievement was measured using Lake’s (2008) college algebra comprehensive final exam, which was prepared by a faculty committee. As a result, similar studies that use a different instrument to assess student achievement might yield different results.
Chapter 2

Review of Related Literature

Introduction

This chapter is organized into three sections. The first section contains a discussion of the underlying theories in which the current study is grounded: individual and social constructivism, and self-efficacy theory. The chapter then transitions its focus to past research studies related to the flipped classroom. The chapter concludes with a summary of the collective findings from the literature and their implications to the current study.

Overview of Underlying Theory

Constructivism. The basic principle of constructivism is that students construct their own knowledge by doing rather than by listening or observing, and therefore teachers should not convey knowledge to students but instead students must take an active role in their learning by creating new knowledge for themselves. There are two major types of constructivism: individual and social. Individual constructivism, which also is commonly referred to as cognitive constructivism, is grounded in Piaget’s (1953) theory of cognitive development whereas social constructivism is grounded in Vygotsky’s (1962) sociocultural theory. As inferred by their respective labels, “In cognitive constructivism, ideas are constructed in individuals through a personal process, as opposed to social
constructivism where ideas are constructed through interaction with the teacher and other students” (Powell & Kalina, 2009, p. 241). A discussion of each type follows.

**Cognitive constructivism.** As noted earlier, cognitive constructivism stems from Piaget (1953) who was one of the first theorists to propose that knowledge is actively constructed by the learner and not passively conveyed by the educator. Thus, learners do not simply absorb information they encounter, but instead they actively try to organize and make sense of it. Piaget posited that learners construct mental representations of their experiences and organize these representations as schemas, a term Piaget used to denote a learner’s conceptual framework. Thus, a schema is the basic structure by which learners mentally represent knowledge. It is a mental unit that represents a class of similar actions or thoughts.

According to Piaget (1953), learning is a process that involves learners trying to adapt new knowledge to their existing conceptual framework. Learners accomplish this either by integrating new knowledge into their own schemas (assimilation) or by modifying their existing schemas (accommodation). If learners can comfortably integrate new knowledge into their existing schemas, then assimilation occurs and learners are considered to be in a state of mental equilibrium. On the other hand, if learners cannot comfortably integrate new knowledge into their existing schemas, then they must modify their existing schemas or create new ones to accommodate this new knowledge. When trying to resolve this inconsistency between new knowledge and their current cognitive
structure, a learner is considered to be in a state of mental disequilibrium, or cognitive dissonance, because “…one has to adjust his or her thinking (schema) to resolve conflict and become more comfortable” (Powell, 2006, pp. 26–27). Only through accommodation can learners modify their existing schemas to fit new information and return to a state of equilibrium—a cognitive state where everything is balanced. Assimilation and accommodation are complementary processes that learners experience as they search for balance, or equilibration, which entails progressing from a state of equilibrium to disequilibrium and back to equilibrium (Ormrod, 2016; Wadsworth, 1996).

For example, when the concept of function is first introduced in college algebra, it is presented from the perspective of linear functions, which is intuitive and generally understood by most students. As part of this presentation, students are introduced to and practice techniques for solving linear equations and many students (incorrectly) develop the notion that an equation is the same as a function. It is natural to follow this discussion with the introduction of quadratic functions. Although the concept of function still holds, not all quadratic equations are functions, and the techniques used to solve quadratic equations are different from those used to solve linear equations. As a result, many students must modify their existing schemas relative to their understanding of functions as well as for solving quadratic equations.
When applied to the context of the current study, the flipped classroom lent itself to cognitive constructivism. Instead of lecturing to the group, the teacher was working with students individually, helping them learn how to understand and solve mathematical problems. As they worked on their assignments, mistakes were made and students experienced disequilibrium. Although this is similar to what occurs when students work on their assignments outside of class, the difference is that now the time spent in a state of disequilibrium was minimized because the teacher was accessible to help students modify their existing cognitive structure. Thus, when couched against theory, students in the flipped classroom had higher achievement than students in the traditional classroom because the former possessed superfluous support for the process of equilibration.

**Social constructivism.** Subsequent to Piaget (1953) describing his theories involving cognitive constructivism, Vygotsky (1962) posited that learning is a social endeavor and is facilitated by community and culture. Although Piaget (1964) also recognized the role of social interaction with the learning process—“interaction with one’s physical and social environments is essential for cognitive development” (p. 178)—construction of knowledge was still an individual endeavor. Vygotsky, on the other hand, whom many consider the founding father of social constructivism, believed that social interaction was an integral part of the learning process. Vygotsky believed that when individuals work cooperatively to solve problems, they develop more sophisticated strategies and thought processes.
than if they worked alone. He stressed that this was particularly the case when someone works with a more intellectually advanced individual such as a teacher, parent, or more advanced student.

According to Vygotsky (1987), learning proceeds from an awareness state, where a student is aware of a concept, to an understanding state, where the student has a true understanding of the concept. Vygotsky referred to this progression from awareness to understanding as "the link of the zone of proximal and actual development" (p. 220, emphasis in original). Thus, the awareness state, which is the zone of proximal development (ZPD), represents a cognitive state where a student has acquired sufficient background information about a concept, but needs help to fully grasp an understanding of the concept. The ZPD, then, refers specifically to the zone where students are able to perform various task when being assisted by someone else but are unable to accomplish them on their own. As a result, cognitive growth occurs when students attempt new tasks that they can only accomplish when being guided by another person.

When applied to the context of the current study, an example of Vygotsky’s (1987) concept of ZPD would be students solving homework problems. Students in all three instructional models (flipped, online, and traditional) had equivalent awareness states of the concepts and problems associated with a specific lesson because all three were taught exactly the same lessons. The difference, though, was that students in the flipped classroom were under the tutelage of their instructor,
who in this context assumed the role of a competent guide, when they completed their homework assignments. As a result and relative to the ZPD, when compared to the other two instructional models, students in the flipped classroom had greater success—and concomitantly, greater cognitive growth and higher achievement—because they were able to work on their assignments with the aid of their teacher. “Once students achieve the goal of the initial activity, their zone grows and the students can do more” (Powell & Kalina, 2009, p. 244). Thus, the ZPD moves and shifts as students master new tasks and more complex ones take their place (Ormrod, 2016).

Inherent in Vygotsky’s (1962) description of ZPD is the concept of scaffolding, which “is an assisted learning process that supports the ZPD, or getting to the next level of understanding, of each student from the assistance of teachers, peers, or other adults” (Powell & Kalina, p. 244). For example, if a student incorrectly applies the zero factor property (if $ab = 0$, then either $a = 0$ or $b = 0$) when solving quadratic equations by factoring, the teacher could point to the error, recite the property aloud with the student, and then guide the student to correctly apply the property. Once the student has mastered this type of problem, its solution becomes internalized and the scaffolding is no longer needed. When applied to the context of the current study, the concept of scaffolding was an integral part of the flipped classroom.
Regardless of the perspective, cognitive or social, “…the actual process of learning with meaning and students constructing concepts to create knowledge is common to both types” (Powell & Kalina, 2009, p. 248). Given the basic tenet of constructivism—students construct their own knowledge—a teacher’s primary role is to guide students in their search for knowledge (Brooks & Brooks, 1993). Poplin (1988, p. 395) asserted that “the more control educators have over the content, the less likely students will be to maintain and generalize skills and or strategies.” Thus, in the constructivist classroom, conversations start with students and end with the teacher, or start and end with students (Knight, 2003). In the current study, the concept of constructivism was manifested in all three instructional models, but was less pronounced in the traditional classroom, which was taught in a didactic manner (conventional lecture). The online classroom model embodied the concept of cognitive constructivism whereas the flipped classroom model incorporated both cognitive and social constructivism.

**Self-efficacy theory.** First introduced by Bandura (1977), self-efficacy refers to a person’s judgment about how confident he or she is in being able to perform a task. It is a belief or self-perception people have about themselves regarding the confidence they have in their ability to do something. Thus, self-efficacy is not related to a person’s actual level of competency, but instead is concerned with how a person judges his or her capabilities relative to performing specific actions. More formally, Bandura (1986) defined self-efficacy as:
… peoples’ judgments of their capabilities to organize and execute courses of action required to attain designated types of performance. It is concerned not with the skills one has but with the judgments of what one can do with whatever skills one possesses. (p. 391)

Bandura (1977) described two sets of efficacy outcomes: efficacy expectancy and efficacy expectation. He defined the former as a person’s estimate that a given behavior will lead to certain outcomes, and he defined the latter as the conviction a person has in his or her ability to successfully execute the behavior that is needed to produce an outcome. A strong belief in a person’s ability to accomplish a task successfully contributes to his or her attempt to cope with a given situation. Thus, the amount of effort and persistence expended in a task can often determine a person’s success or failure in his or her endeavor.

According to Bandura (1977, 1982, 1986a), self-efficacy has a manifold influence on behavior and cognition. For example, self-efficacy can have an effect on a person’s choice of activities—people tend to choose tasks and activities they believe they can be successful at and avoid tasks and activities at which they believe they will fail. People with high self-efficacy also tend to set higher goals for themselves, and are more likely to exert greater effort when attempting to accomplish something and have higher levels of perseverance when encountering obstacles than individuals with low self-efficacy. Specific to student learning and achievement, students with a sense of high self-efficacy tend to learn and achieve
more than students with a low sense of self-efficacy. Thus, given two students with equal abilities, the student with higher self-efficacy is more likely to accomplish a given task successfully than the student who does not believe he or she is capable of success.

The results of the vast majority of self-efficacy studies, including several meta-analyses conducted by Bandura and Locke (2003), have confirmed there is a positive relationship between self-efficacy and performance. Furthermore, this relationship has been reported across many different professions. In education, for example, students with higher academic self-efficacy have shown better academic performance (Robbins et al., 2004), and Costa and Garmston (1992) reported that efficacy might be the most catalytic behavior of successful teachers. External to education, Switzer, Nagy, and Mullins (2005), Chen, Casper, and Cortina (2001), and Stajkovic and Luthans (1998) reported that self-efficacy predicted several work-related outcomes, including job attitudes, training proficiency, and job performance.

Bandura (1977) also identified several factors he believed influence the development of students’ self-efficacy. Relevant to the current study, one key factor is students’ previous success and failures. Students feel more confident that they can succeed at a task when they have succeeded at that task or at a similar one in the past. On the other hand, if students are met with consistent failure in performing a particular task, they tend to have little confidence in their ability to
succeed at that task in the future. For example, college students who had continued success in the mathematics courses they took in high school would have higher mathematics self-efficacy than students who did not have the same level of success. According to self-efficacy theory, then, students with higher mathematics self-efficacy also would be expected to have higher achievement. Another factor relevant to the current study is the messages students receive from others. Students’ self-efficacy is enhanced when they receive direct or indirect assurances from their teachers or peers that success is possible. A third factor is related to the success and failures of other individuals or of the group as a whole. With respect to individuals, observing the successes and failures of peers sometimes influences students’ self-efficacy. Similarly, the concept of collective self-efficacy has been known to impact students’ self-efficacy when they work in a group and the entire group achieves success.

When applied to the context of the current study, the concept of self-efficacy could have been a threat to internal validity because of its possible influence on students’ attitudes and/or achievement. Therefore, self-efficacy was incorporated into the study as an independent variable and a corresponding research question and hypothesis was deduced. The combined theories of constructivism and self-efficacy suggested that the self-efficacy of students in the flipped classroom would improve as the semester progresses because of the one-on-one attention they received when working on homework problems. This in fact led to an increase in
students’ perceived ability to be successful in mathematics and yielded higher achievement. Although not listed formally as a research question, I examined this change in self-efficacy by comparing pre- and post-mathematics self-efficacy scores among all instructional models. Results are reported in Chapter 4.

**Closing comments.** The current study endeavored to determine which instructional model—flipped, online, or traditional—related to higher student achievement. The flipped model represented a combination of cognitive constructivism, social constructivism, and self-efficacy theory. In addition to being responsible for learning the material independently, students in the flipped model also benefited from interacting with their peers (social constructivism) and receiving personal guidance from their teacher (ZPD) as they completed homework problems, both of which could have a positive effect on students’ self-efficacy. The online model was mostly grounded in cognitive constructivism where students were primarily responsible for learning the material on their own independently and completing the homework assignments without the benefit of instructor guidance. The traditional model also was grounded in cognitive constructivism, but students benefited from the explicit instruction provided by the teacher for the lecture component and homework review by modeling problem solving procedures. As a result, the cognitive learning theories presented here support the notion that the flipped classroom model is most appropriate for improving student achievement. In the current study, hypotheses deduced from these theories were tested to determine
which class structure was most effective relative to student achievement in college algebra. Results of hypothesis testing are reported in Chapter 4.

Review of Past Research Studies

The published research on the effect of flipped classrooms has been limited in scope and application. Many such studies also have been anecdotal and have not benefited from a systematic quantitative investigation. Although the research in this area is limited, past studies nevertheless provide invaluable insight into the issue as a whole. This section provides a review of the research from two perspectives: the effect of flipped classrooms in various mathematics and mathematics-related disciplines, and the effect of flipped classrooms in college algebra.

The flipped classroom in mathematics related disciplines.

Computer science. Foertsch, Moses, Strikwerda, and Litzkow (2002) used eTEACH, an online streaming video and multimedia application to teach a computer science course using a flipped classroom. Through their review of literature they concluded that lectures are being portrayed as ineffective ways of teaching; that they are a passive one-way flow of information from professor to student. Foertsch et al. argued that lectures are not really the problem; it is more the timing of the lecture that is the real problem. The most important time for students and professors to spend together is when students have questions and the professors can act as a source of knowledge or guidance. From this notion, the time that students and professors spend together is essentially wasted by a one-sided
conversation (lecture). Foertsch et al. opined that students would have done just as well to read the professor’s lecture notes or view a videotape of the lecture on their own time. Continuing with this train of thought, they asked, “When do students have the most questions?” They surmised that it wasn’t during lecture, but when the students are trying to apply the principles that they learned to application. This led them to believe that professors and students would be better served if their time together were spent on problem solving, not on lectures.

In fall 2000, Foertsch et al. (2002) replaced two classroom lectures per week with eTEACH presentations, which students viewed outside the classroom. The two classroom lecture days were replaced with team labs where students worked in three-person teams to solve problems related to the eTEACH presentations they were to watch prior to attending the lab. To determine the impact of this new delivery method on student achievement, Foertsch et al. hired an educational researcher from the UW-Madison’s Learning through Evaluation Adaptation and Dissemination (LEAD) Center. Data collection included a course survey, which 259 and 270 students completed in the fall and spring semesters respectively. Part of the survey asked students to list the benefits/drawbacks to viewing the lecture material outside of the classroom. The benefits that students mentioned most frequently were: (a) the ability to learn from lectures at one’s own pace, (b) the convenience of watching lectures on their own time, and (c) watching lectures at times that were the most conducive to learning. The disadvantages most
frequently cited were: (a) several students missed having the opportunity to ask questions in the middle of a lecture, (b) having printed course notes and the ability to replay lectures discouraged some students from taking notes, and (c) some students felt the more formal and more focused setting of a live lecture would have encouraged them to pay fuller attention to the lectures. In all, 59% of the students felt that the flipped classroom had a positive effect on their learning while 25% felt it did not make a difference.

Independent of Foertsch et al.’s (2002) survey was the student post-course evaluations (SPCE). The most relevant of the SPCE questions that related to the restructured course were: (a) the usefulness of the lectures, (b) the professor’s responsiveness to students, (c) whether students would recommend the course to others, and (d) whether students would recommend the professor to others. The increase in student ratings was shown to be statistically significant at the .01 level using a two-tailed t test. Foertsch et al. concluded that online applications such as eTEACH provide professors the opportunity to free up face-to-face time with their students to make better use of that time by having students apply what they already know to certain problems under the watchful eye and helpful tutelage of their professors. This provides students with a richer learning experience as pointed out in the end of course surveys.

Foertsch et al.’s (2002) study pointed out that students missed getting the chance to ask questions in the middle of a lecture. Although I was not always
available at exactly the same time students were watching the videos outside of class, I did keep online office hours where they were able to ask questions if they had them. These office hours were available to all students across all three instructional models. Foertsch et al. also reported that having printed course notes discouraged some students from taking notes. In contrast to the notes that Foertsch et al. used, the notes I used during the current study were incomplete. Students had to follow along with the video lecture filling in any missing information as it was presented. Students also had to complete the examples that were contained in the notes. Those notes were then brought to class and served as verification that the students fulfilled their out of class obligation to watch the lecture material.

*High school precalculus and calculus.* Fulton (2012) reported on the success of a flipped classroom at Byron High School (BHS). In 2009, the Byron School District near Rochester, Minnesota, did not have the funds to purchase new textbooks to align with the new state mathematics standards. To combat this lack of funding from their school district, BHS teachers decided to create textbook-free courses. In doing so, the teachers decided that the flipped classroom model would be the best approach to teaching their courses. Starting with the 2010–2011 school year, teachers created their own videos for their courses and uploaded the videos to *YouTube*. Students were allowed to access any teacher’s videos they wanted. Fulton reported that in doing this,
some like to watch a different teacher’s video lesson for review or to see a new angel for understanding a difficult concept. It gives the kids great freedom, and the teachers are benefiting…they learn new approaches for their own teaching when viewing each other’s videos. (p. 14)

At the end of the 1st year of using the flipped classroom model, Fulton reported that the percentage of students who scored 80% or above on unit assessments increased 9.8% in calculus and 6.1% in precalculus.

In addition to the increase in course proficiency, Fulton (2012) also reported that students’ mathematics scores on the Minnesota Comprehensive Assessment (MCA) increased from a mastery level of 29.9% in 2006 to 65.6% in 2010. In 2011, after implementing the flipped classroom model, mastery rose to 73.8%. Fulton did not provide any evidence that the flipped classroom model alone attributed to the gain in mastery levels from 2010 to 2011. She did report, though, that at the end of the 2011–2012 school year, 94.7% of Byron’s seniors completed four or more credits of mathematics, but she did not provide any plausible explanations for this finding.

Student feedback from the study included the following comments (p. 14):

(a) …when I do the homework in class, I can have help right away, which means I ask more questions.
(b) I liked this approach a lot because when we work on homework in class, [the teacher is] here to help us. Otherwise, I would be lost at home…

(c) I liked how I could rewind and pause lectures in case I didn’t understand something.

(d) I liked how we watched the concept at home, but then mastered the concept in class.

Parent feedback included the following comments (p. 16):

(a) The flipped classroom seems to be a much better use of the teacher’s time. It also is less frustrating for the student when they need extra help as the teacher is available during class time ending the necessity of going in before/after school to get needed help.

(b) Prior to the flipped classroom, we had to pay for a math tutor. Now our son is feeling more confident and hasn’t needed the tutor because he is able to get his questions answered on a daily basis.

(c) The flipped classroom approach is a great idea for a hands-on subject, like math. We believe it better utilizes the students’ and teachers’ classroom time…

Feedback provided by students and parents supports the constructivism theory driving the current study. In their feedback they report the flipped-classroom being ideal for students who need guidance from the teacher during hands-on
problem solving. In addition to the support for theory, Fulton (2012) made me aware that while the current study intends to use the videos that accompany the textbook, those videos were not the only videos students had access to. Fulton allowed students to view any videos they wanted. I was sensitive to this and asked students at the end of the semester if they use any videos other than the ones I provide because this would be a threat to external validity.

**Software engineering.** Gannod, Burge, Helmick (2008) used a software engineering course to restructure their instructional approach to accommodate the flipped classroom model. They felt that as an applied discipline, one that involves interacting with customers, collaborating with developers, and hands-on development of software, an active approach to learning in this course would be best for students. Their initial pilot for the flipped classroom was a course on service-oriented architecture (SOA) and web services. To flip this classroom, Gannod et al. created approximately 65 separate podcast episodes ranging in duration of just a few minutes to approximately 50 minutes for students to view outside of class. Gannod et al. also created 15 in-class activities and a semester project for students to work on during class. They reported that the results of an end of course survey showed that all students either strongly agreed or agreed that the use of the flipped classroom helped them in learning how to create C# applications that utilized web services. Gannod did not report any other data that related directly
to the flipped classroom. They did infer, though, that it appeared students’ perceptions of the flipped classroom were generally positive.

**Podcasts for learning calculus prerequisites.** Kay and Kletskin (2012) studied the use of podcasts as a resource for shoring up introductory calculus students’ prerequisite knowledge of precalculus concepts. In the context of their study, Kay and Kletskin defined podcasts as audiovisual files that are distributed in a digital format via the Internet using personal or mobile devices (McGarr, 2009). Although this was not directly related to the flipped classroom model, it did include the aspect of using technology outside the classroom to convey lecture material to students. Kay and Kletskin developed the podcasts to cover five content areas: operations with functions, solving equations, linear functions, exponential and logarithmic functions, and trigonometric functions. To access the podcasts students were sent an email link during the 1st week of class and were informed they could use the podcasts to brush up on their precalculus skills. They also were informed that they would be administered a diagnostic test during the 2nd week of class to assess their prerequisite knowledge. After they received their test results, students were asked to complete a 10- to 15-minute survey about their use and attitudes toward the podcasts.

Approximately two-thirds of the 288 students used the podcasts. Those who chose not to use them reported they believed they did not need a refresher or did not have time to view them. For those who did view the podcasts, 87% of the
students rated them as useful or very useful on the survey. Although Kay and Kletskin (2012) did not conduct a pre- and posttest analysis, they did include self-assessment questions on the survey for students to rate the impact the podcasts had on their understanding of the calculus material. Kay and Kletskin reported,

Correlations between self-reported use of video podcasts and self-reported changes in pre-calculus knowledge were positive and significant for all five pre-calculus concepts including basic functions ($r = .25, p < .001, n = 190$), solving equations ($r = .20, p < .01, n = 190$), linear functions ($r = .21, p < .005, n = 190$), exponential and logarithmic functions ($r = .24, p < .005, n = 190$), and trigonometric functions ($r = .20, p < .01, n = 190$). (p. 623)

Although Kay and Kletskin’s (2012) study did not address the flipped classroom, specifically, it did include information on the use of podcasts as the medium for delivering lectures outside of the traditional classroom. If podcasts are to be used within the flipped classroom model, this study has shown that students have a better chance of using them if they are easy to follow, contain high quality explanations, and can be viewed when needed. Unlike Kay and Kletskin, Pearson Education professionally produced the videos I used during the current study. Pearson’s instructional videos are developed and vetted similar to the way a textbook is before being published and are aligned directly the textbook.

**Statistics.** Strayer (2007) employed a mixed methods comparative study using two college-level introductory statistics courses to compare the flipped
classroom to the traditional classroom. His research took place at a U.S. university where a majority of the students are middle-class White Americans from the Midwest. Fifty of the 55 students contained within both sections (23 in the flipped classroom and 26 in the traditional classroom) volunteered to participate in the study. The participants were evenly split on gender with a majority of the participants in their 1st or 2nd year of study (14 in the flipped classroom and 21 in the traditional classroom).

Quantitative data were collected using the College and University Classroom Environment Inventory (CUCEI), which was developed by Fraser and Treagust (1986) to assess students’ actual and preferred perceptions of the learning environment. Strayer (2007) reported that the CUCEI has seven scales—personalization, innovation, student cohesion, task orientation, cooperation, individualization, and equity—with Cronbach alpha reliability coefficients ranging from .70 to .90. Qualitative data were collected using audio taped classroom sessions, individual and focus group interviews, field notes, and reflective journals.

Strayer (2007) used a repeated measure MANOVA to analyze the CUCEI data. He paired each student’s actual and preferred answers for each scale and used those scores as the within-subjects factors, with instructional method being the between-subjects factors. Strayer reported that the version of the CUCEI (actual or preferred) explained 64.2% of the overall variation and that the type of instructional method explained 44.5% of the overall variation in the data. Both of the reported
effects were significant for $p < .001$. Strayer also reported that the interaction between the version of CUCEI and instructional methods explained 32.5% of the overall variation, which was significant ($p = .02$).

Of the seven scales on the CUCEI, only cooperation, innovation, and task orientation were significant. With regards to cooperation, Strayer (2007) reported that a significantly greater number of students in the flipped classroom were more open to cooperation than those in the traditional classroom. With regards to innovation, the flipped classroom students again reported experiencing/preferring more innovation in the classroom even though at times they indicated they were frustrated by some of the learning activities. Strayer reported he used different activities throughout the semester, which left the flipped classroom students with inconsistencies in the types of assignments they were to complete. Students in the traditional classroom, though, had the same types of assignments all semester long. Students in both groups preferred similar levels of task orientation, however the flipped classroom students felt their actual classroom had significantly lower levels of task orientation than their counterparts. This was more than likely due to the confusion and frustration of the learning activities. Strayer addressed this in his recommendations:

Perhaps the flipped classroom is not the preferred design for an introductory course. Many students in an introductory course do not have a deep interest
in the subject and could be frustrated when they encounter learning tasks that aren’t clearly defined. (p. 191)

From Strayer’s (2007) study I learned that it would be in the best interests of the students if I were to use the same assignments for all groups. As previously indicated, students were confused and frustrated by Strayer’s use of different activities during the semester. Even though the assignments were the same, the location where they were completed was different. In addition to using the same assignments, students in the flipped model were encouraged to work together in pre-assigned groups. Strayer reported students in the flipped model were significantly more open to working in cooperative groups in the classroom. This supported the social constructivist theory driving this study.

**Geology.** Traphagan, Kucsera, and Kishi (2010) studied the impact class lecture webcast availability had on student attendance and learning. Webcasting refers to streaming audio or video broadcasts over the Web, requiring a connection to the Internet throughout the broadcast. The study was conceived through the notion that having accessible class lecture recordings excuses students from attending class. Previous studies by Hartley et al. (2003) and Brotherton and Abowd (2004) support this notion noting that 25% and 33% of students, respectively, believed that webcasts are a substitute replacement for attending lecture. Even though a majority of students did not feel this way and still preferred lectures over webcasts, Traphagan et al. pointed out that by a 2 to 1 ratio, lectures
are the type of class sessions students miss most often when compared to seminars, and by a 5 to 1 ratio when compared to workshops and laboratory sessions (Woodfield, Jessop, & McMillan, 2002). Traphagan et al. expanded on the previous research by determining if there were other mitigating factors besides the availability of webcasts that affected student attendance. The factors they targeted were GPA, gender, reason for taking the course, and access to other online resources.

Traphagan et al. (2010) implemented their study in fall 2005 at a large southwestern university. They applied a quasiexperimental design that involved 364 students taking a geology course, which was split between two sections. There were 153 students in the section that had access to the webcasts via Blackboard, and 211 students in the section that did not have access to the webcasts. Both sections were deemed statistically equivalent on all demographics except for GPA. Students’ mean GPA between sections was reported as being statistically significant with those in the no-webcast section having a higher GPA mean, $t(230) = 2.459, p < .05$.

Traphagan et al. (2010) collected data from two quizzes, a final exam, an end of course survey, and a counter built into Blackboard that monitored the use of the webcasts. To determine if there was a statistical difference in absence frequency between the two sections, Traphagan et al. analyzed the data via ANCOVA so they control for GPA. They reported that the mean difference in absence frequency
between the webcast section and the no-webcast section was statistically significant, \( F(1, 203) = 9.033, p < .01 \). They also reported a significant relationship between absences and webcast viewing, \( r = .40, p < .05 \).

Traphagan et al. (2010) conducted a multiple regression analysis to explore the relationship between the targeted factors of GPA, gender, reason for taking the course, access to other online resources, and webcast viewing frequency on students’ absence frequency. When students’ absence frequency was regressed on these factors, a statistically significant model emerged, \( R^2 = .617, F(5, 57) = 7.014, p < .001 \). Two of the five independent variables were statistically significant: webcast viewing frequency, \( t = 3.14, p = .003 \), and access to other online resources, \( t = 4.318, p = .000 \). The data suggested that the availability of webcasts and other resources negatively impacted attendance.

Traphagan et al. (2010) conducted a MANCOVA to determine if the availability of webcasts made any difference in student performance. When the differences in GPA were controlled for, Traphagan et al. reported there was no significant difference in performance between the two sections. This finding led them to surmise that even though absenteeism was significantly lower in the webcast section than the no-webcast section, in the presence of the available resources, webcasting seemed to nullify the absence effect on performance. With respect to the end of course survey, Traphagan et al. reported that 36% of the students indicated that they often or always used webcasts instead of attending
class, which was consistent with prior research. Traphagan et al. also reported that students’ strongly agreed or agreed that they skipped class because of the availability of the webcasts (71%) or other online resources (76%).

Traphagan et al.’s (2010) findings provide evidence that additional online resources (beyond webcasting) posted by an instructor could suppress class attendance further. In the flipped classroom it was important to ensure that students understood that (a) class attendance was mandatory and not optional, (b) the online material was taking place of the normal lecture material, and (c) the assignments that would have been completed out of class were completed inside of class. It also is important to note that Traphagan et al.’s study has shown that students will use online resources outside of class, which is key to the success of the flipped classroom model, and that performance is not affected regardless of where lecture material is received.

I incorporated Traphagan et al.’s (2010) recommendations from the previous paragraph into the flipped classroom. Attendance was taken by having students turn in their notes from the video they watched outside of class. If they did not have them they were marked absent just as if they missed a face-to-face lecture class. Taking attendance in this manner ensured that students understood the online videos are taking place of the normal lecture material and they are not optional; just like attending class was not optional.
Undergraduate architectural engineering. Within their engineering discipline, Zappe, Leicht, Messner, Litzinger, and Lee (2009) reported that instructors are encouraged to try instructional techniques that gear students to be active learners. To facilitate active learning, Zappe et al. determined a flipped classroom approach to learning would be a good start. To design their ideal setting they used one large undergraduate architectural engineering course entitled “Introduction to the Building Industry” during the spring 2008 semester with an enrollment of 95 students. The only demographic data given was that of the 95 students, approximately 80% were male and less than 10% represented the minority (no indication was given as to what minority meant). Zappe et al.’s research on the flipped classroom was driven by the need to better understand how students used video lectures and their perceptions of the flipped classroom. Zappe et al. decided to start small and use this approach on one of the three main topics in the course, cost estimate.

An initial concern Zappe et al. (2009) had about the flipped classroom was that students might not take the initiative to properly prepare for class by watching the videos, so they decided to administer short pre-class assessments to ensure students accessed the videos. They believed that these assessments would increase the likelihood of students watching the videos and would give the instructors a snapshot of what should be the focus of the in-class activities so they could address any misconceptions or lack of understanding with the material. Another concern
was technology issues: Would students have problems viewing the videos outside of class? Zappe et al. addressed this concern by implementing the flipped classroom concept in one class session prior to applying this model to the targeted unit of cost estimate. Following this “one class flip,” students were asked to write what they liked and/or disliked about the flipped class session.

Zappe et al. (2009) used the information from the writing assignment to create two follow-up surveys. They administered one following the sixth class session and the second at the end of the semester. The first survey was used to see how students utilized the online videos, what benefits students perceived they received from the flipped class, and whether students favored the flipped or traditional class setting. The second survey contained five subscales that measured students’ perceptions of (a) the effectiveness of the video content, (b) video viewing versus textbook reading, (c) online quizzes, (d) beginning-of-class review of online videos, and (d) using practicum time to work on group projects. Zappe et al. noted that no data were available for the reliability and validity of the instruments because they tailored the instruments for their study and therefore this was the first implementation of the instruments.

Despite some of the shortcomings of Zappe et al.’s (2009) study, there were several points of interest I found. First, Zappe et al. reported that 92% of the students indicated that they watched the videos at least one time before class. This more than likely had to do with the pre-class assessments students were required to
complete after viewing the videos. On the second survey only 33.8% of students responded that they would have viewed the videos had they not had to take a quiz on the material covered in the video. Second, students in Zappe et al.’s study reported they preferred videos of shorter length (between 20 to 30 minutes). The preference of shorter lectures leads me to believe that the flipped classroom could be a better setting for students with short attention spans. With the traditional classroom, students have no choice but to capture everything at once. Even if video lectures are longer than 20 to 30 minutes, viewing them outside of class gives students the ability to pause and come back later. Third, although Zappe et al. reported 74% of the students perceived that the flipped classroom was helpful in understanding concepts, a vast majority of the students also reported not wanting every class to be held in the flipped format. There was no reason reported as to why students felt this way. Finally, subsequent to administering the first survey, the instructor began including a review period at the beginning of each class because students reported feeling a little lost transitioning to the in-class activities. This finding was similar to what students reported in Traphagan et al. (2009). This review helped students connect the material covered in the videos with the in-class activities. Zappe et al. noted that this review should serve as a brief reminder of the course material and not a replication of all the information from the videos.

In the current study, I incorporated some of the lessons learned from Zappe et al.’s (2009) study by holding a brief review session at the beginning of class to
clear up any misconceptions that students might have had about the lecture material. Instead of giving pre-class quizzes to ensure that students watch the videos as Zappe et al. did, I collected the notes students took outside of class while watching the videos. Personally, I felt this was a better indicator of whether or not students watched the videos rather than giving a pre-class quiz.

**The flipped classroom in college algebra.** In addition to reviewing the published literature, I also conducted an exhaustive review of dissertations that focused on college algebra. The following is a presentation of three studies that involved the same course that was targeted in the current study.

*Jaster (2013).* Jaster examined college algebra students’ perceptions of and engagement in a flipped classroom as well as the effect a flipped classroom had on achievement. He presented three research questions (p. 5): (a) “What are students’ perceptions of an inverted college algebra classroom?” (b) “What is the relationship, if any, between perceived learning contributions of various elements (video viewing, note taking, and problem solving) of an inverted college algebra classroom and grade outcome?” and (c) “What is the relationship, if any, between levels of engagement with various elements (video viewing, note taking, and problem solving) of an inverted college algebra classroom and grade outcome?”

Jaster cited his accessible population as the 2,295 students at Texas State University enrolled in college algebra on the 12th day of class in fall 2012. The sample consisted of 82 students enrolled in the two sections of college algebra.
taught by Jaster. Population characteristics included ethnicity (as defined by the Texas Higher Education Coordinating Board), class (such as freshman), and gender.

To answer the first research question, Jaster (2013) analyzed each of the three sets of qualitative data. Each analysis resulted in a categorization of perceptions. In the essays, students described perceptions regarding outside-class activity, in-class activity, group work, effectiveness of the inverted format, their independence in learning, amount of work, efficiency, and overall preference for the inverted classroom format. In the transcribed conversations, students identified specific difficulties they perceived in solving the assigned problems. Jaster’s field notes provided indications of how important students perceived the inside- and outside-class activities. Jaster reported 57% of students felt the videos were impersonal, 54% of the students preferred the lecture based class to the flipped class, 48% of the students felt working with classmates or having instructor assistance was helpful, and 46% of the students felt it was helpful to play the video rather than attend lecture.

To answer the second research question, Jaster (2103) analyzed the data using a multiple regression strategy. The results provided strong evidence that perceived learning contributions of video viewing and note taking were associated with grade outcome. Perceived learning contributions explained 6.5% of the variance in grade outcome, $R^2 = .065$, $F(1, 63) = 4.371, p < .01$. Students who
perceived video viewing and note taking as making large learning contributions tended to have higher grade outcomes than students who had a contrary perception.

Jaster (2013) also used a multiple regression strategy to answer the third research question. Survey data, webpage access counts, and instructor evaluation of notes provided supporting evidence that levels of engagement with video viewing, note taking, and problem solving were associated with grade outcome, with levels of engagement explaining 49.9% of the variance in grade outcome, $R^2 = .499$, $F(4, 60) = 14.917$, $p < .001$. Students who had high levels of engagement with the three elements tended to have higher grade outcomes than students who had lower levels of engagement.

Jaster (2013) provided descriptive data and details to help promote generalizability. He also reported that researcher bias, participant observation, and the survey instrument were limitations to his study and therefore could influence the applicability or interpretation of the study’s results.

Several features of Jaster’s (2013) study helped inform the current study. Of these the first was Jaster’s use of note taking to track whether or not students watched the lecture videos outside of class. Unlike Jaster’s study, the videos I used during the current study did not provide any mechanism for determining who watched the videos. Having the students take notes and hand them in was synonymous to taking attendance in my traditionally taught sections. As a result, I employed this note-taking strategy. Second, I did not agree with Jaster’s posting of
the in-class assignments in advance so students could get an early start on the assignments. In traditional classes I lecture, then assign homework. Because the flipped classroom is the inverse of the traditional classroom, I believed homework should not have been assigned prior to the lecture and therefore I did not do so. Third, Jaster gave students extra credit for attendance. I felt as if this would have skewed the results of the research. Students were made aware of the colleges’ attendance policy. For the college’s attendance policy the reader is directed to the course syllabus in Appendix C. In the current study, I maintained student attendance records but did not incorporate student attendance into the study as a research factor.

**Ogden (2014).** Ogden’s study described the design and development of a flipped classroom model in college algebra relative to the model’s design decisions, implementation, and evaluation across three iterations of a college algebra course. The primary research question that guided her study was (p. 3): “How did the flipped classroom teaching model develop over three semesters of teaching college algebra?”

Ogden (2014) used a multiple case study approach to describe the design and development of the flipped classroom model. The first case study focused on Ogden’s first attempt and involved implementing a modified flipped classroom. She denoted this implementation as a modified model because she did not prepare videos for all sections ahead of time. In this first attempt at flipping the classroom,
Ogden taught the experimental group from a hybrid approach (part face-to-face, part online). She assigned videos as homework once or twice a week. In her second case study she used a more traditional flipped classroom model by assigning videos four to five times a week. In her third case study she went back to assigning videos once or twice a week. She did this because feedback from the second case study indicated students had trouble watching four to five videos a week.

Ogden (2014) defined the effectiveness of the flipped model by reporting class averages on unit exams, the final exam, and the percentage of students receiving a final course grade of “D,” “F,” or W (called the DFW rate). Comparing the DFW rates across the four cases, Ogden reported 52.5% (n = 40), 42.5% (n = 40), 30% (n = 40), and 10% (n = 40), respectively. Similarly, she reported final exam averages for each case as 69.5% (n = 30), 73.7% (n = 33), 78.1% (n = 34), and 79.9% (n = 37), respectively.

To measure the appeal and receive feedback on how the participants felt about the design of the course, Ogden (2014) designed/administered surveys and held meetings with the participants. The surveys and meetings were used to improve on the model in each subsequent case study. For example, as noted earlier, with respect to the frequency of video viewing at home, Ogden reported that students’ feedback led her to conclude that students could not watch more than one or two videos and complete all assignments for the week.
One of the ways Ogden’s (2014) study informed the current study is that in addition to using class time to have students work on homework, I also was able to use this time for group assignments. With the traditional classroom there is no time for group work while in class. When using class time for group work, Ogden suggested that students be placed into collaborative groups rather than letting them choose their groups to cut down on distractions and to better pair the abilities of students. In this regard, I used a pre-assessment to gauge the prerequisite knowledge of the students. This strategy of group assignments also is consistent with social constructivism as well as the concept of collective self-efficacy.

Secondly, flipping the classroom and having students work homework in class is only part of the process. Because class time is limited, it is important to craft the assignments so students can complete them during class. As the Ogden noted, having some assignments with 35 questions could present a problem. As an assignment is built in my math lab, the program gives an average time the instructor should expect students to finish said assignment. When I prepared the assignment for each section, I held in reserve the average time for completion to 50 minutes or less. Finally, as students watched the videos outside of class, they could have had questions about the material. I made sure to remind students after each class meeting that they could ask questions via email or my online office hours just as if they were doing regular homework.
Overmyer (2014). Overmyer examined the mathematical achievement differences between students in traditional college algebra classrooms and college algebra classes taught using the flipped classroom method. The research questions that guided his study (p. 14) were: (a) “Is there an overall difference in achievement between students in the traditional environment compared to students taught using the flipped classroom method?” (b) “Is there an interaction between gender and instructional method in regard to achievement?” and (c) “Is there an interaction between prior achievement in mathematics and instructional method in regard to achievement?” Overmyer conducted his study at Colorado State University and used a quasiexperimental design. He reported that the mean enrollment at the university was 12,000 students, which was his accessible population. This population was delimited to consist of only the students who enrolled in college algebra during the fall 2012 semester. From the delimited population the researcher drew a convenient sample that consisted of 301 students. The control group consisted of 165 students and the treatment group (flipped classroom model) had 136 students.

To answer the first research question, Overmyer (2014) conducted an independent samples t test. He reported that the control group’s mean final examination score was $M = 20.14$ ($SD = 5.101$) and the treatment group’s mean final examination score was $M = 21.27$ ($SD = 5.130$). The mean difference of 1.133, though, was not significant, $t(299) = 1.912, p = .057$. 

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To answer the second research question, Overmyer (2014) conducted a regression analysis that compared the final examination mean scores and gender. This analysis found no significant gender difference, $t(297) = 0.776$, $p = .439$. Overmyer also reported that the interaction between treatment and gender relative to final examination scores also was not significant, $t(297) = 0.655$, $p = .513$. Thus, male and female students did not respond differently to the flipped classroom with respect to their achievement in college algebra.

To answer the third research question, Overmyer (2014) used a multiple regression strategy. The analysis showed that students’ ACT scores were a statistically significant predictor of final examination scores with $p = .015$. There was no significant interaction, though, between ACT scores and the treatment with regard to final examination scores ($p = .084$). Thus, students did not respond differently to the flipped classroom based on their ACT mathematics scores.

Overmyer’s (2014) study informed the current study in several ways. First, Overmyer used several instructors across the control and treatment classes. He indicated that the different instructors had different policies relative to how they collected and assessed homework. This was true of both groups therefore there was no consistency in homework assignments or grading schemes. Overmyer also pointed out there was no consistency in the videos that the flipped classes used outside of class. To mitigate this implementation threat to internal validity, I was the sole instructor. Second, Overmyer observed that in the flipped classroom,
teachers must not only be a content expert, but an expert in classroom and facilitation management. It is important that they are able to transition from being a facilitator to a guide. My teaching background for the military helped me during the study, because most military classes are not taught via a didactic approach but more along the lines of group discussions. Finally, Overmyer did not find any significant gender effect, which was consistent with the findings of Traphagan et al. (2010) and Jaster (2013). Nevertheless, as noted in Chapters 1 and 3, I included gender along with student age and race/ethnicity as part of a students’ attribute set for group equivalency purposes. The inclusion of these variables also enabled me to examine possible interactions between student attributes and instructional model relative to achievement. The reader is directed to Chapter 4 for interaction results.

**Summary and Study Implications**

The studies reviewed in the previous section are not exhaustive but they are sufficient to demonstrate the extent to which the concept of the flipped classroom model has been studied and the factors associated with it. The literature, in conjunction with constructivist theory and Bandura’s (1997) self-efficacy theory, have guided me in determining what factors to target and the hypothesized relationships among these variables. For example, Research Question 1, which examined the relationship between group membership and student achievement, was based on the current study’s theoretical grounding, which suggests that students in the flipped classroom would have higher achievement than students in...
either of the other two instructional models. Research Question 2, which addressed student attributes was based on the findings of Overmyer (2014), Traphagan et al. (2010), and Jaster (2013), as noted in the previous section.

The past studies also have provided evidence to suggest that students’ perceptions of the flipped classroom model is beneficial to their learning because it provides them with the opportunity and convenience to view lectures on their own at a time and place that is convenient to them (Foertsch et al., 2002; Fulton, 2012; Jaster, 2013; Traphagan et al., 2009 or 2010; and Zappe et al., 2009). These findings were similar across several different disciplines including college algebra. As a result of these findings, I did not assess students’ perceptions of the flipped model but instead, as noted in Research Question 3, I assessed and compared students’ attitudes toward mathematics across the three targeted groups, and in Research Question 4, I sought to determine what interaction (if any) did group membership have with student attributes or with students’ affective domain, respectively, relative to student achievement.

Finally, the past studies helped inform the current study’s implementation strategies. These included: (a) the importance of using high quality instructional videos (Kay & Kletskin, 2012); (b) the importance of maintaining consistency for the in-class assignments (Strayer, 2007); (c) the need to emphasize to students that the online material supplants the in-class lecture (Traphagan et al., 2010), and that one strategy for facilitating “attendance” includes requiring students to take and
submit notes on the videos (Jaster, 2013); (d) keeping the videos between 20 minutes and 30 minutes long (Zappe et al., 2009); (e) having the researcher keep field notes for treatment verification and fidelity purposes (Jaster, 2013); and (f) allowing flipped classroom students to work collaboratively in groups (Ogden, 2014).
Chapter 3
Methodology

Population and Sample

Population. The target population for this study was all college students who took MAC 1105, college algebra, at a Florida state college that confers 2-year degrees. According to the Florida Department of Education (FLDOE), students attending a Florida state college AY 2013–14 had a mean age of 26 years old, 58% of the population was female, and the race/ethnicity enrollment percentages were as follows: White/Caucasian 44.83%, Hispanic 25.56%, Black 18%, unknown 4.82%, other 3.03%, and 1.84% as two or more races. The FLDOE defines other as American Indian, Alaskan Native, Asian, Native Hawaiian, or Pacific Islanders.

The target population was delimited to a smaller accessible population that consisted of students who enrolled in college algebra at Eastern Florida State College (EFSC) located in Brevard County. EFSC has four main campuses: Cocoa, Melbourne, Palm Bay, and Titusville, with online classes administered through eLearning. In fall 2015 EFSC had an annual enrollment of 15,052 students and employed 227 full-time faculty members, 38 of whom were mathematics teachers. As reported in Table 3.1, the overall mean age of EFSC students was 25 years old, 59.2% of the students were female, and the race/ethnicity enrollment percentages were as follows: White/Caucasian 67.9%, Black 12.5%, Hispanic 11.0%, Asian 2.5%, and other 6.0%.
Sample. From the accessible population, I used a convenience sampling strategy to select the sample from a database provided by the colleges’ Office of Institutional Effectiveness and Strategic Management. This database consisted of the 1,897 students who were enrolled in MAC 1105, College Algebra, for fall 2015. The final sample consisted of the $N = 149$ students who were enrolled in the six sections of intact classes of MAC 1105 that were assigned to me. These included four face-to-face sections from the Palm Bay campus, and two online sections from e-Learning. I purposively assigned the four face-to-face sections to either flipped or traditional so they met on different days and times. As shown in Table 3.2, the group assignments were counter-balanced so that the flipped groups met on Monday and Wednesday mornings or Tuesday and Thursday afternoons, whereas traditional groups met on Monday and Wednesday afternoons or Tuesday and
Thursday mornings. The collected sample sizes for the two flipped groups were \( n = 49 \), online groups \( n = 50 \), and traditional groups \( n = 50 \).

The sample characteristics, which were self-reported by participants in Section 4 of the multicomponent questionnaire, are summarized in Table 3.3. As reported in Table 3.3, the overall mean age was \( M = 25 \) years old and 59\% of the sample was female. With respect to race/ethnicity, 68\% were White/Caucasian, 11\% were Black, 12\% were Hispanic, 2.5\% were Asian, and 6\% were “Other.”

The reader will note that when the demographics of the sample are compared to the demographics of the accessible population in the last two columns of Table 3.3, the sample was representative of the accessible population in every category except for grade level: The sample had a higher percentage of juniors and seniors than the accessible population. In addition the sample was representative to the target population (reported in the first section of this chapter) relative to age and gender, but had a higher proportion of White/Caucasian students and lower proportions of Black and Hispanic students.

**Power analysis.** Post hoc power is the retrospective power of an observed effect based on the sample size and parameter estimates derived from a given data
set. According to Cohen, Cohen, West, and Aiken (2003, p. 92), “statistical power analysis is concerned with the special case of determining the probability that the sample value will be significantly different from some hypothesized value,
typically one of no effect such as a zero $R^2$. To compute the power of this study a computer program called G*Power along with Cohen et al.’s algorithm for calculating effect size was used. Power calculations are a function of the parameters $\alpha = .05$, the number of IVs, the calculated effect size (calculated using Model 1 error), and the overall sample size of $N = 117$. As reported in Table 3.4, separate power analyses were conducted from three different perspectives: (a) With respect to the overall model, power was greater than .99; (b) With respect to each set, power for Set A (Group Membership) was .74, power for Set B (Student Attributes) was .88, and power for Set C (Affective Domain) was .86; and with respect to any single research factor, power values ranged from .33 for $X_{12} =$ Ethnicity, .67 for $X_1 =$ Flipped vs. Combined Online and Traditional, .84 for $X_4 =$ Age, .95 for $X_9 =$ ATMI scores, and .96 for $X_{10} =$ MSES-R scores. As a result, 

<table>
<thead>
<tr>
<th>Sets of Variables*</th>
<th>No. of Variables</th>
<th>$\alpha$</th>
<th>$ES$</th>
<th>Approximate Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Model</td>
<td>5</td>
<td>.05</td>
<td>0.29</td>
<td>&gt; .99</td>
</tr>
<tr>
<td>A = Group Membership</td>
<td>1</td>
<td>.05</td>
<td>0.06</td>
<td>.74</td>
</tr>
<tr>
<td>B = Student Attributes</td>
<td>2</td>
<td>.05</td>
<td>0.11</td>
<td>.88</td>
</tr>
<tr>
<td>C = Affective Domain</td>
<td>2</td>
<td>.05</td>
<td>0.10</td>
<td>.86</td>
</tr>
<tr>
<td>Any single research factor</td>
<td>1</td>
<td>.05</td>
<td>.01 ≤ $ES$ ≤ .05</td>
<td>.33 ≤ power ≤ .96</td>
</tr>
</tbody>
</table>

Note. *Overall represents the five variables that correspond to the targeted factors, which were partitioned into three functional sets: Set A represented group membership and consisted of the dummy-coded variable, $X_1 =$ Flipped vs. Combined Online and Traditional. Set B represented student attributes and consisted of: the continuous variable $X_4 =$ Age, which was measured in years, and the dummy coded variable for ethnicity, $X_{12} =$ Other Race/Ethnic groups vs. White/Caucasian. Set C represented students’ affective domain and consisted of: the continuous variable, $X_9 =$ ATMI scores, which represented scores on Tapia and Marsh’s (2004) Attitudes toward Mathematics Inventory; and the continuous variable, $X_{10} =$ MSES-R scores, which represented scores on Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale Revised, which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale.
with the exception of a few individual variables, all power values were near (.74) or greater than Cohen et al.’s (2003) recommended minimum power of .8.

**Instrumentation**

There were four primary data collection instruments: a multicomponent student questionnaire, which contained the three affective domain instruments and a demographics section; a comprehensive final exam in Intermediate Algebra, which was used to assess students’ prerequisite knowledge; researcher-constructed unit exams, and a comprehensive final exam in MAC 1105. Table 3.5 provides a summary of the reliability of each instrument. A description of each instrument follows, and copies of the instruments are provided in Appendix A.

**Multicomponent student questionnaire.** The multicomponent student questionnaire consisted of four sections: Section 1, Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory; Section 2, Rotter’s (1966) Locus of Control Personality Test; Section 3, Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale Revised, which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale; and Section 4, a researcher-constructed student demographics questionnaire. The multicomponent questionnaire was administered online via EFSC’s Learning Management System (LMS), Canvas, over the weekend between the 1st and 2nd weeks of class after the add-drop period ended. A description of each section follows.
Table 3.5
Summary of Results of Reliability Statistics of Instruments

<table>
<thead>
<tr>
<th>Instrumenta</th>
<th>Number of Items</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>From Literature</th>
<th>From Study Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATMI</td>
<td>40</td>
<td>149</td>
<td>134.15</td>
<td>31.82</td>
<td>.97</td>
<td>.97</td>
</tr>
<tr>
<td>Self-Confidence</td>
<td>15</td>
<td>149</td>
<td>48.95</td>
<td>14.89</td>
<td>.88</td>
<td>.96</td>
</tr>
<tr>
<td>Value</td>
<td>10</td>
<td>149</td>
<td>37.99</td>
<td>7.13</td>
<td>.70</td>
<td>.90</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>10</td>
<td>149</td>
<td>32.13</td>
<td>8.62</td>
<td>.84</td>
<td>.91</td>
</tr>
<tr>
<td>Motivation</td>
<td>5</td>
<td>149</td>
<td>15.08</td>
<td>4.72</td>
<td>.78</td>
<td>.87</td>
</tr>
<tr>
<td>LCPT</td>
<td>23</td>
<td>149</td>
<td>10.13</td>
<td>3.68</td>
<td>—</td>
<td>.69</td>
</tr>
<tr>
<td>MSES-R Problems</td>
<td>52</td>
<td>149</td>
<td>187.37</td>
<td>32.63</td>
<td>.95</td>
<td>.96</td>
</tr>
<tr>
<td>Tasks</td>
<td>18</td>
<td>149</td>
<td>69.18</td>
<td>12.51</td>
<td>.91</td>
<td>.93</td>
</tr>
<tr>
<td>Courses</td>
<td>16</td>
<td>149</td>
<td>51.19</td>
<td>12.11</td>
<td>.91</td>
<td>.92</td>
</tr>
<tr>
<td>TPRS</td>
<td>17</td>
<td>149</td>
<td>9.05</td>
<td>3.12</td>
<td>.75 &amp; .70</td>
<td>.57 / .63c</td>
</tr>
<tr>
<td>Unit 1 Exam</td>
<td>20</td>
<td>137</td>
<td>16.19</td>
<td>3.28</td>
<td>—</td>
<td>.77</td>
</tr>
<tr>
<td>Unit 2 Exam</td>
<td>20</td>
<td>134</td>
<td>10.74</td>
<td>3.93</td>
<td>—</td>
<td>.74</td>
</tr>
<tr>
<td>Unit 3 Exam</td>
<td>20</td>
<td>123</td>
<td>13.32</td>
<td>4.08</td>
<td>—</td>
<td>.79</td>
</tr>
<tr>
<td>Final Exam</td>
<td>25</td>
<td>122</td>
<td>18.58</td>
<td>4.43</td>
<td>.76</td>
<td>.78 / .80a</td>
</tr>
</tbody>
</table>

Note. aATMI = Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory, which used a Likert-scale of 1 = Strongly Disagree to 5 = Strongly Agree. Attitude scores could range from 40 to 200 with higher scores reflecting more positive attitudes. The ATMI has four subscales, or dimensions: Self-Confidence (SC) corresponded to Statements 9–22, 40, and scores could range from 15 to 75; Value (V) corresponded to Statements 1, 2, 4–8, 35, 36, 39, and scores could range from 10 to 50; Enjoyment (E) corresponded to Statements 3, 24–27, 29–31, 37–38, and scores could range from 10 to 50; and Motivation (M) corresponded to Statements 23, 28, 32–34, and scores could range from 5 to 25. LCPT = Rotter’s (1966) Locus of Control Personality Test, which consisted of 29 items—6 of which were filler items and not scored—measured on a Forced Choice scale. Overall scores could range from 0 to 23 with higher scores indicating an orientation toward an external locus of control. MSES-R = Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale Revised, which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale. The MSES-R used a Likert-type scale of 1 = Not At All Confident to 5 = Completely Confident. Overall scores could range from 52 to 260, with higher scores reflecting higher mathematics self-efficacy. The MSES-R has three subscales: Mathematics performance (Problems) assessed students’ perceived confidence to correctly solve mathematics problems (n = 18), and scores could range from 18–90; Everyday math tasks (Tasks) assessed students’ perceived confidence to perform certain mathematics related tasks (n = 18). Scores could range from 18–90; and Math courses (Courses) assessed students’ confidence to earn an A or B in certain mathematics related courses (n = 16), and scores could range from 16–80. Researcher-constructed unit exams were used as formative assessments of students’ college algebra achievement. TPRS = Test of Prerequisite Skills from Lake (2008) and Odu (2008), which consisted of 17 dichotomously scored multiple-choice items designed to assess students level of prerequisite knowledge in intermediate algebra. Three weighted unit exams were given at the end of a specific set of course work and instructional time throughout the semester. Each exam consisted of 20 dichotomously scored multiple-choice questions. The final exam was developed by Lake (2008) and consisted of 25 dichotomously scored multiple-choice questions; scores could range from 0 to 17. aAll reliability coefficients were based on Cronbach’s alpha except for the TPRS and final exam. KR-21 reliability coefficients were reported for these two instruments to make a meaningful comparison with the reported KR-21 values from the literature. aThe first coefficient represents KR-21 and the second represents Cronbach’s alpha.
**Section 1: Attitudes toward mathematics inventory (ATMI).** Developed by Tapia and Marsh (1996), the ATMI consists of 40 items measured on a 5-point Likert scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree. The 40 items also are partitioned into four subscales: self-confidence (SC), value (V), enjoyment (E), and motivation (M). Two sample items are: “I have a lot of self-confidence when it comes to mathematics” and “Mathematics is a very worthwhile and necessary subject.” Aggregate scores could range from 40 to 200, with higher scores indicating a more favorable attitude toward mathematics. The ATMI has an overall Cronbach alpha of .97 based on an initial sample size of 545. A follow-up administration involving 64 of these students had a test-retest coefficient of .89 for the overall inventory. Coefficient alphas for the respective subscales were .88 (SC), .70 (V), .84 (E), and .78 (M), which suggests that scores are stable over time. As reported in Table 3.5, data collected from the administration of the ATMI in the current study yielded an overall Cronbach alpha of .97, and corresponding alphas for each of the subscales were .96 (SC), .90 (V), .91 (E), and .87 (M). A summary of the descriptive statistics related to the ATMI based on sample data is reported in Chapter 4 (see Tables 4.2–4.4).

**Section 2: Locus of control personality test (LCPT).** Developed by Rotter (1966), the LCPT consists of 29 items of which 6 are filler items and not scored. Each item consists of two statements (a and b) and participants are to select the one
they agree with more and that honestly reflects how they really think, feel, and act in general. A sample item follows:

9. a. I have often found that what is going to happen will happen.

b. Trusting to fate has never turned out as well for me as making a decision to take a definite course of action.

Participants receive a score ranging from 0 to 23, with scores closer to zero indicating an internal locus of control and scores closer to 23 indicate an external locus of control. Rotter reported that “Kuder-Richardson reliabilities are also somewhat limited since this is a forced-choice scale in which an attempt is made to balance alternatives so that probabilities of endorsement of either alternative do not include the more extreme splits” (p. 10). He later reported that an item analysis and factor analysis showed reasonably high internal consistency for an additive scale.

As reported in Table 3.5, data collected from the administration of the LCPT in the current study yielded a Cronbach alpha of .69. A summary of the descriptive statistics related to the LCPT based on sample data is reported in Chapter 4 (see Tables 4.5 and 4.6).

Section 3: Mathematics self-efficacy scale-revised (MSES-R). Originally developed by Betz and Hackett (1983), the MSES was designed to measure undergraduate students’ perceived beliefs about their ability to perform math-related tasks and behaviors. The MSES consists of 52 items partitioned into three subscales: mathematics performance (Problems), which assesses students’
perceived confidence to correctly solve mathematics problems \((n = 18)\); *everyday math tasks (Tasks)*, which assesses students’ perceived confidence to perform certain mathematics related tasks \((n = 18)\); and *math courses (Courses)*, which assesses students’ confidence to earn an A or B in certain mathematics related courses \((n = 16)\). An example of a Problem item is, “Suppose you were asked to solve the problem ‘If \(y = 9 + (x/5)\), find \(x\) when \(y = 10\), how confident would you be to select the right answer if the problem were presented in a multiple choice form?’” An example of a Task item is, “How confident are you to successfully add two large numbers (e.g., 5379 + 62543) in your head?” An example of a Course item is, “How confident are you that you could complete a course in statistics with a final grade of A or B?” All items initially were measured on a 10-point scale partitioned into five groups (scores in parentheses): No Confidence at All (0), Very Little Confidence (1, 2, 3), Some Confidence (4, 5), Much Confidence (6, 7), and Complete Confidence (8, 9).

Pajares and Miller (1995) revised the original MSES (denoted MSES-R) in two ways. Whereas Betz and Hackett (1983) used one of Dowling’s (1978) preliminary scales for their Problems subscale, Pajares and Miller replaced this subscale with one of Dowling’s final forms. Pajares and Miller also changed Betz and Hackett’s 10-point scale to a 5-point Likert-type scale ranging from 1 = Not At All Confident to 5 = Completely Confident. Thus, overall scores could range from 52 to 260, with higher scores reflecting higher mathematics self-efficacy. Using the
MSES-R with a 5-point Likert scale in a study involving 520 undergraduates, Langenfeld and Pajares (1993) reported that the MSES-R suffered no loss of internal consistency with Cronbach alphas of .91 for Problems, .94 for Tasks, and .91 for Courses. In a subsequent study involving 391 undergraduates, Pajares and Miller reported Cronbach alphas of .90 for Problems, .91 for Tasks, and .92 Courses. Kranzler and Pajares (1997) also reported similar reliability coefficients for the three subscales (.91, .94, and .91, respectively), and an alpha of .95 for the full instrument based on a sample of 522 undergraduates from three different colleges. As reported in Table 3.5, data collected from the administration of the MSES-R in the current study yielded a Cronbach alpha of .96. A summary of the descriptive statistics related to the MSES-R based on sample data is reported in Chapter 4 (see Tables 4.7–4.9).

Section 4: Demographic information. In the demographics section, students were asked to self-report their gender, age, and race/ethnicity. I also asked students to self-report their grade-level status, the number of hours they currently work per week outside of college, the number of mathematics courses they took in high school, the number of mathematics courses they completed in college, and their college major. This information is reported from a descriptive statistics perspective at the beginning of this chapter to more fully inform the reader about sample demographics. It was also used to confirm group equivalency.
Mathematical knowledge assessments. Several researcher-constructed instruments were used to assess students’ mathematical knowledge. These included a test of prerequisite skills, unit exams, and a comprehensive final exam. A copy of all assessments are provided in Appendix A. A description of each assessment follows.

Test of prerequisite skills (TPRS). To assess students’ prerequisite skills for group equivalency purposes, I administered the same TPRS instrument used by Lake (2008) and Odu (2008), which consisted of 17 dichotomously scored multiple-choice items. Both Lake and Odu reported content validity was confirmed by a cadre of mathematics teachers at EFSC who compared the test items to the prerequisites of the targeted course, MAC 1105. Lake and Odu also reported Kuder-Richardson (KR-21) reliability coefficients of .75 ($N = 196$) and .70 ($N = 166$), respectively. The TPRS was administered via EFSC’s LMS over the weekend between the 1st and 2nd weeks of class after the add-drop period had ended. As reported in Table 3.5, data collected from the administration of the TPRS in the current study yielded a lower KR-21 of .57. Cronbach’s alpha was also computed and yielded .63. A summary of the descriptive statistics related to the TPRS based on sample data is reported in Chapter 4 (see Table 4.10).

Unit exams. Unit exams were used as a formative assessment of students’ college algebra achievement. Three unit exams were administered at the end of a specific set of course work and instructional time throughout the semester. The
Each unit exam served as an assessment of current college algebra knowledge at different stages of the course. In this context, each preceding unit exam effectively was a pre-assessment for each succeeding unit of material. Questions on these exams were selected from corresponding homework assignments and consisted of 20 dichotomously scored multiple-choice questions from all levels of Bloom’s (1956) taxonomy. Students had 1 hour and 20 minutes to complete each unit exam; I was the sole grader of all unit exams. As reported in Table 3.5, data collected from the administration of the three unit exams yielded Cronbach alphas of .77, .74, and .79 respectively. A summary of the descriptive statistics related to the unit exams is reported in Chapter 4 (see Table 4.17).

**Comprehensive final exam.** Student achievement was assessed by Lake’s (2008) college algebra comprehensive final exam. Initially based on Moore (2002), this instrument underwent an extensive revision cycle by several EFSC mathematics instructors for content validity purposes. The final instrument

<table>
<thead>
<tr>
<th>Unit</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Absolute Value, Rectangular Coordinates and Graphs, Circles, Functions, Linear Functions, Equations of Lines, Graphs of Basic Functions</td>
</tr>
<tr>
<td>2</td>
<td>Graphing Techniques, Function Operations and Composition, Quadratic Functions and Models, Polynomial Functions, Rational Functions, Inverse Functions</td>
</tr>
<tr>
<td>3</td>
<td>Exponential Functions, Logarithmic Functions, Evaluating Logarithms and Change-of-Base Theorem, Exponential and Logarithmic Equations, Systems of Linear Equations, Non-linear Systems of Equations, Systems of Inequalities</td>
</tr>
</tbody>
</table>
consisted of 25 dichotomously scored multiple-choice items. Lake reported a KR-21 reliability coefficient of .76 ($N = 192$). The instrument was administered during the last week of the semester on a day and time dictated by the college final exam schedule. This final exam schedule, as it applied to the flipped and traditional groups, is provided in Table 3.7. The students in the online group were administered the final exam on an individual basis on a day and time of their choosing. Students had 2 hours to complete the final exam. The problems and tasks sections of the MSES-R was appended to the final exam and students also were required to complete this instrument on a post-hoc basis as part of the final exam. As reported in Table 3.5, data collected from the administration of the final exam in the current study yielded a KR-21 reliability coefficient of .75 ($N = 192$) and a Cronbach alpha of .80. A summary of the descriptive statistics related to the final exam and a comparison between the a priori and post-hoc scores of the MSES-R are given in Chapter 4 (see Tables 4.11 and 4.12).

<table>
<thead>
<tr>
<th>Day of Final Exam</th>
<th>Time of Final Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:10 A.M.–12:10 P.M.</td>
<td>1:00 P.M.–3:00 P.M.</td>
</tr>
<tr>
<td>Monday</td>
<td>Flipped Group (M/W 10:50 A.M.)</td>
</tr>
<tr>
<td>Tuesday</td>
<td>Traditional Group (T/R 10:50 A.M.)</td>
</tr>
</tbody>
</table>

*Note. M/W = Monday/Wednesday, T/R = Tuesday/Thursday.*
Course Description/Instructional Model

MAC 1105 is a 3-credit-hour, 48-contact hour-course. It satisfies three of the six required mathematics credits students must earn to attain their associates in arts degree from a Florida college. The corresponding catalog description follows:

Prerequisite: MAT 1033 with a grade of “C” or higher or appropriate placement test scores. Meets Gordon Rule and General Education requirements. Prepares the student for precalculus, statistics, essentials of calculus, and other related disciplines. Includes functions and function notation; domain, range, and graphs of functions and relations; operations on functions; inverse functions; linear, quadratic, rational, radical, exponential and logarithmic equations and functions; piecewise and higher degree monomial functions; systems of equations and inequalities; applications. The course learning outcomes are listed in Appendix C.

(“MAC 1105 – College Algebra,” 2015)

The current college-wide adopted textbook for MAC 1105 is Essentials of College Algebra, 11th edition, by Lial, Hornsby, Schneider, and Daniels (2014). The chapters and sections covered in the textbook are provided in Appendix C.

As noted in Chapter 1, three types of instructional models were used in this study: flipped, online, and traditional. In the flipped classroom students met in a face-to-face setting and the class followed a flipped protocol: (a) students accessed and watched an instructional video outside of class (with students taking notes as
the lesson was being viewed) that was related to the present lesson, (b) students completed and reviewed the corresponding homework on the lesson during class under the guidance of the instructor and/or peers, and (c) a new instructional video was assigned to be watched outside of class before the next class session. In the online classroom all lectures were watched via video outside of class rather than receiving a face-to-face lecture, and homework also was completed outside of class. In the traditional classroom students met in a face-to-face setting and the class followed a traditional protocol: (a) homework from the previous class session was reviewed, (b) a new lesson was presented, and (c) homework on the new lesson was assigned and was to be completed outside of class. Students in the flipped and online classes were given preprinted notes (the same preprinted notes as the traditional class students were given) to use while viewing the instructional videos. Students accessed the instructional videos through MyMathLab’s multimedia library. Videos were assigned by instructional model, which meant that the traditional class students were restricted from accessing the videos.

For homework assignments, students used MyMathLab, which is part of a computer-based learning management system developed by Pearson Higher Education and accompanies the textbook. The core features of MyMathLab pertinent to the study include: (a) a homework and test manager module that enables instructors to create, import, and manage online homework assignments, quizzes, and tests that are automatically graded; and (b) comprehensive online
course content, which provides a wealth of content aligned to the textbook that instructors can be add to, remove from, or modify existing instructional material. Instructors also can add their own course materials to suit the needs of their students or department, but this was not done in the current study.

Procedures

**Research methodology/design.** This study employed a quasiexperimental methodology, with a modified between-groups, pretest-posttest design involving intact classes. As noted earlier in this chapter, the sample consisted of students in six intact sections (four face-to-face and two online) of MAC 1105 during the 16-week fall 2015 semester taught at EFSC. The face-to-face sections were from the Palm Bay campus, and the online sections were from the eLearning campus. Table 3.2 shows how the face-to-face sections were grouped. This research design was appropriate because I examined the effect of group membership (flipped, online, and traditional instructional models) on a dependent measure (mathematics achievement). Although I did not administer pre- and posttests in the manner specified by the design, I applied the concept and intent of a pretest-posttest design by administering a prerequisites skills instrument as a pre-assessment to demonstrate group equivalency prior to the implementation of the treatment as well as to mitigate the selection threat to internal validity. It is important to note that no actual treatment was administered in the conventional sense of an experiment. Instead, the “treatment” during the study refers to group membership, which
denotes the manner in which MAC 1105 was taught: flipped online, or traditional. It also is important to reemphasize that the targeted classes were not selected randomly.

**Human subjects research.** To be compliant with research projects involving human subjects at Florida Institute of Technology (FIT) and EFSC, I submitted an application to both FIT’s and ESFC’s respective Institutional Review Boards. Copies of these applications are provided in Appendix B. As noted in the IRB applications, the study was to be conducted in an educational setting and under normal teaching conditions. There were no known physical or mental risks to students during or after the study. I was the sole data collector who stored the data in a secure location. The data were accessible only to my major advisor and me. Participants were identified by their student identification number and not by name during the study. After the study was completed the student identification numbers were replaced with a single number for future data verification.

**Study implementation.** The study was implemented during the 16-week fall 2015 semester at EFSC. The four face-to-face sections met for two 75-minute class sessions each week. Each model (flipped, online, and traditional) consisted of two sections (see Table 3.2 for the class schedules for the flipped and traditional groups). I was the sole implementer for all six sections and used EFSC’s learning management system (LMS), Canvas.
**Flipped classroom model.** A computer equipped classroom (or computer lab) was used for the flipped classroom and consisted of computer tables arranged in four rows with two desktop computers per table. The tables were designed with an attached lower shelf in front of the table for the computer monitor to be positioned below eye level so that it does not interfere with students’ line of sight to the front of the classroom. The shelf is large enough to accommodate the keyboard and mouse so that students had the same amount of workspace as students in the traditional classroom (this was important for days when assessments were administered). On the right side of the classroom were three whiteboards and at the front was the instructor workstation consisting of a computer, document camera, and digital projector. The first day of class consisted of an overview of what students were to expect during the semester, an introduction to *MyMathLab*, and a lecture on Section 1.8 (Absolute Value). Included in the overview was a summary of the electronic syllabus contained in Canvas outlining all policy and procedures for the course (a copy of the course syllabus is provided in Appendix C). Prior to beginning the lecture portion of the first class session I informed students about the research study and the prerequisite skills instrument and the multicomponent questionnaire that would be administered online via Canvas over the weekend. I told the students that both instruments needed to be completed by Sunday night at 11:59 P.M. The remaining class sessions during the semester followed a different protocol. To monitor attendance, students were required to take notes on the lecture
material they viewed outside of class. These notes were then checked the following class session. If students did not have them completed they were marked absent for that lecture just as if they did not attend an in-class lecture via the traditional model. After checking each student's notes, I used on average 5–15 minutes at the beginning of each class to review the material they should have covered prior to attending class. When the review period was completed, students logged into the computers and began working on the assigned homework for the remainder of the class. While students were working, I circulated throughout the room to ensure all students were on task and not having any issues with the lesson. I would randomly check with students to see if they had any problems with the assignments and periodically devoted extended one-on-one sessions with students who were having the most difficulty with the assignments.

All class sessions followed a prescribed timeline found on the last page of the syllabus. All class sessions except the first class session followed the standard protocols of the flipped classroom: course material viewed outside of class followed by homework completed during face-to-face class time. Homework assignments were designed so that they could be completed in one class session. However, to be consistent with the other models all weekly homework assignments were due on Sunday night at 11:59 P.M. All unit exams were administered in class on the days identified on the syllabus during class time. The date and time the comprehensive final exam was administered is given in Table 3.7.
Online classroom model. EFSC’s LMS (Canvas) was the virtual classroom for the online classroom. First day of class activities mirrored that of the flipped classes except students were sent the information given to the flipped group via email and the lecture was provided as a video recording. The remaining class sessions during the semester followed a different protocol than the other models. Attendance was monitored via student activity in MyMathLab. Students were required to view the section material and work the corresponding homework assignments on at least 2 different days during the week (defined as Monday through Sunday). Similar to the other two models, students could receive up to two absences each week. This was determined by the number of days they were active in MyMathLab and the number of assignments they completed. A summary of the criteria used for absences is provided in Table 3.8.

All class sessions followed a prescribed timeline found on the last page of the syllabus (a copy of the course syllabus is provided in Appendix C). Unlike the traditional and flipped models, though, students were not required to view the course material and complete their homework on any specific day during the week.

<table>
<thead>
<tr>
<th>Number of Absences</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Student was not active in MyMathLab on any day during the week.</td>
</tr>
<tr>
<td>1</td>
<td>Student was active in MyMathLab only once during the week.</td>
</tr>
<tr>
<td>0</td>
<td>Student was active in MyMathLab a minimum of 2 days during the week.</td>
</tr>
</tbody>
</table>
Students were given the flexibility to complete their assignments at any time that was convenient to their schedule. All weekly homework assignments were due on Sunday night at 11:59 P.M. All unit exams and the comprehensive final exam were administered (a) at any of Eastern Florida State College’s (EFSC) five testing labs, (b) through Proctor-U (an online test proctoring service), or (c) with an instructor-approved outside proctor. Commensurate with the eLearning testing polices, students were given 1 week (specified on the syllabus) to complete all unit exams and the comprehensive final exam. Students also were given the flexibility to decide the location, day, and time to take their exams.

**Traditional classroom model.** The traditional classroom consisted of tables arranged in four rows with two students seated at each table. At the front of the classroom were three whiteboards and an instructor workstation consisting of a computer, document camera, and digital projector. First day of class activities mirrored that of the flipped classes and consisted of an overview of what students were to expect during the semester, an introduction to *MyMathLab*, and a lecture on Section 1.8 (Absolute Value). Included in the overview was a summary of the electronic syllabus contained in Canvas outlining all policy and procedures for the course (a copy of the course syllabus is provided in Appendix C). Prior to beginning the lecture portion of the first class session I informed students about the research study and the prerequisite skills instrument and the multicomponent questionnaire that would be administered online via Canvas over the weekend. I
told the students that both instruments needed to be completed by Sunday night at 11:59 P.M.

All class sessions followed the standard protocols of didactic instruction: students attended face-to-face lectures and completed assigned homework outside of class. All weekly homework assignments were due Sunday night at 11:59 P.M. All unit exams were administered in class on the days identified on the syllabus during class time. The date and time the comprehensive final exam was administered is given in Table 3.7.

**Threats to internal validity.** Internal validity is the extent to which changes in a dependent variable (DV) are related directly to the targeted independent variables (IVs). In the context of the current study, the primary targeted IVs were the group membership variables, which represent the three instructional models of flipped, online, and traditional, and the DV was student achievement. If anything other than the targeted variables could have accounted for or explained student achievement, then these alternative explanations are referred to as threats to internal validity. Thus, it is incumbent for a researcher to control for threats to internal validity. Building on Campbell and Stanley (1963) and Cook and Campbell (1979), Ary, Jacobs, and Sorensen (2010) identified 12 threats to internal validity. A discussion of these threats follows, including their definitions, a description of how they could have impacted the current study, and how I controlled for or mitigated these threats.
**History.** A history threat is defined as any unforeseen event(s) that emerges during a study that could influence the DV. These include but are not limited to major political, economic, or cultural events that happen while the study is being implemented. For example, if the college administration implemented a new STEM (science, technology, engineering, and mathematics) student initiative during fall 2015 that provided free learning resources for improving students’ mathematics skills, then this new initiative could serve as an alternative explanation to the results. Fortunately there were no external events during the course of the study that could have impacted the results of the study.

**Maturation.** Maturation refers to any biological or psychological changes participants might experience over time. Examples include but are not limited to age, wisdom, experience, and motivation, all of which can lead to different outcomes on the DV (Ary et al., 2010). This was not a serious threat to the proposed study because my sample consisted of adults and took place over 16 weeks, which is not a lengthy time period for maturation to take effect. Nevertheless, it is still conceivable that some participants’ final exam scores could be explained by age or a change in attitudes toward mathematics as a result of their group membership. To control for this threat, I collected data on participants’ age and attitudes toward mathematics, and examined them for any possible interactions between group membership and students’ demographics and affective domain.
relative to achievement. Results of the analysis of these possible interactions are reported in Chapter 4.

**Testing.** A testing threat refers to situations in which participants are administered a pretest prior to treatment and then administered the same test a second time as a post-assessment after treatment. When this occurs it is possible that participants would know what is expected of them on the post-assessment because of their prior exposure to the items on the pre-assessment and therefore they could properly prepare themselves independent of the treatment. As a result, Ary et al. (2010) recommended administering a pre-assessment only when necessary. In the context of the current study, although students were administered a pre- and posttest, the two instruments were not the same. The pretest was designed to assess students’ prerequisite knowledge of the skills and concepts needed to be successful in college algebra whereas the posttest was designed to assess students’ accrued knowledge of college algebra skills and understanding of corresponding concepts. The pretest also was used to confirm group equivalency. As a result, the testing threat was not applicable to the current study.

**Instrumentation.** An instrumentation threat refers to any changes in how the dependent variable is measured from one assessment to another. “Changes may involve the type of measuring instrument, the difficulty level, the scorers, the way the tests are administered, using different observers for pre- and postmeasures, and so on” (Ary et al., 2010, p. 275). If any changes are made to the instrument or its
administration during the course of a study, then it is possible for these changes to impact the outcome because it would be difficult to determine if the observed outcome was a result of treatment or a result of changes to instrument. As an example, consider the situation where unit exams in college algebra are open-ended so that students could show all their work in solving problems and be awarded partial credit for their responses. If students are then administered a comprehensive final exam that consists of dichotomously scored multiple-choice items with no partial credit being awarded, then an instrumentation threat is possible. A similar situation would exist if the final exam were similar in structure to the unit exams but a different person graded the final exam than the person who graded the unit exams. An instrumentation threat was applicable to the current study and controlled as follows: (a) All assessments were structured in exactly the same manner and consisted of dichotomously scored multiple-choice items; (b) I was the sole person who administered all assessments to all students in the flipped and traditional groups; this was not possible for the online group. Students in the online group had their assessments administered by a proctor (there were no anomalies reported by any of the proctors during the testing process); and (c) I followed the same protocols for the administration of all assessments so that students in all groups received exactly the same instructions prior to being administered the assessments. Each student received a copy of the exam, a Scantron, and a Texas Instruments TI-30XIIS calculator (for those who wanted to use one). I then informed them to make
sure to read the test instructions on the first page and that they may begin when ready.

**Statistical regression.** A statistical regression threat is defined as the tendency for participants who score extremely high or extremely low on a pre-assessment to score closer to the mean on a post-assessment. In other words, it is the statistical phenomenon in which extreme scores tend to move toward the common mean on subsequent measures. For example, if I were to select only students who scored in the 1st quartile on the college algebra prerequisite skills test to participate in this study, then it is possible that these students’ final exam scores would be closer to the overall mean independent of treatment. Because I did not focus on any subgroup(s), this threat was not applicable to the current study.

**Selection.** The selection threat refers to situations when the selection of a sample results in participants who are different relative to key characteristics that could influence the DV prior to treatment implementation. For example, in the context of the current study, consider the situation where students in the flipped classroom are older, more intelligent, and have a more positive attitude toward mathematics than students in either the traditional or online groups. As a result, it is possible that the flipped classroom model might yield higher student achievement, not because of the instructional approach, but because of the selection threat. Because I used intact classes, the selection threat was applicable to the current study. To control for this threat I collected data on key student attributes that the
literature has shown to possibly influence achievement. These included gender, age, race/ethnicity, grade-level, hours working per week, number of mathematics courses taken in high school and college, college major, and students’ prerequisite knowledge. I used these variables to demonstrate group equivalency, thus this threat was mitigated.

Experimental mortality (attrition). Experimental mortality (attrition) refers to the differential loss of participants during the course of a study. This loss of participants has the potential to change the characteristics of the sample, which in turn could impact the outcome of a study. For example, by EFSC policy students in the current study had until the end of the 10th week of classes to withdraw from the course without any penalty to their academic standing. If several of the lowest performing students in the flipped group were to withdraw from the course throughout the semester, the remaining participants in the flipped group would have a higher final exam mean because of the absence of the lower performing students. In addition to biased results, a loss of participants also could lead to limited generalizability because group makeup has changed, and a possible reduction in statistical power because sample size could be lower than the required minimum. In the current study, the mortality threat was applicable because the attrition rate of MAC 1105 in the previous three fall semesters (fall 2012, 2013, and 2014) was 15.4%, 10.7%, 15.4%, respectively.
To help control for this threat I (a) tried to acquire more students than the minimum required amount reflected from an a priori power analysis, (b) began data collection after the add-drop period, and (c) encouraged students not to withdraw from the course. Despite all my efforts to minimize attrition, 27 students (18.1%) ended up dropping the course. Although this generally is not considered a large loss (e.g., > 20%), I included a comparison between the final sample and the students who dropped the course to confirm that the students who dropped the course were similar to those who remained. This comparison showed that the two groups were similar on all variables except hours worked. Results of the comparison are provided in Chapter 4 (Table 4.13).

*Selection-maturation interaction.* The selection-maturation interaction threat refers to a situation in which treatment group participants have different maturation rates. The interaction between those selected for treatment and their maturation could be mistaken for a treatment effect. For example, if the flipped group consisted of a mix of dual-enrolled, first time in college, returning to college, and older adult students, it is possible that the interaction between these and their maturation could be mistaken for a treatment effect. Because it is possible for MAC 1105 to have such a diverse mix of students, the selection-maturation interaction threat was applicable to this study. To control for this threat I analyzed the student attribute data to determine the extent to which each of the groups were homogeneous. The findings are reported in Chapter 4.
**Experimenter effect.** An experimenter effect is defined as any unintentional behavior or bias of a researcher that could cause the researcher to unconsciously influence the participants of a study. For example, in the context of the current study, if different faculty members were assigned to the flipped, online, and traditional classrooms, then it is possible that student achievement could be a function of teacher characteristics such as age, gender, level of education, years of teaching experience, or any other bias or stereotype on the part of the faculty members instead of group membership. As the sole implementer of the study, the experimenter effect threat was mitigated to a certain degree. However, as the sole implementer, an experimenter effect was still applicable because I could have unknowingly projected a certain attitude or bias toward a certain group, which in turn could have impacted achievement. To help control for this, my advisor served as devil’s advocate met with me regularly to discuss the progress of the study’s implementation and make me cognizant of any unintentional influences I might have been rendering by reviewing the recorded events of my interactions with students from each group.

**Subject effect.** A subject effect is defined as changes in the attitudes of participants during a study. For example, participants during the course of a study might want to do well regardless of the treatment (called a Hawthorne effect) or they might intentionally perform poorly (called a John Henry effect). Either attitude could lead to changes in participants’ performance. In the current study, it was
possible that students in the traditional group might have felt slighted because they did not have access to the instructional videos that were provided to the flipped classroom students. As such, it was conceivable that these students might have decreased their effort to do well in the course and underperform. It also was possible that students in the flipped classroom might have increased their effort because they wanted this mode of instruction to succeed or they felt special to be a part of the model. As a result, these students’ extra effort could have led them to perform beyond their expectations. To control for the former, I made the instructional videos available to all of my students after the study was completed. To control for the latter, I made the experience as normal as possible and did not provide any more encouragement to the flipped group than the traditional group. Concomitant to the Hawthorne and John Henry effects is a novelty effect, which can be manifested when students are introduced to something new during a study. Although the flipped classroom model might be new to some students, whatever novelty this instructional model might have had waned as the semester progressed and therefore was not a concern.

**Diffusion.** Diffusion refers to the communication about a treatment between participants in the control and treatment groups. If control group participants were to learn about the treatment and its corresponding effect, the participants might experience a “placebo” effect, which could have led both treatment and control group students to perform similarly on the dependent measure. In the context of the
current study, it was possible that students in either the traditional or online groups could access the instructional videos being used by students in the flipped group. This threat was applicable to the study and was difficult to control because I could not prevent students from all three groups from interacting with each another. To help mitigate this threat, I removed access to the videos from the traditional groups MyMathLab course. Although unlikely, this does not mean that students in the flipped and online groups did not share access to their MyMathLab course with students in the traditional group. Because of the difficulty in controlling for diffusion, I treated this threat as a study limitation.

**Location.** A location threat refers to the setting in which a study takes place that can influence the results. For example, treatment group participants who are assessed in an environment more comfortable with improved lighting and space than the room in which control group participants are being assessed, might perform better as a result of their location. In the context of the current study, although the flipped and traditional groups were assessed in similar locations, the online students were not assessed in the same classroom environment. Thus, it is conceivable that a location threat was possible. This threat was mitigated, however, because online students were able to select where and when they would complete their exams, and presumably they selected an environment to their liking.

**Treatment verification and fidelity.** Treatment verification and fidelity refer to the steps taken by a researcher to ensure that a study is implemented
exactly as intended (Shaver, 1983). If the implementer of a study were to follow different protocols than what is outlined, then replication of the study might not be possible. As part of this process, Shaver indicated that verification of the independent variables in a study is critical to the valid interpretation of effects and estimation of generalizability. Following Shaver’s guidance I described each IV in Table 3.9, and in the Instrumentation section of this chapter I provided information about the items in each instrument.

Shaver (1983) also noted that to ensure the integrity of the IVs of a study, researchers should confirm that the actual implementation of a study was true to the proposed implementation. To address this issue I self-reported all classroom activities in separate journals for each group to detail exactly what took place during each class session. Because there were no class sessions per se for the online group, the corresponding journal did not include class session information but instead a summary of the interactions that occurred. I also meet with my advisor on a regular basis during the implementation phase to ensure that all aspects of this study were being followed. To promote treatment fidelity, I standardized all course material, including the syllabus, textbook, homework assignments, in-class assignments, videos, and lesson plans.

**Data Analysis**

**Description of independent and dependent variables.** A description of the independent and dependent variables is summarized in Table 3.9. As reported
Table 3.9
Summary and Description of Independent and Dependent Variables

<table>
<thead>
<tr>
<th>Sets/Variables</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Set A = Group Membership</strong></td>
<td></td>
</tr>
<tr>
<td>$X_1 =$ Flipped</td>
<td>$X_1$ and $X_2$ were categorical variables representing group membership and were dummy coded as $X_1 =$ flipped classroom and $X_2 =$ online classroom, with the traditional classroom as the reference group.</td>
</tr>
<tr>
<td>$X_2 =$ Online</td>
<td></td>
</tr>
<tr>
<td><strong>Set B = Student Attributes</strong></td>
<td></td>
</tr>
<tr>
<td>$X_3 =$ Female</td>
<td>$X_3$ was a categorical variable representing gender and was dummy coded with male as the reference group.</td>
</tr>
<tr>
<td>$X_4 =$ Age</td>
<td>$X_4$ was a continuous variable and was measured in years.</td>
</tr>
<tr>
<td>$X_5 =$ Black</td>
<td>$X_5$, $X_6$, $X_7$, $X_8$ were categorical variables representing five categories of race/ethnicity and were dummy coded as shown with White/Caucasian as the reference group.</td>
</tr>
<tr>
<td>$X_6 =$ Hispanic</td>
<td></td>
</tr>
<tr>
<td>$X_7 =$ Asian</td>
<td></td>
</tr>
<tr>
<td>$X_8 =$ Other</td>
<td></td>
</tr>
<tr>
<td><strong>Set C = Students’ Affective Domain</strong></td>
<td></td>
</tr>
<tr>
<td>$X_9 =$ ATMI scores</td>
<td>$X_9$ was continuous variable and represented scores on Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory, which was measured on a 5-point Likert scale. Higher aggregate scores reflect a more positive attitude toward mathematics.</td>
</tr>
<tr>
<td>$X_{10} =$ MSES-R scores</td>
<td>$X_{10}$ was a continuous variable and represented scores on Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale-Revised, which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale, was measured on a 5-point Likert-type scale. Higher aggregate scores reflected a higher level of mathematics self-efficacy.</td>
</tr>
<tr>
<td>$X_{11} =$ LCPT scores</td>
<td>$X_{11}$ was a continuous variable and represents scores on Rotter’s (1966) Locus of Control Personality Test, which was measured on a 5-point Likert scale. Higher aggregate scores reflected an external orientation.</td>
</tr>
<tr>
<td><strong>Set D = Dependent Variable</strong></td>
<td></td>
</tr>
<tr>
<td>$Y =$ Student Achievement</td>
<td>Set D was single-variable set comprised of the dependent measure, student achievement, which represented scores on Lake’s (2008) College Algebra Cumulative Final Exam.</td>
</tr>
</tbody>
</table>
in Table 3.9, the independent variables were organized into three functional sets (Cohen et al., 2003). Set A = Group Membership consisted of two dummy coded variables, \( X_1 = \text{Flipped vs. Traditional} \) and \( X_2 = \text{Online vs. Traditional} \), with the traditional group as the reference group. Set B = Student Attributes consisted of six variables: \( X_3 = \text{Female vs. Male} \), a dummy coded variable representing gender, with male as the reference group; \( X_4 = \text{Age} \), which represented students’ age in years; and \( X_5, X_6, X_7, \) and \( X_8 \) represented dummy coded race/ethnicity variables, which compared Black, Hispanic, Asian, and Other, respectively, with White/Caucasian as the reference group. Set C = Students’ Affective Domain consisted of three variables: \( X_9 = \text{ATMI scores} \), which referred to scores on Tapia and Marsh’s (2004) Attitudes toward Mathematics Inventory; \( X_{10} = \text{MSES-R scores} \), which referred to scores on Pajares and Miller’s (1995) revised version of Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale; and \( X_{11} = \text{LCPT scores} \), which referred to scores on Rotter’s (1996) Locus of Control Personality Test. The dependent measure was students’ scores on the end of course final exam.

**Descriptive statistics.** The descriptive statistics reported in Chapter 4 include the following:

- Percentage composition of male and female students.
- Mean and standard deviation of students’ age.
- Percentage composition of the targeted race/ethnicities.
- Means, standard deviations, and percentages of students’ work hours.
• Means and standard deviations of prerequisite college algebra scores, unit exam scores, and comprehensive final exam scores.

• Mean and standard deviation of students’ ATMI scores.

• Mean and standard deviation of students’ MSES scores.

• Mean and standard deviation of students’ LCPT scores.

**Inferential statistics.** To answer the current study’s four research questions and their corresponding hypotheses (see Chapter 1), I employed a hierarchical multiple regression strategy using functional sets (Cohen et al., 2003). According to Cohen et al. (2003), this statistical approach is appropriate for analyses that involve a single, continuous dependent measure and more than one nominal or continuous independent measure. The overall model consisted of the three IV sets and the single-variable DV set. Preliminary data screening activities were conducted prior to testing the current study’s hypotheses. These activities and the results of the hypothesis testing are reported in Chapter 4.
Chapter 4

Results

Introduction

This chapter is organized into three sections. The first section contains a discussion of the descriptive statistics relative to the data collected from the multi-component questionnaire and the assessment instruments used during the study. The chapter then transitions its focus to the inferential statistics provided by the analysis of the collected data. The chapter concludes with the results from testing the study’s four hypotheses.

Descriptive Statistics

**Pre-assessments.** At the end of the 1st week of classes, which also marked the end of the add/drop period, students were given a set of pre-assessment instruments to complete as a take-home assignment over the weekend. These pre-assessments included the multicomponent questionnaire and Lake’s (2008) Test of Prerequisite Skills (TPRS). The questionnaire consisted of four sections: Section 1 was Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory (ATMI), Section 2 was Rotter’s (1966) Locus of Control Personality Test (LCPT), Section 3 was Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale-Revised (MSES-R), and Section 4 was a set of student demographics questions. The data acquired from the first three sections of the questionnaire and the TPRS were used to assess group equivalency. Table 4.1 contains a summary of this analysis and shows there
was no statistical difference among the three groups relative to their attitudes toward mathematics, mathematics self-efficacy, locus of control, and prerequisite mathematics knowledge. A discussion of the corresponding descriptive statistics for each assessment follows.

**Attitudes toward mathematics inventory (ATMI).** As discussed in Chapter 3, Tapia and Marsh’s (1996) ATMI consisted of 40 items measured on a 5-point Likert-type scale ranging from 1 = Strongly Disagree to 5 = Strongly Agree. Thus, aggregate scores could range from 40 to 200, with higher scores indicating a more
favorable attitude toward mathematics. Items are both positively and negatively worded with negatively worded items reverse scored. The items also are partitioned into four subscales: self-confidence, value, enjoyment, and motivation. Descriptive statistics from the ATMI are summarized in Tables 4.2–4.4.

As reported in Table 4.2, the overall mean attitude score was $M = 134.15$ ($SD = 31.82$). Comparing the scores for each group shows that the flipped group had more positive attitudes than the other two groups, $M = 136.31$ ($SD = 30.03$). This was followed by the traditional group, $M = 134.02$ ($SD = 28.99$), and the online group $M = 132.16$ ($SD = 34.69$). As noted in Table 4.1, when the ATMI data were analyzed for group equivalency, there was no significant differences among the groups, $R^2 = .003$, $F(2, 146) = 0.21$, $p = .812$.

Table 4.3 presents a summary of the mean ATMI scores by group and subscales. The self-confidence subscale, which measures how comfortable students feel toward mathematics, corresponded to Statements 9–22, and 40, and scores could range from 15 to 75. The value subscale, which measures students’ beliefs on the usefulness of mathematics, corresponded to Statements 1, 2, 4–8, 35, 36, and 39, and scores could range from 10 to 50. The enjoyment subscale, which measures the extent to which students enjoy mathematics, corresponded to Statements 3, 24–27, 29–31, 37, and 38, and scores could range from 10 to 50. The motivation subscale, which measures how useful students find the course, corresponded to Statements 23, 28, and 32–34, and scores could range from 5 to 25. As reported in
Table 4.2
Summary of Means and Standard Deviations for Scores on the Attitudes toward Mathematics Inventory (ATMI)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>49</td>
<td>136.31</td>
<td>32.03</td>
<td>71–194</td>
</tr>
<tr>
<td>Online</td>
<td>50</td>
<td>132.16</td>
<td>34.69</td>
<td>63–194</td>
</tr>
<tr>
<td>Traditional</td>
<td>50</td>
<td>134.02</td>
<td>28.99</td>
<td>58–187</td>
</tr>
<tr>
<td>Overall</td>
<td>149</td>
<td>134.15</td>
<td>31.82</td>
<td>58–194</td>
</tr>
</tbody>
</table>

Note. Attitudes were measured using Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory (ATMI), which used a Likert-scale of 1 = Strongly Disagree to 5 = Strongly Agree. Attitude scores could range from 40 to 200 with higher scores reflecting more positive attitudes.

Table 4.3
Summary of Means for Subscale Scores on the Attitudes toward Mathematics Inventory (ATMI) by Subscales

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>SC</th>
<th>V</th>
<th>E</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>49</td>
<td>49.78</td>
<td>37.88</td>
<td>32.98</td>
<td>15.67</td>
</tr>
<tr>
<td>Online</td>
<td>50</td>
<td>46.64</td>
<td>38.94</td>
<td>31.76</td>
<td>14.82</td>
</tr>
<tr>
<td>Traditional</td>
<td>50</td>
<td>50.44</td>
<td>37.14</td>
<td>31.68</td>
<td>14.76</td>
</tr>
<tr>
<td>Overall</td>
<td>149</td>
<td>48.95</td>
<td>37.99</td>
<td>32.13</td>
<td>15.08</td>
</tr>
</tbody>
</table>

Note. Attitudes were measured using Tapia and Marsh’s (1996) 40-item Attitudes toward Mathematics Inventory (ATMI), which used a Likert-scale of 1 = Strongly Disagree to 5 = Strongly Agree. Attitude scores could range from 40 to 200 with higher numbers reflecting more positive attitudes.

*The four subscales of the ATMI are: The self-confidence subscale (SC) corresponded to Statements 9–22, and 40; scores could range from 15 to 75. The value subscale (V) corresponded to Statements 1, 2, 4–8, 35, 36, 39; scores could range from 10 to 50. The enjoyment subscale (E) corresponded to Statements 3, 24–27, 29–31, 37–38; scores could range from 10 to 50. The motivation subscale (M) corresponded to Statements 23, 28, 32–34; scores could range from 5–25.

Table 4.3, students’ mean ATMI scores by group were very similar for each subscale. The self-confidence subscale mean scores ranged from $M = 49.78$ for the flipped group to $M = 50.44$ for the traditional group, with an overall mean of $M = 48.95$. The value subscale mean scores ranged from $M = 37.14$ for the traditional group to $M = 38.94$ for the online group, with an overall mean of $M = 37.99$. The
enjoyment subscale mean scores ranged from $M = 31.68$ for the traditional group to $M = 32.98$ for the flipped group, with an overall mean of $M = 32.13$. The motivation subscale mean scores ranged from $M = 14.76$ for the traditional group to $M = 15.67$ for the traditional group, with an overall mean of $M = 15.08$. Comparing the attitude scores for each group by subscales shows that students in the flipped group had the most positive attitudes relative to their enjoyment of and their motivation to do math. Students in the traditional group, however, had the least positive attitudes toward mathematics relative to all but one of the subscales, self-confidence, where they had the most positive attitude of the three groups. Although not statistically significant, these differences might be of practical significance and are discussed further in Chapter 5.

Table 4.4 presents an analysis of items from the overall ATMI results. Examining the table as a whole, the majority of attitude scores ranged around Neutral (i.e., 3.0). Overall, students Agreed-to-Strongly Agreed with only 3 of the 40 statements: Statement 1 = “Mathematics is a very worthwhile and necessary subject,” $M = 4.0$; Statement 2 = “I want to develop my mathematical skills,” $M = 4.1$; Statement 4 = “Mathematics helps develop the mind and teaches a person to think,” $M = 4.1$.

**Locus of control personality test (LCPT).** As discussed in Chapter 3, Rotter’s (1966) LCPT was used to determine the extent to which people believe they are in control over the events and circumstances affecting their lives. The
Table 4.4
Analysis of Items on the Attitudes toward Mathematics Inventory (ATMI)

<table>
<thead>
<tr>
<th>Statement</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mathematics is a very worthwhile and necessary subject.</td>
<td>4.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2. I want to develop my mathematical skills.</td>
<td>4.1</td>
<td>1.0</td>
</tr>
<tr>
<td>3. I get a great deal of satisfaction out of solving a mathematics problem.</td>
<td>3.7</td>
<td>1.1</td>
</tr>
<tr>
<td>4. Mathematics helps develop the mind and teaches a person to think.</td>
<td>4.1</td>
<td>0.9</td>
</tr>
<tr>
<td>5. Mathematics is important in everyday life.</td>
<td>3.8</td>
<td>0.9</td>
</tr>
<tr>
<td>6. Mathematics is one of the most important subjects to study.</td>
<td>3.6</td>
<td>1.0</td>
</tr>
<tr>
<td>7. Community College math courses are very helpful no matter what I decide to study.</td>
<td>3.7</td>
<td>1.0</td>
</tr>
<tr>
<td>8. I can think of many ways that I use math outside of school.</td>
<td>3.7</td>
<td>1.0</td>
</tr>
<tr>
<td>9. Mathematics is one of my most dreaded subjects.</td>
<td>2.9</td>
<td>1.3</td>
</tr>
<tr>
<td>10. My mind goes blank and I am unable to think clearly when working with mathematics.</td>
<td>3.3</td>
<td>1.2</td>
</tr>
<tr>
<td>11. Studying mathematics makes me feel nervous.</td>
<td>3.2</td>
<td>1.3</td>
</tr>
<tr>
<td>12. Mathematics makes me feel uncomfortable.</td>
<td>3.5</td>
<td>1.3</td>
</tr>
<tr>
<td>13. I am always under a terrible strain in a math class.</td>
<td>3.3</td>
<td>1.3</td>
</tr>
<tr>
<td>14. When I hear the word mathematics, I have a feeling of dislike.</td>
<td>3.2</td>
<td>1.3</td>
</tr>
<tr>
<td>15. It makes me nervous to even think about having to do a mathematics problem.</td>
<td>3.5</td>
<td>1.3</td>
</tr>
<tr>
<td>16. Mathematics does not scare me at all.</td>
<td>3.1</td>
<td>1.3</td>
</tr>
<tr>
<td>17. I have a lot of self-confidence when it comes to mathematics.</td>
<td>3.1</td>
<td>1.3</td>
</tr>
<tr>
<td>18. I am able to solve mathematics problems without too much difficulty.</td>
<td>3.1</td>
<td>1.1</td>
</tr>
<tr>
<td>19. I expect to do fairly well in any math class I take.</td>
<td>3.6</td>
<td>0.9</td>
</tr>
<tr>
<td>20. I am always confused in my mathematics class.</td>
<td>3.4</td>
<td>1.1</td>
</tr>
<tr>
<td>21. I feel a sense of insecurity when attempting mathematics.</td>
<td>3.3</td>
<td>1.2</td>
</tr>
<tr>
<td>22. I learn mathematics easily.</td>
<td>3.1</td>
<td>1.2</td>
</tr>
<tr>
<td>23. I am confident that I could learn advanced mathematics.</td>
<td>3.5</td>
<td>1.0</td>
</tr>
<tr>
<td>24. I have usually enjoyed studying mathematics in school.</td>
<td>3.1</td>
<td>1.2</td>
</tr>
<tr>
<td>25. Mathematics is dull and boring.</td>
<td>3.3</td>
<td>1.1</td>
</tr>
<tr>
<td>26. I like to solve new problems in mathematics.</td>
<td>3.2</td>
<td>1.1</td>
</tr>
<tr>
<td>27. I would prefer to do an assignment in math than to write an essay.</td>
<td>3.4</td>
<td>1.5</td>
</tr>
<tr>
<td>28. I would like to avoid taking mathematics courses in college.</td>
<td>3.2</td>
<td>1.2</td>
</tr>
<tr>
<td>29. I really like mathematics.</td>
<td>3.1</td>
<td>1.2</td>
</tr>
<tr>
<td>30. I am happier in a math class than in any other class.</td>
<td>2.5</td>
<td>1.1</td>
</tr>
<tr>
<td>31. Mathematics is a very interesting subject.</td>
<td>3.3</td>
<td>1.1</td>
</tr>
<tr>
<td>32. I am willing to take more than the required amount of mathematics.</td>
<td>2.8</td>
<td>1.2</td>
</tr>
<tr>
<td>33. I plan to take as much mathematics as I can during my education.</td>
<td>2.6</td>
<td>1.2</td>
</tr>
<tr>
<td>34. The challenge of math appeals to me.</td>
<td>3.0</td>
<td>1.1</td>
</tr>
<tr>
<td>35. I think studying advanced mathematics is useful.</td>
<td>3.5</td>
<td>1.1</td>
</tr>
<tr>
<td>36. I believe studying math helps me with problem solving in other areas.</td>
<td>3.6</td>
<td>0.9</td>
</tr>
<tr>
<td>37. I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in math.</td>
<td>3.4</td>
<td>1.0</td>
</tr>
<tr>
<td>38. I am comfortable answering questions in math class.</td>
<td>3.2</td>
<td>1.1</td>
</tr>
<tr>
<td>39. A strong math background could help me in my professional life.</td>
<td>3.7</td>
<td>1.1</td>
</tr>
<tr>
<td>40. I believe I am good at solving math problems.</td>
<td>3.3</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Note. N = 149. Attitudes were measured using Tapia and Marsh’s (1996) 40-item Attitudes toward Mathematics Inventory (ATMI), which used a Likert-scale of 1 = Strongly Disagree to 5 = Strongly Agree. Attitude scores could range from 40 to 200 with higher scores reflecting more positive attitudes. Statements 9–22, and 40 measured self-confidence; Statements 1, 2, 4–8, 35, 36, 39 measured value; Statements 3, 24–27, 29–31, 37–38 measured enjoyment; Statements 23, 28, 32–34 measured motivation (see also Table 4.2). Statements 9–15, 20–21, 25, and 28 were negatively worded and results shown in the table reflect reverse scoring.
LCPT consisted of 29 items of which 6 were filler items and not scored. Each item consisted of two statements (a and b) and participants were to select the one they agreed with more and that honestly reflected how they really think, feel, and act in general. Aggregate scores could range from 0 to 23, with scores closer to zero indicating an internal locus of control and scores closer to 23 indicating an external locus of control. Descriptive statistics from the LCPT are summarized in Tables 4.5 and 4.6.

As reported in Table 4.5, the overall mean locus score was $M = 10.13$ ($SD = 3.68$). Comparing the scores for each group shows that the online group had a more internal locus than the other two groups, $M = 8.96$ ($SD = 3.43$). This was followed by the flipped group, $M = 10.39$ ($SD = 3.48$) and the traditional group $M = 11.04$ ($SD = 3.88$). As noted in Table 4.1, when the LCPT data were analyzed for group equivalency (after removing 11 outliers), there was no significant differences among the groups, $R^2 = .017$, $F(2, 135) = 1.19$, $p = .308$.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>49</td>
<td>10.39</td>
<td>3.48</td>
<td>3–19</td>
</tr>
<tr>
<td>Online</td>
<td>50</td>
<td>8.96</td>
<td>3.43</td>
<td>2–15</td>
</tr>
<tr>
<td>Traditional</td>
<td>50</td>
<td>11.04</td>
<td>3.88</td>
<td>3–18</td>
</tr>
<tr>
<td>Overall</td>
<td>149</td>
<td>10.13</td>
<td>3.68</td>
<td>2–19</td>
</tr>
</tbody>
</table>

*Note.* The LCPT (Rotter, 1966) consisted of 29 items measured on a Forced Choice scale with six filler items that do not get scored. Overall scores could range from 0 to 23 with higher scores indicating an orientation toward an external locus of control.
### Table 4.6

**Analysis of Items on the Locus of Control Personality Test (LCPT) (Part 1 of 2)**

<table>
<thead>
<tr>
<th>Item&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Statement&lt;sup&gt;b&lt;/sup&gt;</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;*&lt;/sup&gt;</td>
<td>a. Children get into trouble because their parents punish them too much.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. The trouble with most children nowadays is that their parents are too easy with them.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>a. Many of the unhappy things in people’s lives are partly due to bad luck.</td>
<td>149</td>
<td>0.22</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>b. People’s misfortunes result from the mistakes they make.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>a. One of the major reasons why we have wars is because people don’t take enough interest in politics.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. There will always be wars, no matter how hard people try to prevent them.</td>
<td>149</td>
<td>0.82</td>
<td>0.15</td>
</tr>
<tr>
<td>4</td>
<td>a. In the long run people get the respect they deserve in this world.</td>
<td>149</td>
<td>0.50</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>b. Unfortunately, an individual’s worth often passes unrecognized no matter how hard he tries.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>a. The idea that teachers are unfair to students is nonsense.</td>
<td>149</td>
<td>0.49</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>b. Most students don’t realize the extent to which their grades are influenced by accidental happenings.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>a. Without the right breaks one cannot be an effective leader.</td>
<td>149</td>
<td>0.32</td>
<td>0.22</td>
</tr>
<tr>
<td></td>
<td>b. Capable people who fail to become leaders have not taken advantage of their opportunities.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>a. No matter how hard you try some people just don’t like you.</td>
<td>149</td>
<td>0.81</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>b. People who can’t get others to like them don’t understand how to get along with others.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8&lt;sup&gt;*&lt;/sup&gt;</td>
<td>a. Heredity plays the major role in determining one’s personality.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. It is one’s experiences in life which determine what they’re like.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>a. I have often found that what is going to happen will happen.</td>
<td>149</td>
<td>0.48</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>b. Trusting to fate has never turned out as well for me as making a decision to take a definite course of action.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>a. In the case of the well prepared student there is rarely if ever such a thing as an unfair test.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Many times exam questions tend to be so unrelated to course work that studying is really useless.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>a. Becoming a success is a matter of hard work, luck has little or nothing to do with it.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Getting a good job depends mainly on being in the right place at the right time.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>a. The average citizen can have an influence in government decisions.</td>
<td>149</td>
<td>0.52</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>b. This world is run by the few people in power, and there is not much the little guy can do about it.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>a. When I make plans, I am almost certain that I can make them work.</td>
<td>149</td>
<td>0.25</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>b. It is not always wise to plan too far ahead because many things turn out to be a matter of good or bad fortune anyhow.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14&lt;sup&gt;*&lt;/sup&gt;</td>
<td>a. There are certain people who are just no good.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. There is some good in everybody.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>a. In my case getting what I want has little or nothing to do with luck.</td>
<td>149</td>
<td>0.15</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>b. Many times we might just as well decide what to do by flipping a coin.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4.6
Analysis of Items on the Locus of Control Personality Test (LCPT) (Part 2 of 2)

<table>
<thead>
<tr>
<th>Item</th>
<th>Statement</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
</table>
| 16   | a. Who gets to be the boss often depends on who was lucky enough to be in the right place first.  
     b. Getting people to do the right thing depends upon ability. Luck has little or nothing to do with it. | 149 | 0.15 | 0.13 |
| 17   | a. As far as world affairs are concerned, most of us are the victims of forces we can neither understand, nor control.  
     b. By taking an active part in political and social affairs the people can control world events. | 149 | 0.48 | 0.25 |
| 18   | a. Most people don’t realize the extent to which their lives are controlled by accidental happenings.  
     b. There really is no such thing as “luck.” | 149 | 0.51 | 0.25 |
| 19*  | a. One should always be willing to admit mistakes.  
     b. It is usually best to cover up one's mistakes. | -   | -   | -   |
| 20   | a. It is hard to know whether or not a person really likes you.  
     b. How many friends you have depends upon how nice a person you are. | 149 | 0.76 | 0.18 |
| 21   | a. In the long run the bad things that happen to us are balanced by the good ones.  
     b. Most misfortunes are the result of lack of ability, ignorance, laziness, or all three. | 149 | 0.50 | 0.25 |
| 22   | a. With enough effort we can wipe out political corruption.  
     b. It is difficult for people to have much control over the things politicians do in office. | 149 | 0.59 | 0.24 |
| 23   | a. Sometimes I can’t understand how teachers arrive at the grades they give.  
     b. There is a direct connection between how hard I study and the grades I get. | 148 | 0.16 | 0.13 |
| 24*  | a. A good leader expects people to decide for themselves what they should do.  
     b. A good leader makes it clear to everybody what their jobs are. | -   | -   | -   |
| 25   | a. Many times I feel that I have little influence over the things that happen to me.  
     b. It is impossible for me to believe that chance or luck plays an important role in my life. | 148 | 0.43 | 0.25 |
| 26   | a. People are lonely because they don’t try to be friendly.  
     b. There’s not much use in trying too hard to please people, if they like you, they like you. | 148 | 0.72 | 0.20 |
| 27*  | a. There is too much emphasis on athletics in high school.  
     b. Team sports are an excellent way to build character. | -   | -   | -   |
| 28   | a. What happens to me is my own doing.  
     b. Sometimes I feel that I don’t have enough control over the direction my life is taking. | 147 | 0.24 | 0.18 |
| 29   | a. Most of the time I can’t understand why politicians behave the way they do.  
     b. In the long run the people are responsible for bad government on a national as well as on a local level. | 144 | 0.65 | 0.23 |

Note. The LCPT (Rotter, 1966) consisted of 29 items measured on a Forced Choice scale. Each question was worth either 0 or 1 point. Overall scores could range from 0 to 23 with higher scores indicating an external locus of control orientation.  
*Starred (*) items are filler items and were not included in the scoring. Bold statements reflect an external locus orientation.
Table 4.6 presents an analysis of items from the overall LCPT results. Examining the table as whole, students responded to the majority of statements at the far ends of the spectrum. In other words, students selected responses that reflected either mostly an internal or external orientation. Overall, students were split on 7 of the 17 statements: Statements 4, 5, 9, 12, 17, 18, and 21.

Mathematics self-efficacy scale-revised (MSES-R). As discussed in Chapter 3, Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale was revised by Pajares and Miller (1995) (denoted MSES-R). Although both scales were designed to measure undergraduate students’ perceived beliefs about their ability to perform math-related tasks and behaviors, the latter scale was used in the current study. The MSES-R consisted of 52 items measured on a 5-point Likert-type scale ranging from 1 = Not At All Confident to 5 = Completely Confident. Aggregate scores could range from 52 to 260, with higher scores reflecting higher mathematics self-efficacy. The MSES-R can be partitioned into three subscales: mathematics performance (Problems), which assesses students’ perceived confidence to correctly solve mathematics problems \((n = 18)\); everyday math tasks (Tasks), which assesses students’ perceived confidence to perform certain mathematics related tasks \((n = 18)\); and math courses (Courses), which assesses students’ confidence to earn an A or B in certain mathematics related courses \((n = 16)\). Descriptive statistics from the MSES-R are summarized in Tables 4.7–4.9.
As reported in Table 4.7, the overall mean self-efficacy score was $M = 187.37$ ($SD = 32.63$). Comparing the scores for each group showed that students in the online classes had a slightly higher level of self-efficacy than the other two groups $M = 190.08$ ($SD = 35.27$). This was followed by the flipped group, $M = 188.14$ ($SD = 34.19$) and the traditional group $M = 183.90$ ($SD = 27.98$). As reported in Table 4.1, when the MSES-R data were analyzed for group equivalency, there was no significant differences among the groups, $R^2 = .01$, $F(2, 146) = 0.47$, $p = .627$.

Table 4.7 presents a summary of the mean MSES-R scores by group and subscales. The Problems subscale assessed students’ perceived confidence to correctly solve mathematics problems and corresponded to Statements 1–18 with possible scores ranging from 18 to 90. The Tasks subscale assessed students’ perceived confidence to perform certain mathematics related tasks and

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>49</td>
<td>188.14</td>
<td>34.19</td>
<td>120–260</td>
</tr>
<tr>
<td>Online</td>
<td>50</td>
<td>190.08</td>
<td>35.27</td>
<td>117–260</td>
</tr>
<tr>
<td>Traditional</td>
<td>50</td>
<td>183.90</td>
<td>34.19</td>
<td>113–232</td>
</tr>
<tr>
<td>Overall</td>
<td>149</td>
<td>187.37</td>
<td>32.63</td>
<td>113–260</td>
</tr>
</tbody>
</table>

Note. Self-efficacy was measured using Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale Revised (MSES-R), which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale. The MSES-R used a Likert-scale of 1 = Not At All Confident to 5 = Completely Confident. Overall scores could range from 52 to 260, with higher scores reflecting higher mathematics self-efficacy.
corresponded to Statements 1, 2, 4–8, 35, 36, and 39 with possible scores ranging from 10 to 50. The Courses subscale assessed students’ confidence to earn an A or B in certain mathematics related courses and corresponded to Statements 37–52 with possible scores ranging from 16 to 80. As reported in Table 4.8, students’ mean MSES-R scores by group were very similar for each subscale. The Problems subscale mean scores ranged from $M = 64.88$ for the traditional group to $M = 69.08$ for the online group, with an overall mean of $M = 66.99$. The Tasks subscale mean scores ranged from $M = 68.18$ for the flipped group to $M = 70.08$ for the traditional group, with an overall mean of $M = 69.18$. The Courses subscale mean scores ranged from $M = 48.94$ for the traditional group to $M = 52.94$ for the flipped group.
with an overall mean of $M = 51.19$. Comparing the self-efficacy scores for each group by subscales showed that students in the online classes had the highest mean scores for both the Problems and Courses subscales, with the traditional group having the lowest. This indicates that although students in the traditional group had the lowest self-confidence to correctly solve math problems and to earn an A or B in a related math course, they had the highest self-confidence to perform certain math related tasks. Nevertheless, these mean group differences were not significant. Problems: $R^2 = .02, F(2, 146) = 1.23, p = .295$; Tasks: $R^2 = .004, F(2, 146) = 0.28, p = .754$; and Courses: $R^2 = .02, F(2, 146) = 1.43, p = .242$. Although not statistically significant, these differences might be of practical significance and are discussed further in Chapter 5.

Table 4.9 presents analysis of items on the MSES-R results. Examining the table as a whole, the majority of mathematics self-efficacy scores had a range of 3.6 (some confidence to much confidence). Overall, students averaged above a 3 on all Problems and Tasks related statements except Statement 16 = “A ferris wheel measures 80 feet in circumference. The distance on the circle between two of the seats is 10 feet. Find the measure in degrees of the central angle SOT whose rays support the two seats,” $M = 2.9$. This suggests that students had low self-efficacy toward their ability to perform a trigonometry problem. This was not surprising because trigonometry is not a required course in high school, and college algebra is a prerequisite for college trigonometry.
Table 4.9
Analysis of Items on the Mathematics Self-Efficacy Scale Revised (MSES-R) (Part 1 of 2)

<table>
<thead>
<tr>
<th>Item</th>
<th>Statement</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In a certain triangle, the shortest side is 6 inches. The longest side is twice as long as the shortest side, and the third side is 3.4 inches shorter than the longest side. What is the sum of the three sides in inches?</td>
<td>149</td>
<td>4.0</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>ABOUT how many times larger than 614,360 is 30,668,000?</td>
<td>149</td>
<td>4.0</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>There are three numbers. The second is twice the first and the first is one-third of the other number. Their sum is 48. Find the largest number.</td>
<td>149</td>
<td>3.4</td>
<td>1.0</td>
</tr>
<tr>
<td>4</td>
<td>Five points are on a line. T is next to G. K is next to H. C is next to T. H is next to G. Determine the positions of the points along the line.</td>
<td>149</td>
<td>3.8</td>
<td>1.0</td>
</tr>
<tr>
<td>5</td>
<td>If $y = 9 + x/5$, find x when $y = 10$.</td>
<td>149</td>
<td>4.4</td>
<td>0.9</td>
</tr>
<tr>
<td>6</td>
<td>A baseball player got two hits for three times at bat. This could be represented by $2/3$. Which decimal would most closely represent this?</td>
<td>149</td>
<td>4.2</td>
<td>1.0</td>
</tr>
<tr>
<td>7</td>
<td>If $P = M + N$, then which of the following will be true?</td>
<td>149</td>
<td>4.3</td>
<td>0.9</td>
</tr>
<tr>
<td>I.</td>
<td>$N = P - M$</td>
<td>149</td>
<td>4.2</td>
<td>1.0</td>
</tr>
<tr>
<td>II.</td>
<td>$P - N = M$</td>
<td>149</td>
<td>3.8</td>
<td>1.0</td>
</tr>
<tr>
<td>III.</td>
<td>$N + M = P$</td>
<td>149</td>
<td>3.6</td>
<td>1.2</td>
</tr>
<tr>
<td>8</td>
<td>The hands of a clock form an obtuse angle at ____ o’clock.</td>
<td>149</td>
<td>4.2</td>
<td>1.0</td>
</tr>
<tr>
<td>9</td>
<td>Bridget buys a packet containing 9-cent and 13-cent stamps for $2.65. If there are 25 stamps in the packet, how many are 13-cent stamps?</td>
<td>149</td>
<td>3.8</td>
<td>1.0</td>
</tr>
<tr>
<td>10</td>
<td>On a certain map, 7/8 inch represents 200 miles. How far apart are two towns whose distance apart on the map is 3 1/2 inches?</td>
<td>149</td>
<td>3.6</td>
<td>1.2</td>
</tr>
<tr>
<td>11</td>
<td>Fred’s bill for some household supplies was $13.64. If he paid for the items with a $20 bill, how much change should he receive?</td>
<td>149</td>
<td>4.6</td>
<td>0.8</td>
</tr>
<tr>
<td>12</td>
<td>Some people suggest that the following formula be used to determine the average weight for boys between the ages of 1 and 7: $W = 17 + 5A$ where $W$ is the weight in pounds and $A$ is the boy’s age in years. According to this formula, for each year older a boy gets, should his weight become more or less, and by how much?</td>
<td>149</td>
<td>3.6</td>
<td>1.0</td>
</tr>
<tr>
<td>13</td>
<td>Five spelling tests are to be given to Mary’s class. Each test has a value of 25 points. Mary’s average for the first four tests is 15. What is the highest possible average she can have on all five tests?</td>
<td>149</td>
<td>3.8</td>
<td>1.0</td>
</tr>
<tr>
<td>14</td>
<td>$3, \frac{4}{5} - 1/2 = ____$</td>
<td>149</td>
<td>4.0</td>
<td>1.0</td>
</tr>
<tr>
<td>15</td>
<td>In an auditorium, the chairs are usually arranged so that there are x rows and y seats in a row. For a popular speaker, an extra row is added, and an extra seat is added to every row. Thus, there are $x+1$ rows and $y+1$ seats in each row, and there will be $(x+1)$ and $(y+1)$ seats in the auditorium. Multiply $(x+1)$ $(y+1)$.</td>
<td>149</td>
<td>3.6</td>
<td>1.1</td>
</tr>
<tr>
<td>16</td>
<td>A ferris wheel measures 80 feet in circumference. The distance on the circle between two of the seats is 10 feet. Find the measure in degrees of the central angle SOT whose rays support the two seats.</td>
<td>149</td>
<td>2.9</td>
<td>1.2</td>
</tr>
<tr>
<td>17</td>
<td>Set up the problem to be done to find the number asked for in the expression “six less than twice 4 5/6”?</td>
<td>149</td>
<td>3.7</td>
<td>1.1</td>
</tr>
<tr>
<td>18</td>
<td>The two triangles shown on the right are similar. Thus, the corresponding sides are proportional, and $AC/BD = XZ/YZ$. If $AC = 1.7$, $BC = 2$, and $XZ = 5.1$, find $YZ$.</td>
<td>149</td>
<td>3.4</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Indicate how much confidence you have to successfully perform each of the following tasks?

<table>
<thead>
<tr>
<th>Item</th>
<th>Task</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Add two large numbers (e.g., 5739 + 62543) in your head.</td>
<td>149</td>
<td>3.7</td>
<td>1.1</td>
</tr>
<tr>
<td>20</td>
<td>Determine the amount of sales tax on a clothing purchase.</td>
<td>149</td>
<td>3.6</td>
<td>1.2</td>
</tr>
<tr>
<td>21</td>
<td>Figure out how much material to buy in order to make curtains.</td>
<td>149</td>
<td>3.6</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Table 4.9
Analysis of Items on the Mathematics Self-Efficacy Scale Revised (MSES-R) (Part 2 of 2)

<table>
<thead>
<tr>
<th>Item</th>
<th>Statement</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>Determine how much interest you will end up paying on a $675 loan over 2 years at 14 3/4% interest.</td>
<td>149</td>
<td>3.2</td>
<td>1.2</td>
</tr>
<tr>
<td>23</td>
<td>Use a scientific calculator.</td>
<td>149</td>
<td>4.3</td>
<td>0.9</td>
</tr>
<tr>
<td>24</td>
<td>Calculate your car's gas mileage.</td>
<td>149</td>
<td>3.8</td>
<td>1.1</td>
</tr>
<tr>
<td>25</td>
<td>Balance your checkbook without a mistake.</td>
<td>149</td>
<td>3.8</td>
<td>1.1</td>
</tr>
<tr>
<td>26</td>
<td>Understand how much interest you will earn on your savings account in 6 months, and how that interest is computed.</td>
<td>149</td>
<td>3.4</td>
<td>1.2</td>
</tr>
<tr>
<td>27</td>
<td>Figure out how long it will take to travel from City A to City B driving 55 mph.</td>
<td>149</td>
<td>3.9</td>
<td>1.0</td>
</tr>
<tr>
<td>28</td>
<td>Set up a monthly budget for yourself.</td>
<td>149</td>
<td>4.2</td>
<td>0.9</td>
</tr>
<tr>
<td>29</td>
<td>Compute your income taxes for the year.</td>
<td>149</td>
<td>3.1</td>
<td>1.3</td>
</tr>
<tr>
<td>30</td>
<td>Understand a graph accompanying an article on business profits.</td>
<td>149</td>
<td>3.6</td>
<td>1.1</td>
</tr>
<tr>
<td>31</td>
<td>Figure out how much you would save if there is a 15% markdown on an item you wish to buy.</td>
<td>149</td>
<td>3.9</td>
<td>1.0</td>
</tr>
<tr>
<td>32</td>
<td>Estimate your grocery bill in your head as you pick up items.</td>
<td>149</td>
<td>3.9</td>
<td>1.0</td>
</tr>
<tr>
<td>33</td>
<td>Figure out which of two summer jobs is the better offer; one with a higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses.</td>
<td>149</td>
<td>4.2</td>
<td>0.9</td>
</tr>
<tr>
<td>34</td>
<td>Figure out the tip on your part of a dinner bill split 8 ways.</td>
<td>149</td>
<td>3.8</td>
<td>1.1</td>
</tr>
<tr>
<td>35</td>
<td>Figure out how much lumber you need to buy in order to build a set of bookshelves.</td>
<td>149</td>
<td>3.6</td>
<td>1.1</td>
</tr>
</tbody>
</table>

*Items 1–18 dealt with mathematics performance (Problems), which assesses students’ perceived confidence to correctly solve mathematics problems; 19–36 dealt with everyday math tasks (Tasks), which assess students’ perceived confidence to perform certain mathematics related tasks; and 37–52 listed math courses (Courses), which assess students’ confidence to earn an A or B in certain mathematics related courses.

Note. Mathematical self-efficacy was measured using Pajares and Miller’s (1995) MSES-R, which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale, used a Likert-scale of 1 = Not At All Confident to 5 = Completely Confident. Overall scores range from 52 to 260, with higher scores reflecting higher mathematics self-efficacy.
**Test of prerequisite skills (TPRS).** As discussed in Chapter 3, Lake’s (2008) TPRS was used to determine students’ level of intermediate algebra (the prerequisite course for college algebra) knowledge at the beginning of the semester. The test consisted of 17 dichotomously scored multiple-choice items, and was used to ensure groups were statistically equivalent on prior mathematical knowledge.

As reported in Table 4.10, group means were similar for all three groups (Flipped: $M = 9.37$, $SD = 3.16$; Online: $M = 9.10$, $SD = 3.32$; and Traditional: $M = 8.70$, $SD = 2.88$). As reported in Table 4.1, there was no significant difference among the groups’ mean scores, $R^2 = .01$, $F(2, 142) = 0.71$, $p = .492$, which indicated that students in all three groups were equivalent in the prerequisite knowledge needed for college algebra.

**Post-assessment.** The post-assessment was administered at the end of the study during final exams week and consisted of two components: the comprehensive final

<table>
<thead>
<tr>
<th>Group</th>
<th>$N$</th>
<th>$M$</th>
<th>$SD$</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>49</td>
<td>9.37</td>
<td>3.16</td>
<td>2–16</td>
</tr>
<tr>
<td>Online</td>
<td>50</td>
<td>9.10</td>
<td>3.32</td>
<td>0–15</td>
</tr>
<tr>
<td>Traditional</td>
<td>50</td>
<td>8.70</td>
<td>2.88</td>
<td>2–14</td>
</tr>
<tr>
<td>Overall</td>
<td>149</td>
<td>9.05</td>
<td>3.12</td>
<td>0–16</td>
</tr>
</tbody>
</table>

*Note.* The TPRS was a modified version of a comprehensive intermediate algebra final exam developed for use by Lake (2008). It was used to assess students’ mathematical background and establish group equivalency. The TPRS consisted of 17 dichotomously scored multiple-choice questions. Scores could range from 0 to 17.
exam, which measured student achievement, and the Problems and Tasks subscales of the MSES-R. Student achievement was assessed by Lake’s (2008) college algebra comprehensive final exam. Initially based on Moore (2002), this instrument underwent an extensive revision cycle by several EFSC mathematics instructors for content validity purposes. The final instrument consisted of 25 dichotomously scored multiple-choice items. Students had 2 hours to complete the exam. The Problems and Tasks subscales of the MSES-R was appended to the final exam and students were required to complete this instrument on a post-hoc basis as part of the final exam. A descriptive statistics summary of the college algebra comprehensive final exam is provided in Table 4.1. A descriptive statistics summary of the MSES-R comparing a priori and post-hoc administrations of the instrument are provided in Table 4.12.

As reported in Table 4.11, the flipped group had the highest mean \( (M = 19.84) \) and the least variability in scores (Range: 12–25, \( SD = 3.66 \)) among the three groups whereas the online group had the lowest mean \( (M = 17.48) \) and greatest variability in scores (Range: 15–25, \( SD = 5.04 \)). A discussion of the statistical significance relative to the differences in group means is reserved for the inferential statistics section of this chapter. As reported in Table 4.12, students’ mean overall scores (independent of group membership) on the Problems and Tasks subscales of the MSES-R increased from pre- to post-study. This increase in self-efficacy was expected and reasonable given that all students just completed the
same college algebra course. When the data were disaggregated by group membership, a different picture is painted. The traditional group had the largest increase (+9.46) in perceived confidence to correctly solve mathematics problems (Problems subscale), and the flipped group had the largest increase (+2.02) in perceived confidence to perform certain mathematics related tasks (Tasks Subscale). Moreover, both the online and traditional groups’ mean Tasks subscale

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>43</td>
<td>19.84</td>
<td>3.66</td>
<td>12–25</td>
</tr>
<tr>
<td>Online</td>
<td>37</td>
<td>17.48</td>
<td>5.04</td>
<td>5–25</td>
</tr>
<tr>
<td>Traditional</td>
<td>42</td>
<td>18.26</td>
<td>4.07</td>
<td>8–23</td>
</tr>
<tr>
<td>Overall</td>
<td>122</td>
<td>18.58</td>
<td>4.43</td>
<td>5–25</td>
</tr>
</tbody>
</table>

Note. The final exam was developed by Lake (2008) and consisted of 25 dichotomously scored multiple-choice questions. Scores could range from 0 to 25.

Table 4.12

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>Diff</th>
<th>Pre</th>
<th>Post</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>43</td>
<td>67.77</td>
<td>71.28</td>
<td>3.51</td>
<td>68.98</td>
<td>71.58</td>
</tr>
<tr>
<td>Online</td>
<td>37</td>
<td>66.16</td>
<td>68.95</td>
<td>2.79</td>
<td>69.41</td>
<td>68.89</td>
</tr>
<tr>
<td>Traditional</td>
<td>42</td>
<td>65.52</td>
<td>74.98</td>
<td>9.46</td>
<td>71.52</td>
<td>71.10</td>
</tr>
<tr>
<td>Overall</td>
<td>122</td>
<td>66.51</td>
<td>71.84</td>
<td>5.33</td>
<td>69.98</td>
<td>70.60</td>
</tr>
</tbody>
</table>

Note. See Table 4.8 note for MSES-R description.
scores actually decreased from pre- to post-study (-0.52 and -0.42, respectively). This will be discussed in Chapter 5.

**Inferential Statistics**

**Overview.** The primary purpose of the current study was to determine the relationship each of three different instructional models—traditional, online, and flipped—had with students’ mathematics achievement. The initial factors that were targeted were partitioned into three functional sets (Cohen et al., 2003): Set A = Group Membership, which represented the three instructional models; Set B = Student Attributes, which consisted of students’ gender, age, and race/ethnicity; and Set C = Students’ Affective Domain, which consisted of scores on Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory (ATMI), Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale (MSES-R) which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale; and Rotter’s (1996) Locus of Control Personality Test (LCPT). For a detailed description of these set memberships, the reader is directed to Chapter 3 (Table 3.7).

The study was implemented as modified (because there was not an administration of a pre- and posttest in the manner specified by the design) quasi-experimental design involving intact classes of students. It is important to note that no actual treatment was administered in the conventional sense of an experiment. Instead, the “treatment” during the study refers to group membership, which denotes the manner in which MAC 1105 was taught. To answer the current study’s
four research questions and test the corresponding null hypotheses (see Chapter 1),
two primary analyses were conducted. The first primary analysis focused on the
first three research questions and examined the relationship the targeted sets of
variables had with student achievement. The second primary analysis focused on
the fourth research question and examined the interactions between the
instructional models and the targeted factors. In both analyses, a hierarchical
multiple regression strategy was used (Cohen et al., 2003).

**Preliminary analyses.** Several preliminary data screening activities were
carried out prior to testing the study’s hypotheses to ensure the data set was
appropriate and “clean.” The activities associated with this step included reviewing
the data set for any possible modifications, performing missing data and outlier
analyses, checking for multicollinearity, and confirming that the data set was
compliant with the assumptions of ordinary least squares regression.

**Data set modifications.** To prepare the raw data for analysis, I made several
modifications to the initial data set. These included: (a) converting all of the Likert
responses for the various instruments into their numerical equivalents, (b) reverse
coding all of the negatively worded items, and (c) coding all of the nominal
variables using a dummy coding strategy as reported in Chapter 3 (Table 3.7). I
also included a “row number” column so that I could maintain numerical order
relative to the raw data for subsequent manipulations. Once this row number
column was created, I then deleted all student names and corresponding B-numbers.

After these data preparation tasks were completed, I then reviewed the data set for incomplete cases, which consisted of students who did not complete all of the study protocols. Of the 149 students enrolled in the six sections of College Algebra after the add/drop week of the fall 2015 semester, 27 students (18.1%) dropped the course before the end of the semester and therefore did not take the comprehensive final exam. Because the final exam was the dependent measure, I had no choice but to drop these 27 cases, which reduced the sample size to \( N = 122 \).

When examined from a group membership perspective, the flipped group lost 7 students (pre-\( N = 49 \), post-\( N = 43 \)), the online group lost 13 students (pre-\( N = 50 \), post-\( N = 37 \)), and the traditional group lost 8 students (pre-\( N = 50 \), post-\( N = 42 \)). The loss of these 27 students resulted in a minimal reduction in overall power (from .999 to .998, see Table 3.4). Table 4.13 provides an overall summary of the comparison between the 27 dropped cases and the 122 complete cases. As noted in Table 4.13, students representing the complete cases (Final Sample) had higher group means compared to students who dropped the course relative to age, hours worked, and scores on the Test of Prerequisite Skills (TPRS), Mathematics Self-Efficacy Scale (MSES-R), and Attitudes toward Mathematics Inventory (ATMI). Of these mean differences, though, only Hours Worked was statistically significant, \( M \text{ Diff} = 15.99, t(147) = 4.29, p < .001 \). This is discussed further in Chapter 5.
**Missing Data.** Missing data is an essential factor in any research study and can occur in a number of ways. For example, participants might not respond or respond incorrectly to a question, be absent when an assessment is administered, or could drop out of an experiment. In the current study and independent of the missing data on the DV described above, the only missing data from the independent variables came from the LCPT; five students did not respond to all the questions on the test. Those five student scores were part of the 11 outliers previously discussed in the locus of control section.

<table>
<thead>
<tr>
<th>Attributea</th>
<th>Final Sample</th>
<th>“Dropped”</th>
<th>M Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>122</td>
<td>20.53</td>
<td>27</td>
</tr>
<tr>
<td>Hours Worked</td>
<td>122</td>
<td>17.86</td>
<td>27</td>
</tr>
<tr>
<td>TPRS</td>
<td>122</td>
<td>9.33</td>
<td>27</td>
</tr>
<tr>
<td>MSES-R</td>
<td>122</td>
<td>187.93</td>
<td>27</td>
</tr>
<tr>
<td>ATMI</td>
<td>122</td>
<td>135.33</td>
<td>27</td>
</tr>
</tbody>
</table>

*Note.* Final Sample refers to the combined treatment and control group students who took the comprehensive final exam. “Dropped” refers to those students who either withdrew from the course or did not take the final exam.

“Age = students’ age in years; Hours Worked = number of hours students worked per week; TPRS = Test of Prerequisite Skills which was a modified version of a comprehensive intermediate algebra final exam developed for use by Lake (2008). The test consisted of 17 dichotomously scored multiple-choice questions. Each question was equally weighted; scores could range from 0 to 17; MSES-R = Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale Revised which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale. The MSES-R used a Likert-scale of 1 = Not At All Confident to 5 = Completely Confident. Overall scores range from 52 to 260, with higher scores reflecting higher mathematics self-efficacy; and ATMI = Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory which used a Likert-scale of 1 = Strongly Disagree to 5 = Strongly Agree. Attitude scores range from 40 to 200 with higher numbers reflecting more positive attitudes. LCPT = Rotter’s (1966) Locus of Control Personality Test which consisted of 29 items measured on a Forced Choice scale. Overall scores range from 0 to 23 with higher scores indicating an orientation toward an external locus of control.

b\(t(147) = 4.29, p < .001\)
**Outlier analysis.** Outliers are one or more atypical data points that do not fit with the rest of the data. Any “extreme” data points inconsistent with the data set can arise in two ways: contaminated observations resulting from coding or data entry error, or from rare cases that are outside the norm of the observations in the population (e.g., a 12-year-old college graduate). By removing any outliers, the sample should be more representative of the population from which it was selected. Should any outliers not be removed, they could mask significance or worse, produce a false claim of significance.

The simplest method to detect outliers is to visually inspect the data when dealing with a small sample and one or two IVs. However, when the sample is not small (e.g., $N > 25$) and there are several IVs, an outlier analysis should be performed using a statistical software package. For this study, JMP’s Jacknife distance method was used from a multivariate perspective to detect any potential outliers. The Jackknife method depends on estimates of the mean, standard deviation, and correlation matrix that do not include the observation itself. The distance is plotted for each observation number. The extreme multivariate outliers are then identified by highlighting the points with the largest distance values and those beyond the upper control limit (UCL) are excluded from the analysis. The UCL computed for the data set of the current study was 4.95.

Seventeen outliers were detected. Removing these outliers produced a singularity between two of the ethnicity variables, $X_7 = \text{Asian}$ and $X_8 = \text{Other}$. To
mitigate this singularity and to address the disparate sample sizes among the
different race/ethnic groups, the ethnicity variables were recoded to a single,
dichotomous, dummy coded variable in which all other race/ethnic groups were
compared to White/Caucasian with the latter as the reference group. The new
variable was labeled $X_{12} = \text{Ethnicity}$. An outlier analysis was then rerun using the
new variable $X_{12}$ in place of the previously four dummy coded race/ethnicity
variables. This new analysis flagged five outliers. With outliers present, $R^2 = .20,
F(8, 113) = 3.53, p = .001$; with outliers absent, $R^2 = .237, F(8, 108) = 4.20, p < .001$. Thus, it appeared that the outliers were masking significance. Because the
model with outliers absent explained more of the variability in final exam scores
than the model with outliers present, the five outliers were removed from the
model. As a result of removing these outliers, the sample size was reduced to $N =
117: N_{\text{Flipped}} = 42, N_{\text{Online}} = 33, \text{and } N_{\text{Traditional}} = 42$. Due to the increase in $R^2$, the
loss of these five cases resulted in an overall increase of power (from .992 to .998,
see Chapter 3).

Regression assumptions. As noted earlier, the statistical strategy used to
test the study’s hypotheses was hierarchical multiple regression. According to
Cohen et al. (2003), in the mathematical development of all statistical procedures,
assumptions are required to be made. In the case of multiple linear regression,
Cohen et al. defined six essential assumptions that must be satisfied to produce a
valid model that correctly relates the independent variables (IV) to the dependent
measure (DV). Any violation of an assumption will lead to one of two problems: an incorrect estimate of the regression coefficients and/or the estimate of their standard error. The former will lead to an incorrect estimate of the population based on the sample; the latter could lead to incorrect hypothesis tests and confidence intervals. A further discussion of these assumptions and the techniques used to verify their compliance in the current study follows.

**Linearity.** Regression analysis assumes a linear relationship between $Y$ and each of the IVs in the population. That is, the slope of the predictor equation is constant over the full range of the IV. If the data are related in a curvilinear manner, for example, the slope would change as the IV changes specifying a nonlinear relationship between $Y$ and $X$. To show that the linearity assumption was satisfied a plot of the residuals by predicted values was constructed. This plot yielded no discernable pattern. This was confirmed by examining the Kernel smoother line against the linear fit (i.e., zero line). The Kernel smoother line followed the trend of the zero line to the point where the two lines were nearly coincidental. As a result, the data set was compliant with the linearity assumption.

**Correct specification of the IVs.** The assumption of correct specification of the IVs is related to the first assumption and implies that all variables identified by the theory are included in the model, are properly measured, and that the form of the relationship between each IV and DV has been properly specified. If these three conditions are met then the IVs and residuals will be independent in the population.
and the regression coefficient estimates will be unbiased. In short, this assumption answers the question: Should all the IV’s be included in the model?

To determine if the IVs were correctly specified, I examined the respective leverage plots of the targeted factors. These plots examine the relationship between the residuals of the dependent measure (i.e., what remains after all of the factors’ contribution to the DV has been accounted for) and the residuals of the targeted IV (i.e., what remains after all of the other factors’ relationship with the targeted IV has been accounted for). The results of these plots showed that $X_2 = \text{Online vs. Traditional}$, $X_3 = \text{Female vs. Male}$, and $X_{11} = \text{LCPT scores}$ had near zero slopes, with corresponding $p$ values greater than .15. Thus, these variables were incorrectly specified relative to the achievement model and therefore should be removed. I eliminated $X_3$ and $X_{11}$ from the final data set. However, because $X_2$ represented one of the group membership variables, I decided to restructure the Group Membership set from two IVs ($X_1 = \text{Flipped vs. Traditional}$ and $X_2 = \text{Online vs. Traditional}$) to a single IV, namely, $X_1 = \text{Flipped vs. Combined Traditional and Online}$ to preserve the online group data. I then checked this reconstituted IV for compliance to the correct specification of the IVs assumption and found it to be compliant. Therefore, instead of eliminating the online vs. traditional comparison, I merged the two groups into a single group and compared them collectively to the flipped group.

*Measurement error specification.* This assumption states that each IV in the regression equation is measured without error. Measurement error commonly leads
to bias in the estimate of the regression coefficients and their standard errors as well as incorrect significance tests and confidence intervals. Measurement error is easily detected via a measure of reliability. Cohen et al. (2003) indicated that a reliability coefficient between .70 and .90 is to be expected when dealing with instruments that measure attitudes and personality traits. As presented in Chapter 3 (Table 3.5): (a) the Attitudes toward Mathematics Inventory (ATMI) had an overall Cronbach alpha of .97, and the respective alphas for the Enjoyment, Self-Confidence, Motivation, and Value subscales were .96, .90, .91 and .87; (b) the Mathematics Self-Efficacy Scale Revised (MSES-R) had a Cronbach alpha of .96 and the respective alphas for the Problems, Tasks, and Courses subscales were .93, .93, and .92; and (c) the Locus of Control Personality Test (LCPT) had a Cronbach alpha of .69. With the exception of the LCPT, the reliability coefficients of the instruments satisfied Cohen et al.’s threshold of .7. This was of little consequence, though, because as noted earlier, the variable representing LCPT scores was not correctly specified and removed from the final model. As a result, the data set was compliant with the perfect reliability assumption.

**Constant variance of residuals.** This assumption is commonly referred to as the assumption of homoscedasticity, which means that the variance of $Y$ is the same for any $X$. In other words, the variance of the residuals should not be related to any of the IVs or to the predicted value of the DV. If the variance changes as the value of $X$ changes, then this assumption is violated and the statistics from the regression
analysis will be incorrect. Violations of the homoscedasticity of the residuals assumption can be detected by using the same residual analysis (i.e., the residual vs. predicted plot) used for the linearity assumption. Because there was no discernable pattern in this plot, which was confirmed by the Kernel smoother line, the data set satisfied the homoscedasticity of residuals assumption.

**Independence of residuals.** In addition to the constant variance of residuals, the residuals of the observations also must be independent of one another. In other words, there must be no relationship among the residuals for any subset of cases in the analysis. As long as the sample is chosen randomly from the population this assumption will be met. Violations of this assumption usually occur when different observations are made on the same individual at different times and leads to significance tests and standard errors that are incorrect. To determine if this assumption was met, a residual analysis was performed in which the residuals were plotted against the case numbers. This plot yielded no discernable pattern, which was confirmed by examining the Kernel smoother line relative to the fit line. Similar to the linearity assumption, the two lines were nearly coincidental. Thus, the data set was compliant with the independence of the residuals assumption.

**Normality of residuals.** The normality of the residuals assumption implies that for any value of the IV, the residuals around the regression line are assumed to have a normal distribution. Confirmation of this assumption generally is achieved by constructing a normal q-q plot. This plot, which consisted of a superimposed
straight line and a 95% confidence band, showed that nearly all of the data coincided with the line and were enclosed within the confidence band. As a result, the normality assumption was satisfied.

**Summary of preliminary analyses.** As a result of the preliminary analyses presented in this section, the initial data set of $N = 149$ cases and 11 predictors was modified relative to sample size and number of IVs. With respect to the former, 27 students dropped out of the study and an additional five students were identified as outliers. As a result, these 32 cases were removed from the final data set, which reduced the final sample size to $N = 117$. With respect to the latter: (a) the two coded variables representing online and traditional groups were combined into a single IV because one was not compliant with the second regression assumption; (b) the four race/ethnicity variables representing the comparison between Black, Hispanic, Asian, and Other vs. White/Caucasian, respectively, were combined into a single dummy coded IV because of singularity issues and disparate sample sizes; and (c) the variable that represented LCPT scores was removed because it was not compliant with the second regression assumption. As a result, this reduced the final data set to five predictor variables: $X_1 = \text{Flipped vs. Combined Online and Traditional}$, $X_4 = \text{Age}$, $X_9 = \text{ATMI scores}$, $X_{10} = \text{MSES-R scores}$, and $X_{12} = \text{Ethnicity (Other race/ethnic groups vs. White/Caucasian)}$.

**Primary analysis 1: Hypotheses 1–3.** As noted at the beginning of this section, the study’s data were analyzed via a hierarchical multiple regression
strategy with functional sets (Cohen et al., 2003). Students’ final exam scores were regressed hierarchically on the IVs using the entry order of Set A = Group Membership ($X_1$), Set B = Student Attributes ($X_4, X_{12}$), and Set C = Students’ Affective Domain ($X_9, X_{10}$). Table 4.14 contains a summary of the results of these analyses, and a discussion of the unique contribution each set made at each stage of the analysis along with any corresponding follow-up analyses follows.

Table 4.14
Summary of Results from Hierarchical Regression

<table>
<thead>
<tr>
<th>Factor</th>
<th>Model 1 $B^{b}$</th>
<th>Model 2 $B^{c}$</th>
<th>Model 3d $B$</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>17.87***</td>
<td>23.68***</td>
<td>15.30***</td>
<td>[8.71, 21.88]</td>
</tr>
<tr>
<td>$X_1$</td>
<td>2.06*</td>
<td>2.30**</td>
<td>1.98*</td>
<td>[0.46, 3.49]</td>
</tr>
<tr>
<td>$X_4$</td>
<td>-0.28**</td>
<td>-0.21*</td>
<td>-0.21*</td>
<td>[-0.40, -0.02]</td>
</tr>
<tr>
<td>$X_{12}$</td>
<td>-1.44</td>
<td>-1.05</td>
<td>-1.05</td>
<td>[-2.69, 0.58]</td>
</tr>
<tr>
<td>$X_9$</td>
<td>0.02</td>
<td>-</td>
<td>-</td>
<td>[-0.01, 0.05]</td>
</tr>
<tr>
<td>$X_{10}$</td>
<td>0.02</td>
<td>-</td>
<td>-</td>
<td>[-0.01, 0.05]</td>
</tr>
</tbody>
</table>

Statistical Results

| $R^2$ | .054 | .148 | .223 |
| $F$ | 6.580 | 6.530 | 6.370 |
| $p$ | .012 | < .001 | < .001 |
| $\Delta R^2$ | .094** | .075*** |
| $\Delta F$ | 6.230 | 5.36 |

Note. $N = 117$. Set entry order was A-B-C.

*a* Set A = Group Membership consisted of one dummy coded variable, $X_1 =$ Flipped vs. Combined Online and Traditional. Set B = Student Attributes consisted of two variables: $X_4 =$ Age, which represented students’ age in years and $X_{12} =$ Other Race/Ethnic groups vs. White/Caucasian. Set C = Students’ Affective Domain consisted of two variables: $X_9 =$ ATMI scores, which referred to scores on Tapia and Marsh’s (2004) Attitudes toward Mathematics Inventory, and $X_{10} =$ MSES-R scores, which referred to scores on Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale Revised which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale. *b* Model 1 corresponded to $Y = $ student achievement regressed on Set A. *c* Model 2 corresponded to $Y = $ student achievement regressed on Set B in the presence of Set A. *d* Model 3 corresponded to $Y = $ student achievement regressed on Set C in the presence of Sets A and B.

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

Students’ final exam scores were regressed hierarchically on the IVs using the entry order of Set A = Group Membership ($X_1$), Set B = Student Attributes ($X_4, X_{12}$), and Set C = Students’ Affective Domain ($X_9, X_{10}$). Table 4.14 contains a summary of the results of these analyses, and a discussion of the unique contribution each set made at each stage of the analysis along with any corresponding follow-up analyses follows.
Set A = group membership. As noted above, group membership for the final data set consisted of the single variable $X_1 = \text{Flipped vs. Combined Online and Traditional.}$ When final exam scores were regressed on $X_1$, $R^2_{Y,A} = .05$ and the corresponding regression equation was $\hat{Y} = 2.06X_1 + 17.87$. Thus, without any influence from the other sets of variables, students in the flipped classroom averaged 2.06 points higher on their final exam scores than students in the combined online and traditional groups. As reported in Table 4.14, this 2-point difference was significant, $F(1, 115) = 6.58$, $p = .012$, and the group comparison explained 5% of the variance in final exam scores.

Applying the Fisher protected $t$ concept in which follow-up analyses are warranted for significant omnibus results without inflating Type I error rates, I conducted a follow-up analysis to determine the source of the significance. Table 4.15 contains a summary of this follow-up analysis. As reported in Table 4.15, pairwise comparisons showed that the mean group differences in final exam scores between the flipped and online groups was significant, $M_{\text{Diff}} = 2.57$, $t(114) = 2.64$, $p = .009$, but there were no significant mean differences between either the flipped and traditional groups, $M_{\text{Diff}} = 1.67$, $t(114) = 1.83$, $p = .070$, or between the traditional and online groups, $M_{\text{Diff}} = 0.90$, $t(114) = 0.93$, $p = .357$. With respect to the flipped vs. traditional group comparison, although this was not significant at the preset alpha level of .05, if the reader were to accept a slightly higher probability of a Type I error, then this difference was significant at $\alpha = .07$.  

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**Set B = student attributes.** When the student attribute variables consisting of $X_4 = \text{Age}$ and $X_{12} = \text{Other Race/Ethnic groups vs. White/Caucasian}$ entered the analysis in the presence of the Group Membership set, $R_{Y,AB}^2 = .148$ and the corresponding regression equation was $\hat{Y} = 2.30X_1 - 0.28X_4 - 1.44X_{12} + 23.68$. Thus, this overall model explained approximately 15% of the variance in final exam scores, which was significant, $F(3, 113) = 6.53, p < .001$. Furthermore, the unique contribution the two student attribute variables made in explaining the variance in final exam scores was $sR_B^2 = .09$, which also was significant, $F(2, 113) = 6.23, p = .003$. This means that the student attributes of age and the comparison between other race/ethnic groups vs. White/Caucasian collectively provided an additional 9.4% knowledge in the variance of final exam scores in the presence of group membership.

Given a significant omnibus, corresponding follow-up tests found that $X_4 = \text{Age}$ was significant, $B_4 = -0.29, t(114) = -2.85, p = .005$, but the comparison involving race/ethnicity was not significant, $B_{12} = -0.95, t(114) = -1.16, p = .248$. 

---

**Table 4.15**

*Summary of Follow-up Analysis for Set A = Group Membership*

<table>
<thead>
<tr>
<th>Group</th>
<th>$N$</th>
<th>$M$</th>
<th>Pairwise Comparison</th>
<th>$M_{diff}$</th>
<th>$SE_{diff}$</th>
<th>$t(114)$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flipped</td>
<td>43</td>
<td>19.93</td>
<td>Flipped vs. Traditional</td>
<td>1.67</td>
<td>0.91</td>
<td>1.83</td>
<td>.070</td>
</tr>
<tr>
<td>Online</td>
<td>42</td>
<td>17.36</td>
<td>Online vs. Traditional</td>
<td>0.90</td>
<td>0.97</td>
<td>0.93</td>
<td>.357</td>
</tr>
<tr>
<td>Traditional</td>
<td>37</td>
<td>18.26</td>
<td>Flipped vs. Online</td>
<td>2.57</td>
<td>0.97</td>
<td>2.64</td>
<td>.009**</td>
</tr>
</tbody>
</table>

*Note.** $**p < .01.*
This is summarized in Table 4.16. Thus, with respect to the former, the data indicate that age had a significantly negative, or inverse, relationship with achievement: For every 1-year older a student was in age, there was a corresponding approximate 0.29 unit decrease in their final exam score. More concretely, this means that 40-year old students would average approximately three units lower on their final exam scores than 30-year-old students.

**Set C = students’ affective domain.** When the affective domain variables consisting of $X_9 = \text{ATMI (attitudes)}$ scores and $X_{10} = \text{MSES-R (mathematics self-efficacy)}$ scores entered the analysis in the presence of the Group Membership and Student Attributes sets, $R^2_{Y, ABC} = .22$ and the corresponding regression equation was $\hat{Y} = 1.398X_1 - 0.21X_4 - 1.05X_{12} + 0.02X_9 + 0.02X_{10} + 15.30$. Thus, this overall (and final) model explained approximately 22% of the variance in final exam scores, which was significant, $F(5, 111) = 6.37, p < .001$. The unique contribution Set C made in explaining the variability of the final exam scores was $sR^2_C = .075$. 

### Table 4.16

**Summary of Follow-up Analysis for Set B = Student Attributes**

<table>
<thead>
<tr>
<th>$X_i$</th>
<th>$B_i$</th>
<th>SE</th>
<th>$t(114)$</th>
<th>$p_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_4 = \text{Age}$</td>
<td>-0.29</td>
<td>0.10</td>
<td>-2.85</td>
<td>.005**</td>
</tr>
<tr>
<td>$X_{12} = \text{Ethnicity}$</td>
<td>-0.95</td>
<td>0.82</td>
<td>-1.16</td>
<td>.248</td>
</tr>
</tbody>
</table>

*Note. N = 117. The results shown reflect the analysis in which final exam scores were regressed on $X_4$ and $X_{12}$ independent of any other IV. These variables were examined independently because the increment Set B made in explaining the variance in the DV in the presence of Set A was significant, $sR^2_y = .094$, $F(2, 111) = 6.23, p = .003$. 
**See Table 4.14 note for a description of the variables. 
***p < .01.*
This means that when students’ ATMI and MSER-R scores entered the analysis in the presence of group membership and student attributes, students’ affective domain provided an additional 7.5% knowledge in the variance of final exam scores, and this unique contribution was significant, \( F(2, 111) = 5.36, p = .006. \)

Given a significant omnibus, corresponding follow-up tests found that \( X_{10} = \) MSES-R scores was significant, \( B_{10} = 0.03, t(114) = 2.10, p = .038, \) but the relationship involving \( X_9 = \) ATMI scores was not significant, \( B_9 = 0.03, t(114) = 1.70, p = .092. \) This is summarized in Table 4.17. Thus, with respect to the former, the data indicate that a 1-unit increase in mathematics self-efficacy scores equates to a 0.03-unit increase in final exam scores. More concretely, this means that students with a MSES-R score of 200 would average approximately three units higher on their final exam scores than students with a MSES-R score of 100. Although this finding was statistically significant, its practical significance is problematic. This will be discussed further in Chapter 5.

### Table 4.17

<table>
<thead>
<tr>
<th>( X_i )</th>
<th>( B_i )</th>
<th>( SE )</th>
<th>( t(114) )</th>
<th>( p_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( X_9 ) = ATMI</td>
<td>0.03</td>
<td>0.01</td>
<td>1.70</td>
<td>.092</td>
</tr>
<tr>
<td>( X_{10} ) = MSES-R</td>
<td>0.03</td>
<td>0.01</td>
<td>2.10</td>
<td>.038*</td>
</tr>
</tbody>
</table>

*Note. N = 117. The results shown reflect the analysis in which final exam scores were regressed on \( X_9 \) and \( X_{10} \) independent of any other IV. These variables were examined independently because the increment Set C made in explaining the variance in the DV in the presence of Sets A and B was significant, \( \Delta R^2_c = .075, F(2, 111) = 5.36, p = .006. \)

*See Table 4.14 Note for description of variables.

*p < .05.
Primary analysis 2: Hypothesis 4. At this stage of the analysis, only the main effects of the IVs have been considered; that is, the association each factor had with student achievement was examined while holding all other factors constant. This presumes that the effects of group membership, student attributes, and students’ affective domain are additive and that there are no interactions between the effects of these variables. For example, it has been assumed that the effect of group membership relative to achievement is the same for all ages, or equivalently, that the effect of age is the same in any group. However, there is the possibility that group membership and age might interact with respect to their effect on student achievement, and if so, then the relationship between age and student achievement would not be the same for each group.

In any multiple linear regression model there exists the possibility of interaction effects. For example, in the current study’s model with five IVs, there are 10 possible pairs of IVs that could interact. It is unwieldy to test all possible combinations and indeed such blanket testing could give rise to spurious effects, simply because at the 5% significance level some of the interactions might be statistically significant by chance alone. Because the primary objective of the current study was to seek the optimal group membership relative to student achievement, I confined my examinations of interactions to those between group membership and the other IVs. A brief discussion follows.
Group membership vs. student age. The overall interaction model involving group membership ($X_1$), student age ($X_4$), and the interaction between the factors ($X_1 \times X_4$) was significant, $R^2 = .125$, $F(3, 113) = 5.39$, $p = .002$. However, the increment the interaction term made in explaining the variance in final exam scores was not significant, $sr^2 = .001$, $F(1, 113) = 0.13$, $p = .682$. The corresponding interaction plot in Figure 4.1 shows a disordinal interaction. Although the interaction was not significant, the reader should note that as age increases, final exam scores decreases regardless of the instructional group, but in all cases the flipped group was superior with respect to achievement than the other two groups.

![Interaction plot between group membership and age.](image)

*Figure 4.1. Interaction plot between group membership and age.*
Group membership vs. ethnicity (other race/ethnic groups vs. white/caucasian). The overall interaction model involving group membership ($X_1$), ethnicity ($X_{12}$), and the interaction between the factors ($X_1 \times X_{12}$) was significant, $R^2 = .112$, $F(3, 113) = 4.73$, $p = .004$. However, the increment the interaction term made in explaining the variance in final exam scores was not significant, $sr^2 = .024$, $F(1, 113) = 3.05$, $p = .088$. The corresponding interaction plot in Figure 4.2 shows an ordinal interaction. Although the interaction was not significant, the reader will note that regardless of race/ethnic group, the flipped group had higher achievement than the other two groups.

Figure 4.2. Interaction plot between group membership and race/ethnicity (0 = Other Race/Ethnic Groups and 1 = White/Caucasian).
Group membership vs. ATMI scores. The overall interaction model involving group membership ($X_1$), students’ attitudes toward mathematics ($X_9$), and the interaction between the factors ($X_1 \times X_9$) was significant, $R^2 = .155, F(3, 113) = 6.93, p < .001$. However, the increment the interaction term made in explaining the variance in final exam scores was not significant, $sr^2 = .016, F(1, 113) = 2.25, p = .137$. The corresponding interaction plot in Figure 4.3 shows a disordinal interaction. The reader will note that although not significant, it appears that students with more positive attitudes toward mathematics (ATMI scores $\geq 100$) had higher achievement in the flipped group whereas students whose ATMI scores were less than 100 had higher achievement in the traditional class. Overall, though, students in the flipped class had higher achievement than students in the online class regardless of their attitudes toward mathematics.
**Group membership vs. MSES-R scores.** The overall interaction model involving group membership ($X_1$), students’ mathematics self-efficacy ($X_{10}$), and the interaction between the factors ($X_1 \times X_{10}$) was significant, $R^2 = .18$, $F(3, 113) = 8.28, p < .001$. However, the increment the interaction term made in explaining the variance in final exam scores was not significant, $sr^2 = .02$, $F(1, 113) = 2.82, p = .096$. The corresponding interaction plot in Figure 4.4 shows a disordinal interaction. Although not significant, the reader will note that for practical purposes, students in the flipped group had higher achievement compared to the other two instructional models until self-efficacy scores were approximately 240, at which time online students had slightly higher achievement.

**Supplementary analyses 1: Stepwise regression.** Given the exploratory nature of the current study, coupled with the dearth of systematic studies involving
flipped classrooms in college algebra, I ran a stepwise regression analysis to see how the results compared with the findings from the first primary analysis. I employed a forward approach strategy with a probability of .15 to enter the model. As summarized in Table 4.18, the stepwise model yielded three IVs (from strongest to weakest): $X_{10} = \text{MSES-R scores}$, $X_1 = \text{Flipped vs. Combined Traditional-Online groups}$, and $X_4 = \text{Age}$. As indicated in Table 4.17’s note, the stepwise model was significant, $R^2 = .20$, $F(3, 113) = 9.39$, $p < .001$. These variables collectively explained 20% of the variance in final exam scores. The reader will note that these results are nearly identical to the results and corresponding follow-up analyses from the first primary analysis. Thus, the variables that explained a significant amount of variance in final exam scores were: (a) the comparison between the flipped vs. the combined traditional-online groups, which was significant for flipped vs. online via a post-hoc analysis; (b) student age, which had an negative relationship with achievement (final exam scores); and (c) students’ level of mathematics self-efficacy, which had a positive relationship with achievement.

| Table 4.18 | Summary of the Results from Stepwise Regression |
|---|---|---|---|---|
| Independent Variables$^a$ | $B_t$ | $SE$ | $t_{(113)}$ | $p$ |
| Constant | 15.16 | 3.25 | 4.67 | <.001*** |
| $X_{10} = \text{MSES-R scores}$ | 0.04 | 0.01 | 3.27 | .001** |
| $X_1 = \text{Flipped vs. Traditional and Online}$ | 1.90 | 0.75 | 2.54 | .012* |
| $X_4 = \text{Age}$ | -0.23 | 0.10 | -2.37 | .020* |

*Note. $N = 117$. $R^2 = .20$, $F(3, 113) = 9.39$, $p < .001$. Forward stepwise with $p = .15$ to enter. $^a$The order in which the IVs are listed is based on the strength of their association with the DV. $^*p < .05$. $**p < .01$. $***p < .001$. |
Supplementary analyses 2: Formative assessments. Unit exams were used as a formative assessment of students’ college algebra achievement. Three unit exams were administered at the end of a specific set of course work and instructional time throughout the semester. The reader is directed to Chapter 3 (Table 3.4) for the topics covered on each unit exam. Questions on these exams were selected from corresponding homework assignments and consisted of 20 dichotomously scored multiple-choice questions from all levels of Bloom’s (1956) taxonomy. Students had 1 hour and 20 minutes to complete each unit exam. Copies of these exams are provided in Appendix A. Table 4.19 presents a summary of the descriptive statistics results of the unit exams. When the unit exams were analyzed via multiple regression, the results showed that the overall models were not significant and hence there were no differences in scores across the three groups for the three unit exams (see Table 4.20).

Table 4.19
Summary of Means and Standard Deviations for Scores on Unit Exams

<table>
<thead>
<tr>
<th>Group</th>
<th>Unit 1 Exam</th>
<th>Unit 2 Exam</th>
<th>Unit 3 Exam*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Flipped</td>
<td>44</td>
<td>16.57</td>
<td>3.32</td>
</tr>
<tr>
<td>Online</td>
<td>45</td>
<td>15.73</td>
<td>3.46</td>
</tr>
<tr>
<td>Traditional</td>
<td>49</td>
<td>16.16</td>
<td>3.13</td>
</tr>
<tr>
<td>Overall</td>
<td>138</td>
<td>16.19</td>
<td>3.28</td>
</tr>
</tbody>
</table>

Note. Three weighted unit exams were given at the end of a specified set of course work and instructional time throughout the semester. Each exam consisted of 20 dichotomously scored multiple-choice questions. Scores could range from 0 to 20.

*Unit 3 Exam was given the Monday and Tuesday before Thanksgiving Holiday.
This section contains the conclusions regarding the study’s hypotheses testing and are based on results from the two primary analyses that were previously reported in this chapter. All hypotheses were tested at the .05 level of significance. For the convenience of the reader each research hypothesis from Chapter 1 has been restated in null form.

**Null hypothesis 1.** There will be no significant difference in student achievement between students taking college algebra via the flipped classroom and students taking college algebra via the traditional or online classroom. A hierarchical regression analysis in which Set A = Group Membership (flipped vs. combined online and traditional) was entered into the model first resulted in statistical significance, $R^2_{YA} = .05$, $F(1, 115) = 6.58$, $p = .012$ (see Table 4.14). A follow-up analysis showed that the significance in achievement was between students in the flipped and online groups: Students in the flipped group averaged 2

<table>
<thead>
<tr>
<th>Exam</th>
<th>$R^2$</th>
<th>$N$</th>
<th>df</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>.01</td>
<td>138</td>
<td>2, 135</td>
<td>0.71</td>
<td>.493</td>
</tr>
<tr>
<td>Unit 2</td>
<td>.02</td>
<td>134</td>
<td>2, 131</td>
<td>1.43</td>
<td>.243</td>
</tr>
<tr>
<td>Unit 3</td>
<td>.01</td>
<td>123</td>
<td>2, 120</td>
<td>0.58</td>
<td>.562</td>
</tr>
</tbody>
</table>

Note. Each exam consisted of 20 dichotomously scored multiple-choice questions. See Table 3.6 for topics covered on each exam.
units higher on their final exam scores than students in the online group. As a result, Hypothesis 1 was rejected.

**Null hypothesis 2. Student attributes of age, gender, and race/ethnicity will provide no significant predictive gain in the relationship with student achievement when examined in the presence of group membership.** When the student attributes set entered the analysis in the presence of the group membership set, the increment was significant, was $sR^2_B = .09, F(2, 113) = 6.23, p = .003$. The results of follow-up analyses were then used to test the significance of the null hypotheses that corresponded to each attribute factor.

**Null hypothesis 2a. Student age will have no significant effect on student achievement.** Follow-up analysis showed that $X_4 = \text{Age}$ was significant, $B_4 = -0.29, t(114) = -2.85, p = .005$. As a result, Hypothesis 2a was rejected: Student age had a significant negative effect on student achievement.

**Null hypothesis 2b. Student gender will have no significant effect on student achievement.** Preliminary analyses that checked for compliance with the regression assumptions indicated that student gender was not correctly specified and therefore was removed from the final regression model. As a result, Hypothesis 2b was not tested and therefore was not rejected.

**Null hypothesis 2c. Students’ race/ethnicity will have no significant effect on student achievement.** Follow-up analysis showed that $X_{12} = \text{Ethnicity}$, which was a comparison between all other race/ethnic groups and White/Caucasian was
not significant, $B_{12} = -0.95$, $t(114) = -1.16$, $p = .248$. Therefore, Hypothesis 2c was not rejected: Race/Ethnicity had no significant effect on student achievement.

Null hypothesis 3. Students’ affective domain involving attitudes toward mathematics, mathematics self-efficacy, and locus of control will provide no significant predictive gain in the relationship with student achievement when examined in the presence of group membership and student attributes. When the affective domain set entered the analysis in the presence of the group membership and student attributes set, the increment was significant, was $sR^2 = .075$, $F(2, 111) = 5.54$, $p = .006$. The results of follow-up analyses were then used to test the significance of the null hypotheses that corresponded to each attribute factor.

Null hypothesis 3a. Students’ attitudes toward mathematics will not have a significant effect on student achievement. Follow-up analysis showed that $X_9 = $ ATMI scores was not significant, $B_9 = 0.03$, $t(114) = 1.70$, $p = .092$. As a result, Hypothesis 3a was not rejected: Students’ attitudes toward mathematics did not have a significant effect on student achievement.

Null hypothesis 3b. Students’ mathematics self-efficacy will not have a significant effect on student achievement. Follow-up analysis showed that $X_{10} = $ MSES-R scores was significant, $B_{10} = 0.03$, $t(114) = 2.10$, $p = .038$. Therefore, Hypothesis 3b was rejected: Students’ mathematics self-efficacy had a significant effect on student achievement.
Null hypothesis 3c. Students’ locus of control will not have a significant effect on student achievement. Preliminary analyses that checked for compliance with regression assumptions indicated that the $X_{11} = \text{LCPT}$ scores was not correctly specified and therefore was removed from the final regression model. As a result, Hypothesis 3c was not tested and therefore was not rejected.

Null hypothesis 4. There will be no significant interaction effect between group membership and any of the targeted variables with respect to student achievement. Four separate interaction models were examined for significance using a hierarchical regression strategy. These analyses involved the respective interactions between group membership and (a) student age, (b) ethnicity, (c) students’ attitudes toward mathematics, and (d) students’ mathematics self-efficacy. *(Note: The factors of gender and locus of control were not tested because they were removed as part of the primary analysis.)* In all four cases the increment the interaction—which was represented by the product of the two factors under discussion—made in explaining the variance in final exam scores was not significant: (a) $sr^2 = .001$, $F(1, 113) = 0.13$, $p = .682$; (b) $sr^2 = .024$, $F(1, 113) = 3.05$, $p = .088$; (c) $sr^2 = .016$, $F(1, 113) = 2.25$, $p = .137$; and (d) $sr^2 = .02$, $F(1, 113) = 2.82$, $p = .096$. Therefore, Hypothesis 4 was not rejected: There is no significant interaction between group membership (flipped, traditional, and online) and the respective factors of age, ethnicity, attitudes toward mathematics, and mathematics self-efficacy relative student achievement.
Chapter 5

Conclusions, Implications, and Recommendations

Summary of Study

The primary purpose of the current study was to examine the relationship three different instructional models—flipped, online, and traditional—had with students’ mathematics achievement. In addition to the group membership set, which consisted of comparisons between online vs. flipped and traditional vs. flipped models, several other research factors were targeted and placed into separate sets. These include the set of student demographics, which consisted of gender, age, and race/ethnicity, and the set of students’ affective domain, which consisted of attitudes toward mathematics, mathematics self-efficacy with respect to algebra, and locus of control. The research methodology/design that best fit the current study was a quasiexperimental research design. This design was appropriate because I endeavored to examine the relationship between various sets of variables and students’ mathematics achievement in college algebra using intact classes.

The target population was all college students who took MAC 1105, College Algebra, at a Florida state college that confers 2-year degrees. The target population was delimited to a smaller accessible population that consisted of students who enrolled in MAC 1105 at Eastern Florida State College (EFSC). Using a convenience sampling strategy, the initial sample size was \( N = 149 \) and consisted of six sections of intact classes of MAC 1105 offered during the 16-week
fall 2015 semester: four face-to-face sections from the Palm Bay campus of ESFC and two online sections from the college’s eLearning component. I purposively assigned the four face-to-face sections to either the flipped or traditional model. After preliminary data screening and before conducting inferential statistics, the final sample was \( N = 117: N_{\text{flipped}} = 42, N_{\text{online}} = 33, \text{ and } N_{\text{traditional}} = 42 \). The composition of the sample obtained in the current study was reported in Chapter 3 (see Tables 3.1–3.3), and a comparison between the students who dropped the course and those who remained was provided in Chapter 4 (see Table 4.13). Each instructional model covered the same material, used the same textbook, completed the same assessments, and followed a set schedule so that concepts were presented and tests were administered during the same week for all models.

The data collection instruments consisted of several different assessments: (a) a four-section questionnaire, (b) a test of prerequisite skills (TPRS), (c) three unit exams, and (d) an end-of-semester comprehensive final exam. The first three sections of the questionnaire employed standardized instruments, and the last section was a researcher-constructed demographic survey. The standardized instruments included Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory (ATMI), Rotter’s (1966) Locus of Control Personality Test (LCPT), and Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale-Revised (MSES-R) which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale. The TPRS was from Lake (2008) and Odu (2008), the unit exams were researcher-
constructed using textbook problems from homework assignments, and the final exam was from Lake (2008). For the nonstandardized instruments, attention was given to content validity, and Cronbach’s alpha was used to assess the reliability of all the instruments based on data acquired from the sample. A complete summary of the reliability information for all the instruments was provided in Chapter 3 (see Table 3.5). The reader will note from Table 3.5 that the overall alphas for the instruments ranged from .63 to .97 and were considered acceptable in practice (Cohen et al., 2003) and for making decisions about groups of individuals (Worthen et al., 1999).

Summary of Findings

Prior to testing the study’s hypotheses, preliminary data screening was done in the form of outlier analysis, multicollinearity, missing data analysis, and confirming the data set was compliant with multiple linear regression assumptions. The result of these analyses reduced the data set from $N = 149$ to $N = 117$. Working with this “clean” data set, two primary hierarchical multiple regression analyses and two supplementary analyses were performed. The first analysis was related to the first three hypotheses and focused on the amount of incremental knowledge each set of variables provided in explaining the variance in final exam scores. The second primary analysis was related to the fourth hypothesis and focused on the respective interactions between group membership and the other predictors relative
to achievement. The two supplementary analyses consisted of a stepwise regression and an examination of the formative assessments. These latter two analyses were performed from an exploratory perspective to provide additional insight into the relationship the instructional models had with the research factors. A brief summary of the findings follows, and Table 5.1 contains the results of the corresponding hypothesis testing with respect to the findings from the two primary analyses.

Table 5.1

Summary of Results from Hypothesis Testing ($\alpha = .05$)

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. There will be no significant difference in student achievement between students taking college algebra via the flipped classroom and students taking college algebra via the traditional or online classroom.</td>
<td>Rejected$^b$</td>
</tr>
<tr>
<td>2a. Student age will have no significant effect on student achievement.</td>
<td>Rejected$^e$</td>
</tr>
<tr>
<td>2b. Student gender will have no significant effect on student achievement.</td>
<td>Failed to Reject</td>
</tr>
<tr>
<td>2c. Students’ race/ethnicity will have no significant effect on student achievement.</td>
<td>Failed to Reject</td>
</tr>
<tr>
<td>3a. Students’ attitudes toward mathematics will not have a significant effect on student achievement.</td>
<td>Failed to Reject</td>
</tr>
<tr>
<td>3b. Students’ mathematics self-efficacy will not have a significant effect on student achievement.</td>
<td>Rejected$^d$</td>
</tr>
<tr>
<td>3c. Students’ locus of control will not have a significant effect on student achievement.</td>
<td>Failed to Reject</td>
</tr>
<tr>
<td>4. There will be no significant interaction effect between group membership and any of the targeted variables with respect to student achievement.</td>
<td>Failed to Reject</td>
</tr>
</tbody>
</table>

Note. $N = 117$.

$^a$Hypotheses were tested using a hierarchical multiple regression strategy with the set entry order of A-B-C where A = group membership, B = student attributes, and C = affective domain. The reported $sR^2$s represent the unique knowledge a variable provided in explaining the variability of the targeted dependent measure in the presence of the other variables (ACH = student college algebra achievement). $^b$Hypothesis 1 was rejected because the increment in final exam score variability explained by group membership set was significant. $^c$Hypothesis 2a was rejected because the increment in final exam score variability explained by students’ age was significant. $^d$Hypothesis 3b was rejected because the increment in final exam score variability explained by students’ mathematics self-efficacy scores was significant.
Primary analysis 1: Hypotheses 1–3. The first primary analysis examined the incremental contribution each set made in explaining the variance in students’ final exam scores based on the set entry order of A-B-C, where: Set A = Group Membership, which consisted of a single variable that compared the flipped model to the combined online and traditional models; Set B = Student Attributes, which consisted of the variables representing students’ age and a comparison between all other race/ethnic groups vs. White/Caucasian; and Set C = Students’ Affective Domain, which consisted of the two variables representing students’ scores on the ATMI and the MSES-R. As reported in Table 4.14 (Chapter 4), significant relationships at the preset alpha level of .05 were found at each step of the analysis. Stage 1 follow-up revealed that the significance was between the flipped and online groups: students in the flipped group had a significantly higher mean final exam score than students in the online group (see Chapter 4, Table 4.16). Stage 2 follow-up revealed that student age had a significant negative relationship with final exam scores: as age increased, final exam scores decreased (see Chapter 4, Table 4.16). Stage 3 follow-up revealed that students’ mathematics self-efficacy related to algebra had a significant positive relationship with final exam scores: As self-efficacy scores increased, final exam scores increased (see Chapter 4, Table 4.17).

Primary analysis 2: Hypotheses 4. As reported in Chapter 4 and illustrated in Figures 4.1–4.4, the four interaction models involving group membership vs. each of the targeted factors of age, race/ethnicity, attitudes toward mathematics,
and mathematics self-efficacy, respectively, and their corresponding interactions were significant. However, none of the increments the interaction terms made in explaining the variance in final exam scores was significant. Although the interactions were not statistically significant, from a practical perspective it appears the flipped instructional model had higher achievement than the other two instructional models with respect to age, race/ethnicity, and attitudes toward mathematics once ATMI scores were greater than 100, and mathematics self-efficacy when MSES-R scores were less than 240.

Supplementary analyses 1: Stepwise regression. The first supplementary analysis was stepwise regression using a forward addition procedure. As reported in Table 4.18 (see Chapter 4), the final model consisted of three significant variables (from strongest to weakest): mathematics self-efficacy, group membership, and student age. These findings were consistent with the findings of the hierarchical regression and suggest that students’ ethnicity and attitudes toward mathematics do not make a significant contribution to student achievement.

Supplementary analyses 2: Formative assessments. The second supplementary analysis examined differences among the three unit exams. As reported in Table 4.19 (see Chapter 4): (a) the online group consistently scored less on each unit exam when compared to the other two groups; (b) the respective mean scores for all three groups decreased from Unit Exam 1 to Unit Exam 2 and then increased from Unit Exam 2 to Unit Exam 3; and (c) from Unit Exam 1 to Unit
Exam 2, the online group’s mean score declined approximately 6 points. As noted in Table 4.20 (see Chapter 4), however, these group mean differences were not significant.

**Conclusions and Inferences**

In this section, the study’s findings are summarized and discussed in terms of the research questions posed in Chapter 1; a separate presentation is given for each question. Included in the presentations are summaries of the findings, interpretations of the results in the context of the research setting, and plausible explanations for the results obtained.

**Research question 1: What is the relationship between group membership and student achievement?** A hierarchical regression analysis in which Set A = Group membership (flipped vs. combined online and traditional) was first entered into the model resulted in statistical significance and accounted for 5.4% of the variability in final exam scores (Table 4.14). Follow-up pairwise comparisons (Table 4.15) showed that students in the flipped group respectively scored on average 2.57 and 1.67 higher on the final exam than students in the online and traditional groups. Relative to the preset alpha level of .05, the flipped-online comparison was significant, but the flipped-traditional comparison was not. However, the latter comparison was significant for $\alpha = .07$. Thus, if the reader is willing to accept this slightly higher alpha level, then students in the flipped group also averaged significantly higher scores than those in the traditional group. There
was no significant difference in final exam scores between the online and traditional groups.

One plausible explanation for these results is grounded in the theory of constructivism (i.e., students learn by doing rather than by observation). Doing rather than observing is exactly what took place in the flipped model. It is feasible that each class session spent via guided practice reinforced the concepts that the students had covered in the lectures outside of class. These guided practice sessions allowed the students to ask questions and shore up any misconceptions in real time while working on their homework. Hence, it is conceivable that the flipped model promoted a more meaningful learning experience that enabled students to strengthen their understanding of the course material, which then led to better retention of the concepts when compared to the other instructional models, particularly the online group where there is little real-time interaction with the instructor or other students.

A second plausible explanation is the social interactions that the students experienced in the flipped model. With the advent of social media, students are more inclined to interact and communicate with one another during class time rather than sitting and listening to a lecture. Because of this, students in the flipped model were more engaged in the learning process from the start of class until the end of class than students in the traditional model.
Research question 2: What is the relationship between student attributes and student achievement? Of the current study’s targeted student attributes—gender, age, and race/ethnicity—students’ gender was flagged during preliminary data screening as not being correctly specified relative to its relationship with achievement and therefore was removed from the final model. Similarly, to address a singularity issue that emerged during preliminary data screening, the race/ethnicity variable was recoded to reflect Other Race/Ethnic groups vs. White/Caucasian. A hierarchical regression analysis in which Set B = Student Attributes (age and the recoded race/ethnicity variable) entered the model in the presence of Set A resulted in a 9.4% incremental increase in explaining the variance in final exam scores (Table 4.14); this increase was significant. Follow-up analysis (Table 4.16) showed that race/ethnicity was not significant, but student age had a significant and negative effect on student achievement. More specifically, for every 10 years older a student was in age, there was a corresponding 2.9-unit decrease in final exam scores.

A plausible explanation for this result is the amount of outside commitments older students have compared to those of younger students. Older students tend to have more life commitments than those of younger students. In general a majority of older students are employed and have young children for whom to care for. It is conceivable that these other commitments could detract from
the time needed to complete their studies. This was evident from the demographic data the students self-reported.

A second plausible explanation is time away from the educational setting. Younger students are more in tune with the educational setting as they’ve just completed (or are not too far removed) from high school and the skills required to be successful in an educational setting are still fresh to them. For older students there is a larger gap in time between high school and college. This gap in time implies older students might no longer possess the skills required to be successful and must relearn them.

**Research question 3: What is the relationship between students’ affective domain and student achievement?** Of the current study’s targeted affective domain factors—attitudes toward mathematics, mathematics self-efficacy, and locus of control—students’ locus of control personality test scores was flagged during preliminary data screening as not being correctly specified relative to its relationship with achievement and therefore was removed from the final model. A hierarchical regression analysis in which Set C = Students’ Affective Domain (ATMI and MSES-R scores) entered into the model in the presence of Sets A and B resulted in a 7.5% incremental increase in explaining the variance in final exam scores (Table 4.14); this increase was significant. Follow-up analysis (Table 4.17) showed students’ attitudes toward mathematics was not significant, but their mathematics self-efficacy had a significant and positive effect on student
achievement. More specifically, for every 100-unit increase in mathematics self-efficacy scores, final exam scores increased 3 points. Given that self-efficacy scores could range from 52 to 260, a 100-point difference is possible particularly for someone with low mathematics self-efficacy (e.g., MSES-R = 100) vs. someone with high mathematics self-efficacy (e.g., MSES-R = 200).

One plausible explanation for this result is grounded in the concept of self-efficacy, namely, it is a belief or self-perception people have about how confident they are in their ability to perform a specific task. In the context of mathematics education, self-efficacy is not related to students’ actual level of mathematics competency, it is concerned with how they judge their ability to be successful in mathematics. Thus, it is conceivable that regardless of their actual mathematics skills, students who perceived as having strong mathematics skills would have better performance, and this is exactly what was found in the current study.

A second plausible explanation for this result is the nature of the MSES-R. As noted in Chapter 3 (Instrumentation section), this mathematics self-efficacy instrument measured undergraduate students’ perceived beliefs about their ability to perform mathematics related tasks and behaviors and was relative to a first course in algebra. Because the MSES-R was administered after the 1st week of classes, it is conceivable that students, regardless of group membership, interpreted the questions as being “easy” to answer and this could have influenced their self-efficacy in a positive manner, which then was carried throughout the semester. In
other words, because of the MSES-R, students could have started the semester with a relatively high level of self-efficacy.

Research question 4: What interaction (if any) does group membership have with student attributes and with students’ affective domain, respectively, relative to student achievement? The current study examined four separate attribute-treatment interaction models between group membership (flipped, online, and traditional instructional models) and each of the respective factors of age, ethnicity, attitudes toward mathematics, and mathematics self-efficacy relative to student achievement. The results of the corresponding hierarchical regression analyses showed there were no significant interactions between group membership and the respective factors.

One plausible explanation for these results is related to the relative homogenous nature of the sample. As reported in Chapter 3 (Table 3.3), there was very little variation in age across all three groups, and the majority of students were White/Caucasian. Similarly, as reported in Chapter 4 (Tables 4.2 and 4.7), there was very little variability in students’ attitudes toward mathematics and self-efficacy across all three groups.

A second plausible explanation is sample size. The effect sizes for each of the interaction models were .001, .024, .016, and .02, respectively, for age, race/ethnicity, attitudes toward mathematics, and mathematics self-efficacy. Based on an alpha level of .05 and a minimum power of .8, to find significant interaction
effects based on these effect sizes would require sample sizes between $N = 329$ and $N = 7,850$. The current study’s sample size was $N = 117$.

**Implications**

This section discusses the implications of the study from three perspectives: (a) implications relative to the theoretical foundation presented in Chapter 2; (b) implications relative to the prior research presented in Chapter 2; and (c) implications relative to educational practice, which inform the reader of what the results mean for the educational community.

**Implications relative to theory.** The theoretical foundation of the current study was based on (a) cognitive constructivism, which was grounded in Piaget’s (1953) theory of cognitive development; (b) social constructivism, which was grounded in Vygotsky’s (1962) sociocultural theory, and (c) Bandura’s (1977) self-efficacy theory. A brief overview of each theory is first presented. This is then followed by a discussion of the implications of the study’s findings relative to each theory and if the study’s findings support or refute the given theory.

**Cognitive constructivism.** The basic principle of the constructivist perspective of cognitive learning theory is that students learn by doing rather than by observing, and therefore teachers should not convey knowledge to students but instead students must take an active role in their learning by creating new knowledge for themselves. According to Powell and Kalina (2009) in cognitive development, ideas are constructed in individuals through a personal process,
where as in social constructivism, ideas are constructed through interactions with the teacher and other students. According to Piaget (1953), learning is a process that involves learners trying to adapt new knowledge to their existing conceptual framework. Learners accomplish this either by integrating new knowledge into their own schemas or by modifying their existing schemas. Piaget referred to this process as assimilation and accommodation. If learners can comfortably integrate new knowledge into their existing schemas, then assimilation occurs and learners are considered to be in a state of mental equilibrium. On the other hand, if learners cannot comfortably integrate new knowledge into their existing schemas, then they must modify their existing schemas or create new ones to accommodate this new knowledge. When trying to resolve this inconsistency between new knowledge and their current cognitive structure, a learner is considered to be in a state of mental disequilibrium, or cognitive dissonance, because “…one has to adjust his or her thinking (schema) to resolve conflict and become more comfortable” (Powell, 2006, pp. 26–27). Only through accommodation can learners modify their existing schemas to fit new information and return to a state of equilibrium—a cognitive state where everything is balanced.

The findings of the current study in which the flipped classroom promoted the concept of cognitive constructivism, supported Piaget’s (1953) theory of cognitive development. As reported earlier, students in the flipped group had significantly higher achievement than students in the online group and students in
the traditional group (for \( \alpha = .07 \)). Relative to theory, this significant difference could be attributed to the manner in which the flipped classroom was designed. Instead of lecturing to students, I worked with them individually to help them learn how to understand and solve mathematical problems. As they worked on their assignments, mistakes were made and students experienced disequilibrium. Although this is similar to what occurs when students work on their assignments outside of class, the difference was that the time spent in the state of disequilibrium was minimized because I was accessible to help students modify their existing cognitive structure.

**Social constructivism.** The concept of social constructivism is grounded in Vygotsky’s (1962) sociocultural theory, which posited that learning is a social endeavor and is facilitated by community and culture. Vygotsky believed that when individuals work cooperatively to solve problems, they develop more sophisticated strategies and thought processes than if they worked alone. He stressed that this was particularly the case when someone works with a more intellectually advanced (competent) individual such as a teacher, parent, or more advanced student. According to Vygotsky (1987), learning proceeds from an awareness state to an understanding state. He referred to this progression from awareness to understanding as "the link of the zone of proximal and actual development" (p. 220, emphasis in original). Thus, the awareness state, which is the zone of proximal development (ZPD), represents a cognitive state where a student has acquired
sufficient background information about a concept, but needs help to fully grasp an understanding of the concept. The ZPD, then, refers specifically to the zone where students are able to perform various tasks when being assisted by someone else but are unable to accomplish them on their own. As a result, cognitive growth occurs when students attempt new tasks that they can only accomplish when being guided by another person.

The findings of the current study supported Vygotsky’s (1987) sociocultural theory, and the concept of Vygotsky’s ZPD was manifested in the flipped classroom by the guidance I provided students as they worked alone or with classmates to complete homework assignments. As expected, there were extensive instructor-student interactions during each class period in which I served in the role of guide or mentor to help clarify concepts, respond to questions about assignments, and assess the level of student understanding by checking their solutions. There also were extensive student-student interactions in which students asked each other questions and exchanged their perspectives on how to solve a problem. This promotion of instructor- and peer-student interactions within the flipped classroom was consistent with the basic foundation of social constructivism. Thus, it is reasonable to speculate that the flipped group’s achievement was higher than that of the other two instructional models because the class structure was more of a manifestation of the constructivist perspective of cognitive learning theory and embodied Vygotsky’s ZPD. Compared to the other
two instructional models, students in the flipped classroom had greater success—and concomitantly, greater cognitive growth and higher achievement—because they were able to work on their assignments under my tutelage. Inherent in Vygotsky’s (1962) description of ZPD is the concept of scaffolding, which “is an assisted learning process that supports the ZPD, or getting to the next level of understanding, of each student from the assistance of teachers, peers, or other adults” (Powell & Kalina, p. 244). When applied to the context of the current study, the concept of scaffolding also was an integral part of the flipped classroom.

**Self-efficacy theory.** A third theoretical grounding of the current study was Bandura’s (1977) theory of self-efficacy, which refers to a person’s judgment about how confident he or she is in being able to perform a task. Thus, self-efficacy is a belief or self-perception people have about themselves regarding the confidence they have in their ability to do something. Self-efficacy is not related to a person’s actual level of competency, but instead is concerned with how a person judges his or her capabilities relative to performing specific actions. Bandura described two sets of efficacy outcomes: efficacy expectancy and efficacy expectation. He defined the former as a person’s estimate that a given behavior will lead to certain outcomes, and he defined the latter as the conviction a person has in his or her ability to successfully execute the behavior that is needed to produce an outcome. People with high self-efficacy tend to set higher goals for themselves, and are more likely to exert greater effort when attempting to accomplish something and have
higher levels of perseverance when encountering obstacles than individuals with low self-efficacy. Specific to student learning and achievement, students with a sense of high self-efficacy tend to learn and achieve more than students with a low sense of self-efficacy. Thus, given two students with equal abilities, the student with higher self-efficacy is more likely to accomplish a given task successfully than the student who does not believe he or she is capable of success.

The findings of the current study supported self-efficacy theory. As reported earlier, there was direct and significant relationship between students’ self-efficacy scores on the MSES-R and student achievement. Students who had a higher level of self-efficacy also had higher achievement than students who had a lower level of self-efficacy. This relationship also was not restricted to any single group. As depicted in Figure 4.4, the slope of the lines representing each group is positive, which confirm that the findings were consistent with Bandura’s (1977) position that as self-efficacy increases so too does performance.

Summary of theoretical grounding. The concept of constructivism was manifested in all instructional models. The flipped classroom embodied the concepts of cognitive and social constructivism as well as self-efficacy theory, whereas the online and traditional classroom models embodied the concept of cognitive constructivism. The concept of self-efficacy also had a direct influence on student achievement regardless of group membership. The combined theories of constructivism and self-efficacy suggest that the self-efficacy of students in the
flipped classroom improved as the semester progresses because of the one-on-one attention they received while working on homework problems. This in turn led to an increase in students’ perceived ability to be successful in mathematics and yielded higher achievement. This change in self-efficacy was confirmed by the difference between pre- and post-MSES-R scores as presented in Chapter 4 (Table 4.12). Even though the traditional group had the highest gain in perceived confidence to solve mathematics problems, their performance on the final exam was lower than that of students in the flipped group. This implies that students in the traditional model had a false sense of confidence in their ability to successfully solve mathematics problems. It would be interesting to see if such high gains still existed after students in the traditional model received their final exam scores. On the other hand, students in the flipped group had the highest pre-to-post gain in self-efficacy with respect to their perceived ability to perform mathematically related tasks whereas students in the other two instructional models had a pre-to-post decrease.

**Implications relative to prior research.** It has been shown by the results of the current study that instructional model (flipped, online, and traditional) had an effect on student achievement in college algebra. More specifically, students taking college algebra via the flipped model had significantly higher achievement than students who took college algebra via the traditional or online model. The implications of these results are compared in this section to the results of prior
research from two perspectives: (a) the effect of the flipped classroom in various mathematics and mathematics-related disciplines, and (b) the effect of the flipped classroom in college algebra.

**Mathematics and mathematics-related disciplines.** The studies reviewed in Chapter 2 described findings from studies that either implemented a flipped classroom or were related to the concept of a flipped classroom. Several of these studies did not focus on achievement, though, but instead focused on students’ perceptions of the flipped model and therefore do not lend themselves to comparison. This section focuses only on those studies to which the findings of the current study could be compared.

Foertsch et al. (2002) used eTEACH, an online streaming video and multimedia application, to teach a computer science course using a flipped classroom. The findings from the current study cannot be compared directly to those of Foertsch et al. because Foertsch et al. did not report student achievement data. Instead, they reported students’ perceptions of the flipped classroom.

According to Foertsch et al., 59% of the students felt that the flipped classroom had a positive effect on their learning while 25% felt it did not make a difference. Although not reported in Chapter 4, at the end of the semester I asked students to rate their preference for the instructional model they would choose if given the choice based on a Likert-type scale of 1 = Strong preference for traditional classroom, 2 = Preference for tradition classroom, 3 = Neutral preference, 4 =
Preference for flipped classroom, and 5 = Strong preference for flipped classroom. Approximately 50% of the students selected a preference-to-strong preference for the flipped mode, which was consistent with Foertsch et al. Students in the flipped group also were asked to express their likes and dislikes about the flipped model. As reported in Appendix D, these comments also are consistent with the comments made by students in Foertsch et al.’s study.

Fulton (2012) reported that teachers at Byron High School (near Rochester, Minnesota) decided that the flipped classroom model would be the best approach to teaching their courses to address the lack of funding to purchase new textbooks aligned to the new state mathematics standards. Starting with the 2010–2011 school year, teachers created their own videos for their courses, uploaded the videos to YouTube, and students were allowed to access any teacher’s videos they wanted. At the end of the 1st year of using the flipped classroom model, Fulton reported that the percentage of students who scored 80% or above on unit assessments increased 9.8% in calculus and 6.1% in precalculus. Furthermore, students’ mathematics mastery level on the Minnesota Comprehensive Assessment increased during this period, and that 94.7% of Byron’s seniors completed four or more credits of mathematics. Although Fulton did not have any comparison groups, the results of the current study are consistent with Fulton’s findings given that students in the flipped group had the highest level of achievement among the three groups. This
higher level of achievement was consistent across the first two unit exams as well as the final exam.

Gannod et al. (2008) used a software engineering course to restructure their instructional approach to accommodate the flipped classroom model. They felt that as an applied discipline that involves interacting with customers, collaborating with developers, and hands-on development of software, an active approach to learning in this course would be best for students; hence the use of the flipped classroom. Gannod et al. reported that the results of an end of course survey showed that all students either strongly agreed or agreed that the use of the flipped classroom helped them in learning how to create C# applications that utilized web services, and that it appeared students’ perceptions of the flipped classroom were generally positive. Once again, based on the results of the end-of-semester query (Appendix D), the findings of the current study were in general agreement with the findings of Gannod et al.

Zappe et al. (2009) used the flipped classroom approach to determine if it would prepare students to be active learners. Zappe et al.‘s research on the flipped classroom was driven by the need to better understand how students used video lectures and their perceptions of the flipped classroom. As part of their study, Zappe et al. administered surveys to students that asked students to report what benefits they perceived from the flipped class and whether they favored the flipped class over a traditional class setting. Zappe et al. reported 74% of the students
perceived that the flipped classroom was helpful in understanding concepts, a vast majority of the students also reported not wanting every class to be held in the flipped format. Based on results and anecdotal information from the end-of-term survey that was administered to the flipped group (Appendix D), the findings of the current study are mostly consistent with those of Zappe et al., although only about 50% of the current study’s students in the flipped group expressed a preference for this model over the traditional model.

**The flipped classroom in college algebra.** Three studies examined the effect of the flipped classroom specifically in college algebra. Jaster (2013) examined college algebra students’ perceptions of and engagement in a flipped classroom as well as the effect a flipped classroom had on achievement using a mixed-methods design. The purposes of his study were to (a) ascertain how students perceived a college algebra flipped classroom, (b) identify any relationship between perceived learning contributions of various elements (video viewing, note taking, and problem solving) of an inverted college algebra classroom and grade outcome, and (c) identify any relationship between levels of engagement with various elements (video viewing, note taking, and problem solving) of an inverted college algebra classroom and grade outcome. As reported in Appendix D, the current study’s findings are similar to those of Jaster who reported that approximately 46% of students indicated that the flipped classroom was beneficial to their success. There was however a little difference when it came to the number
of students in Jaster’s study (54%) who would have preferred the traditional model to the flipped model than in the current study (37.5%).

Overmyer (2014) used a quasiexperimental design to examine the mathematical achievement differences between students in traditional college algebra classrooms and college algebra classes taught using the flipped classroom method. The purpose was to investigate the mathematical achievement differences between students in traditional college algebra classrooms and college algebra classes taught using the flipped classroom method. The results of the current study were partly similar to those of Overmyer who reported there was no significant difference in achievement between the flipped and traditional classrooms. Although this was indeed the case for the current study at the present alpha level of .05, there was a significant different, though, at an alpha level of .07.

**Implications for educational practice.** The implications of the results from the current study for educational practice are substantial. First and foremost, it has been shown in the current study that the flipped classroom supports higher student achievement when compared to that of both the online and traditional classrooms. This implies that the online and traditional instructional models in which practice and application of concepts are performed outside of class and in the absence of instructor support is not as effective as the flipped classroom where instructor support is present.
A second implication of the study’s results to educational practice is related to student’s age. Regardless of group membership, older students were not as successful as younger students when it comes to final grades in college algebra. Despite this lack of success, students in the flipped model still out performed students in the other two models as age increased. Considering this study was conducted at a state college where a majority of the students have families and jobs that can detract them from their studies, older students are still better served via the flipped model as practice sessions are completed free of these everyday distractions. These results imply that perhaps older students, who presumably have never experienced the concept of a flipped instructional model, are not aware of the time commitment needed to view the instructional videos outside of classes.

A third implication of the study’s results to educational practice is related to students’ mathematics self-efficacy. The current study found there was a significant and positive relationship between mathematics self-efficacy and achievement in college algebra regardless of group membership. This implies that it might be beneficial to students for instructors to first assess students’ mathematics self-efficacy at the beginning of a term to determine which students would need to improve their level of self-efficacy.

A fourth implication of the study’s results to educational practice is related to both students’ gender and ethnicity. The current study found no significant difference in college algebra achievement with respect to gender and race/ethnicity.
The implication of this finding relative to gender is that mathematics instructors are doing a good job in ensuring gender equity in their mathematics instruction. With respect to race/ethnicity, though, the implication to practice is there were not enough participants across all the different race/ethnic groups to make any type of meaningful comparisons, and that perhaps this factor was more of a constant than a variable.

A fifth implication of the study’s results to educational practice is related to students’ attitude toward mathematics. The current study found no significant relationship between students’ attitudes toward mathematics and achievement in college algebra. This implies that students’ attitudes toward mathematics were similar across all groups. With respect to the current study, these attitudes were generally positive, which suggests that instructors of the prior mathematics classes students took at EFSC (or in grade school) are doing a respectable job at promoting students’ attitudes toward mathematics.

A sixth implication of the study’s results to educational practice is related to the amount of hours students worked per week. The current study found that students who dropped the course worked on average 16 hours more per week than students who completed the course, and this 16-hour difference was significant. Although this finding was independent of group membership, it implies that perhaps students who take college algebra are not aware of the impact their outside work schedule has on their studies.
Generalizability, Limitations, and Delimitations

Generalizability. The main criteria for external validity is the development of generalization, and whether results acquired from the sample can be extended to make predictions about the entire population. External validity is usually divided into two separate types, population validity and ecological validity, and they are both vital elements in determining the strength of an experimental design. A case for population generalizability, which refers to the samples’ representativeness of the targeted population, has already been made in Chapter 3. Based on the sample demographics (Tables 3.1 and 3.3), the results are generalizable to both the accessible (all campuses of EFSC) and target (all college students who took MAC 1105, college algebra at a Florida state college that confers 2-year degrees) populations based on student demographics provided by the Florida Department of Education (FLDOE).

By virtue of gaining enough control over the experimental method employed in the current study, ecological generalizability, which refers to the extent the method, materials, and settings of a study approximate the real world, is left to the reader to determine. All aspects of this study have been presented in their entirety in this dissertation. As a reminder to the reader, this study was confined to one campus of one 2-year college in the state of Florida; extending the results to a 4-year college in Indiana, for example, could be problematic.
Study limitations and delimitations. As is the case in most research, the current study was subjected to various limitations and delimitations. As a courtesy to the reader, the limitations and delimitations of the current study presented in Chapter 1 are replicated in this section. This replication also provides a transition to the next section, which discusses recommendations for future research relative to these limitations and delimitations.

Limitations. Limitations of a study are events, conditions, or circumstances outside the control of the researcher that limit population and ecological generalizations of a study’s results. Therefore, any interpretations, explanations, or generalizations of the results of the current study should take the following limitations into consideration:

1. Textbook. A college-wide college algebra textbook selection committee selected the textbook that was used in the current study. This textbook also contained a set of instructional videos that were used for the flipped and online classrooms. As a result, similar studies that use a different textbook and/or videos might not yield the same results.

2. Course curriculum. College algebra is a common course, MAC 1105, offered throughout Florida’s colleges and universities and as such has a well-defined curriculum. As a result, similar studies that use a different college algebra curriculum might not yield the same results.
3. Instructional schedule. The instructional schedule for the targeted course will vary among universities and colleges. For example, some schools might offer the course 1, 2, or 3 days per week for a conventional 16-week semester, others might offer it during a 10-week quarter system, and still others might offer it on a nonconventional schedule (e.g., 3 days per week at 4 hours per day for 4 weeks). This means that studies involving an instructional schedule different than that used in the current study might yield different results.

4. Sample demographics. The demographics of the participants of any study influence the results of the study because of the different attributes that define the participants. As a result, similar studies with different sample demographics will not necessarily yield similar outcomes as the current study. Information on the current study’s sample demographics is provided in both Chapters 3 and 4 to aid the reader in making comparisons for generalizability purposes.

5. Add-drop period. During the 1st week of classes, students were free to add or drop any course. This means it is conceivable that students who initially enrolled into one of the targeted sections of MAC 1105 might have dropped or changed sections during this period, which has the potential of altering the complexion of the sections (e.g., all low achieving students might opt for the flipped model). As a result, similar studies that do not include an add-drop period, or studies in which the add-drop period is longer than 1-week, might yield different results.
**Delimitations.** Delimitations of a study are conditions, events, or circumstances a researcher imposes to make a study feasible to implement but which may further limit the generalizability of the results. As a result, any interpretations, explanations, or generalizations of the results of the current study should take the following delimitations into consideration:

1. **Campus location.** The current study was conducted using the Palm Bay and eLearning campuses of EFSC. Because student demographics are specific to these two campuses, it is possible the results of other studies using different locations could be different.

2. **Participating instructors.** The current study was implemented using a single instructor who also was the researcher. As a result, similar studies that employ different instructors for each instructional model, or include a single instructor with different personological and professional characteristics than mine, might not yield the same results.

3. **Semester.** The current study was conducted during the fall semester. The student population characteristics such as age and full-time status are different between the fall and spring semesters. For example, in the fall semester, the MAC 1105 students mainly consist of freshmen whereas students who take MAC 1105 in the spring semester might include sophomores, juniors, and seniors who for some reason failed to take the course during their freshman year. As a result, studies conducted during the spring or summer semesters may not yield the same findings.
4. Students’ attitudes toward mathematics. The current study measured students’ attitudes toward mathematics using Tapia and Marsh’s (1996) Attitudes toward Mathematics Inventory. Thus, similar studies that use a different attitudes scale might yield different results.

5. Students’ mathematics self-efficacy. The current study measured students’ mathematics self-efficacy using Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale-Revised which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale. Thus, similar studies that use a different efficacy scale might yield different results.

6. Students’ locus of control. This study measured students’ mathematics locus of control using Rotter’s (1966) Locus of Control Personality Test. Thus, similar studies that use a different personality test might get different results.

7. Lecture videos. The current study used textbook specific videos developed by the publisher. Thus, similar studies that use different videos might yield different results.

8. Student achievement. Student achievement was measured using Lake’s (2008) college algebra comprehensive final exam, which was prepared by a faculty committee. As a result, similar studies that use a different instrument to assess student achievement might yield different results.
Recommendations for Future Research and Practice

The purpose of this study was to determine the relationship three different instructional models had with students’ mathematics achievement. Previously in this chapter, inferences and implications about the findings were discussed, and a re-listing of the study’s limitations and delimitations from Chapter 1 were given. In this section, a numerical listing of recommendations for future research relative to the study’s limitations, delimitations, and implications are presented. For those who seek to implement the flipped classroom model in their college algebra courses, the section concludes with a set of recommendations for practice relative to the study’s implications.

Recommendations for future research relative to study limitations.

1. Essentials of College Algebra, 11th edition, by Lial, Hornsby, Schneider, and Daniels (2014) was the textbook selected by a college-wide textbook selection committee and used in this study along with the set of instructional videos that accompanied the textbook. A recommendation for future research is to see if similar results are obtained using a different textbook and/or videos.

2. Course objectives were derived from the State of Florida’s course curriculum for the course MAC 1105, College Algebra. Although this course is commonly offered throughout the state’s colleges and universities, colleges are given the flexibility to add additional objectives to the curriculum. Future research
should be conducted to determine the extent to which curricula differ from
college to college.

3. The current study was conducted over the full 16-week fall 2015 semester
using a 2-day per week schedule for the on-campus classes. A recommendation
for future research is to see if similar results are obtained using 6-, 8-, or 12-
week sessions. If using a 16-week session, another recommendation is to
incorporate a 1- and/or 3-day per week schedule.

4. Information on the current study’s sample demographics is provided in
Chapters 3 and 4 to aid the reader in making comparisons for generalizability.
One aspect that the current study did not address, however, was the number of
times students previously attempted college algebra. Being pre-exposed to the
course could have an impact on student performance. Future research should
consider incorporating the number of previous attempts as a research factor.

5. Although the current study did not have any students switch from one section
to another during the add-drop period, it is still conceivable that this could
present a problem for future research. If future research is concerned with this
limitation, it is advised to consider waiting until after the add-drop period to
announce the implementation of the study to students.

   **Recommendations for future research relative to study delimitations.**

1. The current study was conducted using the Palm Bay and eLearning campuses
of EFSC. Because student demographics vary from campus to campus and
college to college, a recommendation for future research is to conduct a similar study using one or more of the other EFSC campuses or a different state college.

2. The current study was implemented using a single instructor (the researcher) who was a White, 36-year-old male, full-time, tenured EFSC faculty member with 15 years of teaching experience (8 years at the high school level and 7 years at the college level). Future research should include instructors with different personological and professional characteristics than mine and incorporate those characteristics as research factors to determine what extent teacher attributes have on student achievement.

3. The current study was conducted over the full 16-week fall 2015 semester using a 2-day per week schedule for the on-campus classes. A recommendation for future research is to see if similar results are obtained by conducting a replication study using the spring and/or summer semesters.

4. Students’ attitudes toward mathematics were measured using Tapia and Marsh’s (2004) Attitudes toward Mathematics Inventory (ATMI). Even though students’ attitudes toward mathematics did not have a significant effect on student achievement, the ATMI was useful in showing group equivalence. Future studies might explore whether the use of a different attitudes scale will affect student achievement differently.
5. Students’ mathematics self-efficacy was measured using Pajares and Miller’s (1995) Mathematics Self-Efficacy Scale-Revised which was based on Betz and Hackett’s (1983) Mathematics Self-Efficacy Scale. The current study found that students’ mathematics self-efficacy had a significant effect on achievement. It would be interesting to see if future studies produced similar results using different efficacy instruments. Future research also might consider using a math anxiety instrument in place of or concurrent with the use of an efficacy instrument.

6. Students’ locus of control was measured using Rotter’s (1966) Locus of Control Personality Test (LCPT). During preliminary data screening, the current study found that the scores from this instrument were not correctly specified (they had no relationship to achievement). As a result, a recommendation for future research is to replicate the study using the LCPT to see if it is correctly specified. If not, then a suggestion would be to seek a different instrument for measuring students’ locus of control.

7. This study used textbook specific videos developed by the publisher that accompanied the textbook. The videos limited the amount of problems and information that could be conveyed to the students. Future research should consider using instructor developed videos that could be tailored to not only cover the content that needs to be covered but also include any additional content the instructor feels would be relevant to the course.
8. Student achievement was measured using a dichotomous, 25 question multiple-choice comprehensive final exam. Even though the reliability of the instrument was satisfactory, it is recommended that any future research use open-ended questions with partial credit awarded. This will ensure that student achievement is a function of student knowledge and not a function of random guessing.

**Recommendations for future research relative to implications.** This section contains a numbered list of recommendations for future research that corresponds to the implications of this study as reported earlier in this chapter.

1. The current study focused on the use of the flipped classroom in college algebra. Future research should investigate the effectiveness of the flipped classroom in other mathematics courses to determine if one course is better suited for the use of the flipped classroom than another.

2. The current study made use of face-to-face class time by having students work problems that were procedural in nature. Future research should be conducted using assignments that are conceptual in nature to determine if the flipped model still promotes higher student achievement.

3. Students in the current study were required to provide notes taken during the viewing of the instructional videos to confirm they actually viewed them. This was done because the videos did not have the capability to track students’ use. Future research should incorporate the use of a tracking method that informs
the instructor of when or if students have viewed the videos to ensure the integrity of the out of class assignments.

4. Mathematics self-efficacy was shown to have a significant effect on student achievement regardless of instructional model. Future research should focus on identifying what aspects of the classroom make the greatest contributions in promoting higher gains in students’ math self-efficacy.

5. Future research should attempt to incorporate a larger sample size. With a larger sample size comes the likelihood that a more diverse sample will have more variability among different race/ethnic groups. This in turn might allow the researcher to make a meaningful comparison between race/ethnicity and student achievement. A larger sample size would also increase the likelihood of finding significant attribute-treatment interactions.

6. Students’ attitudes toward mathematics did not have a significant relationship with student achievement. Future research should incorporate other student attributes such as math anxiety to determine their relationship with student achievement across the three targeted instructional models.

7. The current study used the number of hours students worked per week as a means to confirm group equivalency, but did not treat it as a research factor. Given the significant difference in hours worked per week between the group of students who dropped the course and those who completed the course, future research should incorporate number of hours worked as a research
factor to determine exactly how much of an effect it has on student achievement.

8. The findings of the current study were consistent with cognitive constructivism relative to Piaget’s (1953) theory of cognitive development, social constructivism relative to Vygotsky’s (1987) sociocultural theory, and Bandura’s (1977) self-efficacy theory. A recommendation for future research is to (a) focus subsequent studies on motivation theory and (b) examine the extent to which students’ metacognition, self-regulated learning, and study strategies differ across all three groups and how they impact achievement.

9. The current study neither systematically measured students’ perceptions of the flipped classroom nor did it systematically compare students’ instructional model preferences. A recommendation for future research is to include these perception and preference assessments.

**Recommendations for practice relative to implications.** In addition to recommendations for future research, implications of this study also warrant several recommendations for educational practice. This section contains a numbered list of recommendations for educational practice that corresponds to the implications reported earlier. The section also includes a separate set of recommendations directly for classroom teachers who are considering modifying the learning environment of their classroom by implementing the flipped
instructional model. These recommendations are listed in 7–11 and are based on my experiences in teaching two sections of college algebra as a flipped classroom.

1. Given that the flipped group had higher achievement than either the online or traditional groups underscores the importance of the instructor relative to helping students complete their homework assignments. Therefore, a recommendation for practice is that online and traditional teachers dedicate a period of time to work directly with students on their homework assignments.

2. Given that age had a significant and negative relationship with achievement, a recommendation for practice is that instructors closely monitor their older students to ensure they are committing sufficient time to view the instructional videos outside of class and attend to out-of-class assignments.

3. Given the significant and positive relationship students’ mathematics self-efficacy had with achievement, a recommendation for practice is for instructors to assess students’ mathematics self-efficacy at the beginning of a term to determine which students would need to improve their level of self-efficacy, and then incorporate various strategies to effect this increase. Examples of such strategies are presented in Ormrod (2016, pp. 120–131).

4. Given that gender was not significantly related to achievement suggests that mathematics instructors are maintaining a sense of gender equity within their classrooms. As a result, a recommendation for practice is for mathematics
instructors to continue including students of both sexes in classroom and homework assignment discussions.

5. The current study found that students’ attitudes toward mathematics were generally positive and there was no significant relationship between attitudes toward mathematics and achievement. As a result, a recommendation for practice is for mathematics instructors to continue instilling in their students a positive attitude toward mathematics.

6. Independent of group membership, the current study found that the only significant factor between students who completed the course and those who dropped the course was hours worked per week. Therefore, a recommendation for practice is for instructors to closely monitor students who work at a part- or full-time job while taking their course to ensure they are balancing their work schedule with their school schedule accordingly.

7. The use of the flipped classroom shifts the emphasis of learning from instructor-directed to student-directed giving students the opportunity to be actively engaged in the learning process. It is recommended that instructors shape the in-class-activities properly to ensure they support and enhance the learning process. Board work could be an added addition that instructors might consider incorporating into the flipped classroom.

8. The college in which the study was conducted facilitates study skills, organizational skills, and time management workshops that address a few
abilities that faculty feel students need to be successful in their courses. It is recommended that colleges offer similar workshops on skills students need to be successful in college but are not necessarily taught in most courses. In implementing the flipped classroom instructors are encouraged to find time to spend on a few of these skills at the beginning of the semester.

9. To minimize the confusion of what instructional videos to watch and what not to watch, it is recommended that instructors create their own video lectures whenever possible. Textbooks do not always align perfectly with the curriculum. If, for example, only part of a section is covered and the instructor is using the publisher’s videos based off the textbooks, this might have students searching for what they need (or do not need) to watch.

10. The current study made use of dichotomously scored multiple-choice exams for convenience and analysis purposes. It is recommended that instructors give students the opportunity to display their knowledge of the subject matter by using assessment tools that make use of open ended questions that reflect all levels of Bloom’s (1956) taxonomy.

11. It is recommended that instructors use the results of the current study (and of the previous studies reported in this dissertation) to inform students prior to registration about their intentions to use the flipped instructional model and what types of students would be best served by registering for sections that use this instructional approach.
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Appendix A

Instruments
Section 1:
Attitudes toward Mathematics Inventory

This inventory consists of statements about your attitude toward mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Please indicate the degree to which you agree or disagree with each given statement by circling SD, D, N, A or SA. The number you circle should correspond to the following scale.

<table>
<thead>
<tr>
<th>Strongly Disagree (SD)</th>
<th>Disagree (D)</th>
<th>Neutral (N)</th>
<th>Agree (A)</th>
<th>Strongly Agree (SA)</th>
</tr>
</thead>
</table>

1. Mathematics is a very worthwhile and necessary subject. SD D N A SA
2. I want to develop my mathematical skills. SD D N A SA
3. I get a great deal of satisfaction out of solving a mathematics problem. SD D N A SA
4. Mathematics helps develop the mind and teaches a person to think. SD D N A SA
5. Mathematics is important in everyday life. SD D N A SA
6. Mathematics is one of the most important subjects for people to study. SD D N A SA
7. Community College math courses are very helpful no matter what I decide to study. SD D N A SA
8. I can think of many ways that I use math outside of school. SD D N A SA
9. Mathematics is one of my most dreaded subjects. SD D N A SA
10. My mind goes blank and I am unable to think clearly when working with mathematics. SD D N A SA
11. Studying mathematics makes me feel nervous. SD D N A SA
12. Mathematics makes me feel uncomfortable. SD D N A SA
13. I am always under a terrible strain in a math class. SD D N A SA
14. When I hear the word mathematics, I have a feeling of dislike. SD D N A SA
15. It makes me nervous to even think about having to do a mathematics problem. SD D N A SA
16. Mathematics does not scare me at all. SD D N A SA
17. I have a lot of self-confidence when it comes to mathematics. SD D N A SA
18. I am able to solve mathematics problems without too much difficulty. SD D N A SA
19. I expect to do fairly well in any math class I take. SD D N A SA
20. I am always confused in my mathematics class. SD D N A SA
21. I feel a sense of insecurity when attempting mathematics. SD D N A SA
22. I learn mathematics easily. SD D N A SA
23. I am confident that I could learn advanced mathematics. SD D N A SA
24. I have usually enjoyed studying mathematics in school. SD D N A SA
25. Mathematics is dull and boring. SD D N A SA
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<tr>
<td>26.</td>
<td>I like to solve new problems in mathematics.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>27.</td>
<td>I would prefer to do an assignment in math than to write an essay.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>28.</td>
<td>I would like to avoid taking mathematics courses in college.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
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<tr>
<td>29.</td>
<td>I really like mathematics.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>30.</td>
<td>I am happier in a math class than in any other class.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>31.</td>
<td>Mathematics is a very interesting subject.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>32.</td>
<td>I am willing to take more than the required amount of mathematics.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>33.</td>
<td>I plan to take as much mathematics as I can during my education.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>34.</td>
<td>The challenge of math appeals to me.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>35.</td>
<td>I think studying advanced mathematics is useful.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>36.</td>
<td>I believe studying math helps me with problem solving in other areas.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>37.</td>
<td>I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in math.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>38.</td>
<td>I am comfortable answering questions in math class.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>39.</td>
<td>A strong math background could help me in my professional life.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>40.</td>
<td>I believe I am good at solving math problems.</td>
<td>SD</td>
<td>D</td>
<td>N</td>
<td>A</td>
</tr>
</tbody>
</table>
Section 2:  
Locus of Control Personality Test

Please read each statement carefully and select the given choice (a or b) that you agree with more and that honestly reflects how you really think, feel, and act in general.

<table>
<thead>
<tr>
<th></th>
<th>Statement</th>
<th>Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>a. Children get into trouble because their patents punish them too much.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. The trouble with most children nowadays is that their parents are too easy with them.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>a. Many of the unhappy things in people's lives are partly due to bad luck.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. People's misfortunes result from the mistakes they make.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>a. One of the major reasons why we have wars is because people don't take enough interest in politics.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. There will always be wars, no matter how hard people try to prevent them.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>a. In the long run people get the respect they deserve in this world.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. Unfortunately, an individual's worth often passes unrecognized no matter how hard he tries.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>a. The idea that teachers are unfair to students is nonsense.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. Most students don't realize the extent to which their grades are influenced by accidental happenings.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>a. Without the right breaks one cannot be an effective leader.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. Capable people who fail to become leaders have not taken advantage of their opportunities.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>a. No matter how hard you try some people just don't like you.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. People who can't get others to like them don't understand how to get along with others.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>a. Heredity plays the major role in determining one's personality.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. It is one's experiences in life which determine what they're like.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>a. I have often found that what is going to happen will happen.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. Trusting to fate has never turned out as well for me as making a decision to take a definite course of action.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>a. In the case of the well prepared student there is rarely if ever such a thing as an unfair test.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. Many times exam questions tend to be so unrelated to course work that studying is really useless.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>a. Becoming a success is a matter of hard work, luck has little or nothing to do with it.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. Getting a good job depends mainly on being in the right place at the right time.</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>a. The average citizen can have an influence in government decisions.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. This world is run by the few people in power, and there is not much the little guy can do about it.</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>a. When I make plans, I am almost certain that I can make them work.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. It is not always wise to plan too far ahead because many things turn out to be a matter of good or bad fortune anyhow.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>a. There are certain people who are just no good.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. There is some good in everybody.</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>a. In my case getting what I want has little or nothing to do with luck.</td>
<td>a b</td>
</tr>
<tr>
<td></td>
<td>b. Many times we might just as well decide what to do by flipping a coin.</td>
<td></td>
</tr>
</tbody>
</table>
16. a. Who gets to be the boss often depends on who was lucky enough to be in the right place first.
   b. Getting people to do the right thing depends upon ability. Luck has little or nothing to do with it.
17. a. As far as world affairs are concerned, most of us are the victims of forces we can neither understand, nor control.
   b. By taking an active part in political and social affairs the people can control world events.
18. a. Most people don't realize the extent to which their lives are controlled by accidental happenings.
   b. There really is no such thing as “luck.”
19. a. One should always be willing to admit mistakes.
   b. It is usually best to cover up one's mistakes.
20. a. It is hard to know whether or not a person really likes you.
   b. How many friends you have depends upon how nice a person you are.
21. a. In the long run the bad things that happen to us are balanced by the good ones.
   b. Most misfortunes are the result of lack of ability, ignorance, laziness, or all three.
22. a. With enough effort we can wipe out political corruption.
   b. It is difficult for people to have much control over the things politicians do in office.
23. a. Sometimes I can't understand how teachers arrive at the grades they give.
   b. There is a direct connection between how hard I study and the grades I get.
24. a. A good leader expects people to decide for themselves what they should do.
   b. A good leader makes it clear to everybody what their jobs are.
25. a. Many times I feel that I have little influence over the things that happen to me.
   b. It is impossible for me to believe that chance or luck plays an important role in my life.
26. a. People are lonely because they don't try to be friendly.
   b. There's not much use in trying too hard to please people, if they like you, they like you.
27. a. There is too much emphasis on athletics in high school.
   b. Team sports are an excellent way to build character.
28. a. What happens to me is my own doing.
   b. Sometimes I feel that I don't have enough control over the direction my life is taking.
29. a. Most of the time I can't understand why politicians behave the way they do.
   b. In the long run the people are responsible for bad government on a national as well as on a local level.

Score one point for each of the following:
2. a, 3.b, 4.b, 5.b, 6.a, 7.a, 9.a, 10.b, 11.b, 12.b, 13.b, 15.b, 16.a, 17.a, 18.a, 20.a,
21. a, 22.b, 23.a, 25.a, 26.b, 28.b, 29.a.
A high score = External Locus of Control
A low score = Internal Locus of Control
Section 3:
Mathematics Self-Efficacy Scale-Revised

Problems

Suppose you were asked the following math questions in a multiple choice form. Please indicate how confident you are that you would give the correct answer to each question.

NOTE: PLEASE DO NOT ATTEMPT TO SOLVE THE PROBLEMS. YOU WILL NOT BE ASKED TO SOLVE THESE PROBLEMS AFTER YOU COMPLETE THIS QUESTIONNAIRE.

In responding to these problems, please use the following scale:

<table>
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<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td>Not at all confident</td>
<td>Very little confidence</td>
<td>Some confidence</td>
<td>Much confidence</td>
<td>Completely confident</td>
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1. In a certain triangle, the shortest side is 6 inches. The longest side is twice as long as the shortest side, and the third side is 3.4 inches shorter than the longest side. What is the sum of the three sides in inches? 1 2 3 4 5

2. ABOUT how many times larger than 614,360 is 30,668,000? 1 2 3 4 5

3. There are three numbers. The second is twice the first and the first is one-third of the other number. Their sum is 48. Find the largest number. 1 2 3 4 5

4. Five points are on a line. T is next to G. K is next to H. C is next to T. H is next to G. Determine the positions of the points along the line. 1 2 3 4 5

5. If y = 9 + x/5, find x when y = 10. 1 2 3 4 5

6. A baseball player got two hits for three times at bat. This could be represented by 2/3. Which decimal would most closely represent this? 1 2 3 4 5

7. If P = M + N, then which of the following will be true?
   I. N = P - M
   II. P - N = M
   III. N + M = P 1 2 3 4 5

8. The hands of a clock form an obtuse angle at _____ o'clock. 1 2 3 4 5

9. Bridget buys a packet containing 9-cent and 13-cent stamps for $2.65. If there are 25 stamps in the packet, how many are 13-cent stamps? 1 2 3 4 5

10. On a certain map, 7/8 inch represents 200 miles. How far apart are two towns whose distance apart on the map is 3 1/2 inches? 1 2 3 4 5

11. Fred's bill for some household supplies was $13.64. If he paid for the items with a $20 bill, how much change should he receive? 1 2 3 4 5

12. Some people suggest that the following formula be used to determine the average weight for boys between the ages of 1 and 7: W = 17 + 5A where W is the weight in pounds and A is the boy's age in years. According to this formula, for each year older a boy gets, should his weight become more or less, and by how much? 1 2 3 4 5
13. Five spelling tests are to be given to Mary's class. Each test has a value of 25 points. Mary's average for the first four tests is 15. What is the highest possible average she can have on all five tests?

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14. \(3\frac{4}{5} - \frac{1}{2} = \) _____

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15. In an auditorium, the chairs are usually arranged so that there are \(x\) rows and \(y\) seats in a row. For a popular speaker, an extra row is added, and an extra seat is added to every row. Thus, there are \(x + 1\) rows and \(y + 1\) seats in each row, and there will be \((x + 1)\) and \((y + 1)\) seats in the auditorium. Multiply \((x + 1)(y + 1)\).

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16. A ferris wheel measures 80 feet in circumference. The distance on the circle between two of the seats is 10 feet. Find the measure in degrees of the central angle \(SOT\) whose rays support the two seats.

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17. Set up the problem to be done to find the number asked for in the expression "six less than twice 4 5/6"?

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<td>5</td>
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18. The two triangles shown on the right are similar. Thus, the corresponding sides are proportional, and \(AC / BD = XZ / YZ\). If \(AC = 1.7\), \(BC = 2\), and \(XZ = 5.1\), find \(YZ\).

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<td>4</td>
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**Tasks**

How much confidence do you have that you are able to successfully perform each of the following tasks? In responding to these problems, please use the following scale:

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<td>4</td>
<td>5</td>
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</table>

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<thead>
<tr>
<th>Task</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Add two large numbers (e.g., 5739 + 62543) in your head.</td>
<td></td>
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<tr>
<td>2. Determine the amount of sales tax on a clothing purchase.</td>
<td></td>
</tr>
<tr>
<td>3. Figure out how much material to buy in order to make curtains.</td>
<td></td>
</tr>
<tr>
<td>4. Determine how much interest you will end up paying on a $675 loan over 2 years at 14 3/4% interest.</td>
<td></td>
</tr>
<tr>
<td>5. Use a scientific calculator.</td>
<td></td>
</tr>
<tr>
<td>6. Compute your car's gas mileage.</td>
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<tr>
<td>7. Calculate recipe quantities for a dinner for 41 when the original recipe is for 12 people.</td>
<td></td>
</tr>
<tr>
<td>8. Balance your checkbook without a mistake.</td>
<td></td>
</tr>
<tr>
<td>9. Understand how much interest you will earn on your savings account in 6 months, and how that interest is computed.</td>
<td></td>
</tr>
<tr>
<td>10. Figure out how long it will take to travel from City A to City B driving 55 mph.</td>
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</tr>
<tr>
<td>11. Set up a monthly budget for yourself.</td>
<td></td>
</tr>
<tr>
<td>12. Compute your income taxes for the year.</td>
<td></td>
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</tbody>
</table>
13. Understand a graph accompanying an article on business profits.  
14. Figure out how much you would save if there is a 15% markdown on an item you wish to buy.  
15. Estimate your grocery bill in your head as you pick up items.  
16. Figure out which of two summer jobs is the better offer; one with a higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses.  
17. Figure out the tip on your part of a dinner bill split 8 ways.  
18. Figure out how much lumber you need to buy in order to build a set of bookshelves.

**Courses**

Please rate the following college courses according to how much confidence you have that you could complete the course with a **final grade** of “A” or “B.” In responding to these problems, please use the following scale:

<table>
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<tr>
<th>1</th>
<th>2</th>
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<td>Not at all confident</td>
<td>Very little confidence</td>
<td>Some confidence</td>
<td>Much confidence</td>
<td>Completely confident</td>
</tr>
</tbody>
</table>

| 1. Basic college math | 1 | 2 | 3 | 4 | 5 |
| 2. Economics | 1 | 2 | 3 | 4 | 5 |
| 3. Statistics | 1 | 2 | 3 | 4 | 5 |
| 4. Physiology | 1 | 2 | 3 | 4 | 5 |
| 5. Calculus | 1 | 2 | 3 | 4 | 5 |
| 6. Business administration | 1 | 2 | 3 | 4 | 5 |
| 7. Algebra II | 1 | 2 | 3 | 4 | 5 |
| 8. Philosophy | 1 | 2 | 3 | 4 | 5 |
| 9. Geometry | 1 | 2 | 3 | 4 | 5 |
| 10. Computer science | 1 | 2 | 3 | 4 | 5 |
| 11. Accounting | 1 | 2 | 3 | 4 | 5 |
| 12. Zoology | 1 | 2 | 3 | 4 | 5 |
| 13. Algebra I | 1 | 2 | 3 | 4 | 5 |
| 14. Trigonometry | 1 | 2 | 3 | 4 | 5 |
| 15. Advanced calculus | 1 | 2 | 3 | 4 | 5 |
| 16. Biochemistry | 1 | 2 | 3 | 4 | 5 |
Section 4: Demographic Information

Please respond to the following items.

1. Gender (check one): ☐ Female ☐ Male

2. Current age: ______

3. Race/Ethnicity (check one):
   ☐ White ☐ Black ☐ Hispanic ☐ Asian ☐ Other

4. Grade-level status (check one):
   ☐ Freshman ☐ Sophomore ☐ Junior ☐ Senior ☐ Dual Enrolled

5. Number of hours you currently work per week outside of college: ______

6. Number of mathematics courses you took in high school: ______

7. Number of mathematics courses you completed in college (do not include this semester): ______

8. College major or probable college major (if undecided, please state so): ______
Assessment of Prerequisite Skills for College Algebra

Directions: This assessment contains 17 multiple choice questions. Read each item carefully and select the answer from the given choices that best completes the statement or answers the question. You are not allowed to use any aids, including calculators, to help you answer these questions. Please circle your choice for each question and record your responses on the Scantron form by shading the area that corresponds to your answer. Please write your B number at the top of this page and on the Scantron form.

1. Given the following expression, perform the indicated operation and express the answer in lowest terms.

\[
\frac{z^2 + 6z + 8}{z^2 + 8z + 12} \div \frac{z^3 + 4z}{z^3 - 2z - 48}
\]

A. \(z - 8\)

B. \(\frac{z - 8}{z^2 + 6z}\)

C. \(\frac{z - 8}{z}\)

D. \(\frac{z}{z^2 + 8z + 12}\)

2. Solve the equation: \(|b - 7| + 8 = 11\)

A. \(\emptyset\)

B. \(\{10, 4\}\)

C. \(\{-10, -4\}\)

D. \(\{10\}\)
3. Factor the expression: \( x^3 - 4x^2 - 10x + 40 \)

A. \( (x + 4)(x^3 - 10) \)

B. \( (x^2 - 4)(x - 10) \)

C. \( (x - 4)(x^2 + 10) \)

D. \( (x - 4)(x^2 - 10) \)

4. Find an equation for the line containing the points \((-4, -9)\) and \((-3, -2)\).

A. \( y = 7x + 19 \)

B. \( y = \frac{11}{7}x + \frac{23}{7} \)

C. \( y = -7x + 13 \)

D. \( y = \frac{7}{3}x - \frac{61}{3} \)

5. Divide: \( \frac{4x^3 + 10x^2 + 16x + 34}{2x + 3} \)

A. \( 2x^2 + 2x - 5 \)

B. \( 2x^2 + 2x + 5 + \frac{19}{2x + 3} \)

C. \( x^2 + 5 + \frac{2}{2x + 3} \)

D. \( 2x^2 + 2x + 5 + \frac{22}{2x + 3} \)
6. Graph: \(2x + 3y = 6\)

![Graph options A, B, C, D]

7. Find the numbers that are NOT in the domain of the given function.

\[
f'(x) = \frac{x^2 - 25}{x^2 + 3x - 54}
\]

A. \(-6, 9\)

B. \(-5, 5\)

C. 0

D. \(-9, 6\)
8. Solve the given equation. \(7m^2 + 8m - 2 = 0\)

A. \(\frac{-4 \pm \sqrt{36}}{7}\)

B. \(\frac{-4 \pm \sqrt{2}}{7}\)

C. \(\frac{-8 \pm \sqrt{2}}{7}\)

D. \(\frac{-4 \pm \sqrt{2}}{14}\)

9. Solve the given absolute inequality. Write the solution set using interval notation.

\[|b + 7| - 9 > 6\]

A. \((-22,8)\)

B. \((-\infty, -22) \cup (-10, \infty)\)

C. \((-\infty, 10) \cup (22, \infty)\)

D. \((-\infty, -22) \cup (8, \infty)\)
10. Simplify the given complex fraction.

\[ \frac{4 + \frac{2}{s}}{\frac{s}{4} + \frac{1}{8}} \]

A. \( \frac{16}{s} \)
B. \( \frac{s}{16} \)
C. 16
D. 1

11. Simplify the given expression by combining like radical terms, if possible. Assume all variables and radicands represent nonnegative numbers.

\( \sqrt{2} + 5\sqrt{128} + 3\sqrt{162} \)

A. \( 8\sqrt{2} \)
B. \( 8\sqrt{292} \)
C. \( 68\sqrt{2} \)
D. \( 68\sqrt{292} \)
12. Use the laws of exponents to simplify the given expression. Do not use negative exponents in your answer.

\[
\frac{\frac{2}{z^7}}{\frac{3}{z^7}}
\]

A. \( z^5 \)

B. \( z^7 \)

C. \( z^6 \)

D. \( z^{\frac{1}{7}} \)

13. Find \( f(3) \) when \( f(x) = x^2 + 3x - 1 \).

A. \(-1\)

B. 17

C. 1

D. 19

14. Solve the given system. If the system has an infinite number of solutions, use set-builder notation to write the solution set. If the system has no solution, then state this.

\[
\begin{align*}
-7x + y &= 13 \\
4x + 8y &= -76
\end{align*}
\]

A. \( \{(x, y) \mid 4x + 8y = -76\} \)

B. No Solution

C. (3, 8)

D. (−3, −8)
15. Simplify the given expression by factoring. Assume that no radicals were formed by raising negative numbers to even powers.

\[ \sqrt[3]{216x^4y^5} \]

A. \(2xy\left(\sqrt[3]{xy^2}\right)\)
B. \(6xy\left(\sqrt[4]{xy^2}\right)\)
C. \(6xy\left(\sqrt[3]{xy}\right)\)
D. \(6xy\left(\sqrt[3]{xy^2}\right)\)

16. Add or subtract as indicated. Write the answer in lowest terms.

\[ \frac{2}{r} + \frac{3}{r-5} \]

A. \(\frac{10r - 5}{r(r-5)}\)
B. \(\frac{5r - 10}{r(5-r)}\)
C. \(\frac{5r - 10}{r(r-5)}\)
D. \(\frac{10r - 5}{r(5-r)}\)
17. Simplify the given expression. Write the answer using positive exponents only.

\[
\left( \frac{5x^2y^{-5}}{4y^{-2}} \right)^5
\]

A. \( \frac{5^5}{4^5} \frac{x^{10}}{y^{15}} \)

B. \( \frac{5^5}{4^5} \frac{x^2}{y^{15}} \)

C. \( \frac{5^5}{4^5} \frac{x^{10}y^{15}}{} \)

D. \( \frac{5^5}{4^5} \frac{x^{10}y^{15}}{} \)
College Algebra Final Exam

Directions: This assessment contains 25 multiple choice questions. Read each item carefully and select the answer from the given choices that best completes the statement or answers the question. You are only allowed to use a non-graphing scientific calculator to help you answer these questions. Please circle your choice for each question and record your responses on the Scantron form by shading the area that corresponds to your answer. Please write your B number at the top of this page and on the Scantron form.

1. Solve the quadratic equation $x^2 + 4x = -5$.
   A. \{2 ± i\}
   B. \{-2 ± i\}
   C. \{5, -1\}
   D. \{-5, 1\}

2. Perform the indicated operation. Write the result in standard form.

   $$2i(4 + 7i) - (4 - i)$$

   A. $10 + 9i$
   B. $-18 + 9i$
   C. $-18 + 7i$
   D. $7i + 14i^2 - 4$
3. Find the slope of the line that is perpendicular to the line $5x - 3y = -2$.

A. $-5$
B. $\frac{-5}{3}$
C. $\frac{-3}{5}$
D. $\frac{3}{5}$

4. Solve the inequality: $|x - 4| \geq 6$

A. $(-\infty, -2] \cup [10, \infty)$
B. $(-\infty, -10] \cup [2, \infty)$
C. $[-2, 10]$  
D. $[-10, 2]$

5. Team A and Team B played a basketball game against one another. Team A scored 3 more than twice as many points as Team B scored. Together, the teams scored a total of 90 points. How many points did Team A score?

A. 45
B. 29
C. 61
D. 60
6. If $(3, 9)$ is the endpoint of a line segment and $(7, 4)$ is its midpoint, find the other endpoint.

A. $(11, 14)$
B. $(-5, 19)$
C. $(11, -1)$
D. $(-7, 17)$

7. Find the equation of a line through the points $(1, 1)$ and $(5, -3)$. Write your answer in standard form.

A. $4x + y = -3$
B. $x + y = 2$
C. $x + y = 0$
D. $5x - 3y = 1$

8. Find the equation of the circle with center $(-3, 2)$ and radius $5$.

A. $(x + 3)^2 + (y - 2)^2 = 25$
B. $(x + 3)^2 + (y - 2)^2 = \sqrt{5}$
C. $(x - 3)^2 + (y + 2)^2 = 25$
D. $(x - 3)^2 + (y + 2)^2 = 5$
9. Solve the system: \[ \begin{align*} x^2 + 2y &= -6 \\ x - y &= 3 \end{align*} \]

A. \((-3, 0)\)

B. \((4,1)\) and \((0, -3)\)

C. \((4,1)\)

D. \((-2, -5)\) and \((0, -3)\)

10. Determine which relations are functions:

a) \(y = \sqrt{3x - 6}\)

b) \(x^2 + y^2 = 5\)

c) \(2x - y = 4\)

A. c only

B. b and c only

C. a and c only

D. all three

11. Find the domain and range for the following function \(f(x) = x^2 + 4\).

A. Domain: \((4, \infty)\), Range: \((-\infty, \infty)\)

B. Domain: \((-\infty, \infty)\), Range: \([4, \infty)\)

C. Domain: \((-\infty, \infty)\), Range: \((0, \infty)\)

D. Domain: \([0, \infty)\), Range: \((4, \infty)\)
12. If \( f(x) = 8x^2 - 9x \) and \( g(x) = x^2 - 7x - 18 \) find \( \left( \frac{f}{g} \right)(x) \).

A. \( \frac{8x^2 - 9x}{x^2 - 7x - 18} \)

B. \( \frac{8x}{x+1} \)

C. \( \frac{8 - x}{18} \)

D. \( \frac{8x - 9}{-7} \)

13. Find the distance between the points \((4, -1)\) and \((-2, 3)\).

A. \( 2\sqrt{13} \)

B. 4

C. \( 2\sqrt{2} \)

D. \( 2\sqrt{5} \)

14. Find the composite \( (g \circ f)(x) \) if \( f(x) = \frac{x - 6}{10} \) and \( g(x) = 10x + 6 \).

A. \( 10x + 54 \)

B. \( x + 12 \)

C. \( x \)

D. \( x - \frac{3}{5} \)
15. Find the value of $f(-3)$ for the piece-wise function:

$$f(x) = \begin{cases} 
2x + 1 & \text{if } x \leq 0 \\
4 - 2x & \text{if } 0 < x < 3 \\
x & \text{if } x \geq 3
\end{cases}$$

A. −3 
B. 10 
C. −5 
D. −2 

16. Compared to the graph of $y = f(x)$, the graph of $y = -f(x + 2)$ would be:

A. reflected across the y-axis; shifted 2 units up 
B. reflected across the x-axis; shifted 2 units to the right 
C. reflected across the x-axis; shifted 2 units to the left 
D. reflected across the y-axis; shifted 2 units down 

17. Find the vertex for the parabola $f(x) = 2x^2 - 8x + 1$.

A. $(2, -9)$ 
B. $(-2, 23)$ 
C. $(2, -1)$ 
D. $(8, -2)$
18. Give the equation of the vertical asymptote(s) for \( f(x) = \frac{2x^2 + 1}{x^2 - 1} \).

A. \( x = \pm 1 \)

B. \( y = 2 \)

C. \( x = -\frac{1}{2} \)

D. none

19. Find an equation for the rational function:

A. \( f(x) = \frac{x - 2}{x + 3} \)

B. \( f(x) = \frac{x + 2}{x - 3} \)

C. \( f(x) = \frac{x - 3}{x + 2} \)

D. \( f(x) = \frac{x - 1}{x - 3} \)
20. Determine the intervals over which the function graphed is decreasing.

A. \((-1, \infty)\)

B. \((-1, 0) \cup (1, \infty)\)

C. \((-\infty, -1) \cup (0, 1)\)

D. \((-\infty, -1) \cup (0, -1)\)

21. Find the equation of the inverse if possible: \(2x + 8y = 25\)

A. no inverse; not one-to-one

B. \(f^{-1}(x) = \frac{-8x + 25}{2}\)

C. \(f^{-1}(x) = \frac{-2x + 25}{2}\)

D. \(f^{-1}(x) = \frac{-2x + 8}{2}\)
22. Sketch the graph of \( f(x) = 2^x \).

A.  

![Graph A]

B.  

![Graph B]

C.  

![Graph C]

D.  

![Graph D]

23. Solve the exponential equation: \( 3^{t+2x} = 27 \).

A. \( \{3\} \)

B. \( \{1\} \)

C. \( \{9\} \)

D. \( \{-1\} \)
24. Solve the logarithmic equation: \( \log_3 (x+1) = 2 \)

A. \{1\}
B. \( \emptyset \)
C. \{5\}
D. \{8\}

25. Find the y-intercept for the exponential function \( y = \left(\frac{1}{2}\right)^x \)

A. \( \left(1, \frac{1}{2}\right) \)
B. \( (0,1) \)
C. \( (1,0) \)
D. \( \left(0, \frac{1}{2}\right) \)
Begin answering the following questionnaire using number 51 on the scantron.

Mathematics Self-Efficacy Scale-Revised

The following questions are not graded and your responses will not affect your final exam score. There are two sections of questions to complete: Section 1: Problems and Section 2: Tasks. Answer each question honestly.

Problems

Suppose you were asked the following math questions in multiple choice form. Please indicate how confident you are that you would give the correct answer to each question.

NOTE: PLEASE DO NOT ATTEMPT TO SOLVE THE PROBLEMS. YOU WILL NOT BE ASKED TO SOLVE THESE PROBLEMS AFTER YOU COMPLETE THIS QUESTIONNAIRE.

51. In a certain triangle, the shortest side is 6 inches. The longest side is twice as long as the shortest side, and the third side is 3.4 inches shorter than the longest side. What is the sum of the three sides in inches?

A) 1: Not at all confident
B) 2: Very little confidence
C) 3: Some confidence
D) 4: Much confidence
E) 5: Completely confident
52. ABOUT how many times larger than 614,360 is 30,668,000?
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

53. There are three numbers. The second is twice the first and the first is one-third of the other number. Their sum is 48. Find the largest number.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

54. Five points are on a line. T is next to G. K is next to H. C is next to T. H is next to G. Determine the positions of the points along the line.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident
55. If \( y = 9 + \frac{x}{5} \), find \( x \) when \( y = 10 \).
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

56. A baseball player got two hits for three times at bat. This could be represented by \( \frac{2}{3} \). Which decimal would most closely represent this?
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

57. If \( P = M + N \), then which of the following will be true?
   I. \( N = P - M \)
   II. \( P - N = M \)
   III. \( N + M = P \)
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident
58. The hands of a clock form an obtuse angle at ____ o'clock.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

59. Bridget buys a packet containing 9-cent and 13-cent stamps for $2.65. If there are 25 stamps in the packet, how many are 13-cent stamps?
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

60. On a certain map, 7/8 inch represents 200 miles. How far apart are two towns whose distance apart on the map is 3 1/2 inches?
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident
61. Fred's bill for some household supplies was $13.64. If he paid for the items with a $20 bill, how much change should he receive?

A) 1: Not at all confident
B) 2: Very little confidence
C) 3: Some confidence
D) 4: Much confidence
E) 5: Completely confident

62. Some people suggest that the following formula be used to determine the average weight for boys between the ages of 1 and 7: \( W = 17 + 5A \) where \( W \) is the weight in pounds and \( A \) is the boy's age in years. According to this formula, for each year older a boy gets, should his weight become more or less, and by how much?

A) 1: Not at all confident
B) 2: Very little confidence
C) 3: Some confidence
D) 4: Much confidence
E) 5: Completely confident

63. Five spelling tests are to be given to Mary's class. Each test has a value of 25 points. Mary's average for the first four tests is 15. What is the highest possible average she can have on all five tests?

A) 1: Not at all confident
B) 2: Very little confidence
C) 3: Some confidence
D) 4: Much confidence
E) 5: Completely confident
64. $\frac{4}{5} - \frac{1}{2} = _____$

A) 1: Not at all confident  
B) 2: Very little confidence  
C) 3: Some confidence  
D) 4: Much confidence  
E) 5: Completely confident

65. In an auditorium, the chairs are usually arranged so that there are $x$ rows and $y$ seats in a row. For a popular speaker, an extra row is added, and an extra seat is added to every row. Thus, there are $x + 1$ rows and $y + 1$ seats in each row, and there will be $(x + 1)$ and $(y + 1)$ seats in the auditorium. Multiply $(x + 1)(y + 1)$.

A) 1: Not at all confident  
B) 2: Very little confidence  
C) 3: Some confidence  
D) 4: Much confidence  
E) 5: Completely confident

66. A ferris wheel measures 80 feet in circumference. The distance on the circle between two of the seats is 10 feet. Find the measure in degrees of the central angle SOT whose rays support the two seats.

A) 1: Not at all confident  
B) 2: Very little confidence  
C) 3: Some confidence  
D) 4: Much confidence  
E) 5: Completely confident
67. Set up the problem to be done to find the number asked for in the expression "six less than twice 4 5/6"?

A) 1: Not at all confident
B) 2: Very little confidence
C) 3: Some confidence
D) 4: Much confidence
E) 5: Completely confident

68. The two triangles shown on the right are similar. Thus, the corresponding sides are proportional, and AC / BD = XZ / YZ. If AC = 1.7, BC = 2, and XZ = 5.1, find YZ.

A) 1: Not at all confident
B) 2: Very little confidence
C) 3: Some confidence
D) 4: Much confidence
E) 5: Completely confident

Tasks

Please indicate how much confidence you have that you are able to successfully perform each of the following tasks?

69. Add two large numbers (e.g., 5739 + 62543) in your head.

A) 1: Not at all confident
B) 2: Very little confidence
C) 3: Some confidence
D) 4: Much confidence
E) 5: Completely confident

70. Determine the amount of sales tax on a clothing purchase.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

71. Figure out how much material to buy in order to make curtains.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

72. Determine how much interest you will end up paying on a $675 loan over 2 years at 14 3/4% interest.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident
73. Use a scientific calculator.
A) 1: Not at all confident
B) 2: Very little confidence
C) 3: Some confidence
D) 4: Much confidence
E) 5: Completely confident

74. Compute your car's gas mileage.
A) 1: Not at all confident
B) 2: Very little confidence
C) 3: Some confidence
D) 4: Much confidence
E) 5: Completely confident

75. Calculate recipe quantities for a dinner for 41 when the original recipe is for 12 people.
A) 1: Not at all confident
B) 2: Very little confidence
C) 3: Some confidence
D) 4: Much confidence
E) 5: Completely confident
76. Balance your checkbook without a mistake.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

77. Understand how much interest you will earn on your savings account in 6 months, and how that interest is computed.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

78. Figure out how long it will take to travel from City A to City B driving 55 mph.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident
79. Set up a monthly budget for yourself.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

80. Compute your income taxes for the year.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

81. Understand a graph accompanying an article on business profits.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident
82. Figure out how much you would save if there is a 15% markdown on an item you wish to buy.
   
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

83. Estimate your grocery bill in your head as you pick up items.
   
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

84. Figure out which of two summer jobs is the better offer; one with a higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses.
   
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident
85. Figure out the tip on your part of a dinner bill split 8 ways.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident

86. Figure out how much lumber you need to buy in order to build a set of bookshelves.
   A) 1: Not at all confident
   B) 2: Very little confidence
   C) 3: Some confidence
   D) 4: Much confidence
   E) 5: Completely confident
Unit 1 Exam

Directions: This assessment contains 20 multiple choice questions. Read each item carefully and select the answer from the given choices that best completes the statement or answers the question. You are not allowed to use any aids to help you answer these questions except a non-graphing scientific calculator. Please write your choice for each question in the answer column and record your responses on the Scantron form by shading the area that corresponds to your answer. Please write your B number at the top of this page and on the Scantron form.

Solve the inequality. Write the solution set in interval notation.

\[ |5x - 4| - 9 < -1 \]

1) \( A) \emptyset \) \( B) \left[ -\frac{4}{5}, \frac{12}{5} \right] \)
\( C) \left[ -\frac{4}{5}, \frac{4}{5} \right] \) \( D) \left[ -\frac{4}{5}, \frac{12}{5} \right] \)

2) \( A) \left\{ \frac{1}{2}, 2 \right\} \) \( B) \emptyset \)
\( C) \left\{ \frac{2}{3}, \frac{8}{3} \right\} \) \( D) \left\{ \frac{1}{2}, 3 \right\} \)

Solve the equation.

\[ 4x + 31 - 1 = 4 \]

3) \( A) \emptyset \) \( B) \left\{ \frac{11}{8} \right\} \)
\( C) \left[ -\frac{8}{5}, \frac{11}{8} \right] \) \( D) \left[ -\frac{8}{5}, \frac{3}{8} \right] \left[ \frac{11}{8}, 8 \right] \)

For the points P and Q, find the distance \( d(P, Q) \).

4) \( P(2, 5), Q(-1, -3) \)

\( A) \sqrt{53} \) \( B) 21 \) \( C) \sqrt{3} \) \( D) -5 \)
Find the coordinates of the other endpoint of the segment, given its midpoint and one endpoint.

5) midpoint (3, 1), endpoint (10, 5)
   A) (4, 13)     B) (16, 9)    C) (2, 11)    D) (16, -3)

Use the graph to determine the equation of the circle in center-radius form.

6)

A) \((x - 3)^2 + (y - 4)^2 = 4\
B) \((x - 3)^2 + (y + 4)^2 = 16\
C) \((x - 3)^2 + (y + 4)^2 = 4\
D) \((x + 5)^2 + (y - 4)^2 = 16\

Decide whether or not the equation has a circle as its graph. If it does not, describe the graph.

7) \(x^2 + y^2 + 8x - 10y + 41 = 0\
   A) yes; center: (4, -5); radius: 32
   B) no; the graph is the point (4, -5)
   C) no; the graph is non-existent
   D) no; the graph is the point (-4, 5)

Find the center and radius of the circle.

8) \(x^2 + y^2 - 4x - 18y + 49 = 0\
   A) center: (-2, -9); radius: 36
   B) center: (-9, -2); radius: 36
   C) center: (2, 9); radius: 6
   D) center: (9, 2); radius: 6
Give the domain and range of the relation.

9) 

A) domain: \((-\infty, 0) \cup (0, \infty)\); range: \((-\infty, 0) \cup (0, \infty)\)
B) domain: \((-\infty, 0); range: \((-\infty, 0)\)
C) domain: \((-\infty, \infty); range: [0, \infty)\)
D) domain: \(0, \infty); range: [3, \infty)\)

Determine the intervals of the domain for which the function is increasing, decreasing, and constant.

10) 

A) Increasing \((3, \infty)\); Decreasing \((-\infty, 3)\); Constant \((-3, 3)\)
B) Increasing \((-\infty, 3); Decreasing (-3, \infty); Constant \((-3, 3)\)
C) Increasing \((3, \infty)\); Decreasing \((-3, \infty)\); Constant \((-3, 3)\)
D) Increasing \((-\infty, 3); Decreasing (-3, \infty); Constant \((-3, 3)\)
Graph the line described.

12) through (3, 4); \( m = -\frac{1}{3} \)

A) \[ \text{Diagram A} \]

B) \[ \text{Diagram B} \]

C) \[ \text{Diagram C} \]

D) \[ \text{Diagram D} \]
Solve the problem.

13) A school has just purchased new computer equipment for $15,000.00. The graph shows the depreciation of the equipment over 5 years. The point (0, 15,000) represents the purchase price and the point (5, 0) represents when the equipment will be replaced. Find and interpret the average rate of change in cost per year:

![Graph showing depreciation over 5 years]

A) $15,000 per year; the value of the equipment increases by $15,000 per year during these years.
B) $3000 per year; the value of the equipment decreases by $3000 per year during these years.
C) $15,000 per year; the value of the equipment decreases by $15,000 per year during these years.
D) $3000 per year; the value of the equipment increases by $3000 per year during these years.

Write an equation for the line described. Give your answer in the form specified.

14) through (2, 8) and (0, -7); slope-intercept form.

A) \( y = \frac{5}{2} x - 7 \)  
B) \( y = -\frac{15}{2} x - 7 \)  
C) \( y = -\frac{6}{5} x - 7 \)  
D) \( y = \frac{15}{2} x - 7 \)

Find the slope and the y-intercept of the line.

15) 6x - 8y = 8

A) slope: \( \frac{3}{4} \), y-intercept: 1  
B) slope: \( \frac{4}{3} \), y-intercept: -1
C) slope: \( \frac{4}{3} \), y-intercept: 1  
D) slope: \( \frac{3}{4} \), y-intercept: 1
The graph of a linear function \( f \) is shown. Write the equation that defines \( f \). Write the equation in slope-intercept form.

16) _____

A) \( x = -3 \)  
B) \( y = -3 \)  
C) \( x = 3 \)  
D) \( y = 3 \)

Write an equation for the line described. Write the equation form specified.

17) parallel to \( y + 8x = 4 \), through \((3, 4)\) slope-intercept form.

A) \( y = 8x - 28 \)  
B) \( y = -8x + 28 \)  
C) \( y = -8x - 28 \)  
D) \( y = -\frac{1}{8}x - \frac{7}{2} \)

Find the requested value.

18) \( f(6) \) for \( f(x) = \begin{cases} 2x + 1, & \text{if } x < 1 \\ 6x, & \text{if } 6 \leq x < 10 \\ 6 - 6x, & \text{if } x \geq 10 \end{cases} \)

A) -30  
B) 36  
C) 3  
D) 61

Write an equation for the line described. Write the equation form specified.

19) perpendicular to \( 7x - 8y = 71 \), through \((9, 1)\); standard form.

A) \( 8x - 7y = 79 \)  
B) \( 9x + 8y = 71 \)  
C) \( 8x + 7y = 79 \)  
D) \( 7x + 8 = 7 \)
Graph the function.

20) \( f(x) = \begin{cases} 
3, & \text{if } x \geq 1 \\
1 - x, & \text{if } x < 1 
\end{cases} \)
Evaluate.

1) Find \( f'(x) \) when \( f(x) = 2x^2 - 2 \) and \( g(x) = 2x^2 + 14x + 5 \).
   
   \[ \frac{1}{2} \quad \text{A)} \quad \frac{2}{9} \quad \text{B)} \quad \frac{8}{9} \quad \text{C)} \quad -\frac{8}{9} \quad \text{D)} \quad \frac{8}{9} \]

2) Compute and simplify the difference quotient \( \frac{f(x + h) - f(x)}{h} \), \( h \neq 0 \).
   
   \[ f(x) = 7x^2 + 9x \]
   
   \[ \text{A)} \quad 14x^2 + 7h + 9x \quad \text{B)} \quad 21x - 9h + 18 \quad \text{C)} \quad 14x + 9 \quad \text{D)} \quad 14x + 7h + 9 \]

For the given functions \( f \) and \( g \), find the indicated composition.

3) \( f(x) = \frac{4}{x + 7} \quad g(x) = \frac{1}{8x} \)
   
   \( f \circ g(x) \)
   
   \[ \text{A)} \quad \frac{32x}{x + 20x} \quad \text{B)} \quad \frac{4}{8x^2 + 50x} \quad \text{C)} \quad \frac{x + 7}{32x} \quad \text{D)} \quad \frac{4x}{1 + 20x} \]

4) For the given functions \( f \) and \( g \), find the indicated composition.
   
   \( f(x) = 4x^2 + 4x + 3 \quad g(x) = 4x - 4 \)
   
   \( (g + f)(x) \)
   
   \[ \text{A)} \quad 16x^2 - 16x^2 + 12x - 12 \quad \text{B)} \quad 4x^2 + 8x - 1 \quad \text{C)} \quad 16x^2 + 16x + 8 \quad \text{D)} \quad 16x^2 + 16x + 12 \]

Find the domain and range of the function.

5) \( f(x) = x^2 - 6x + 9 \)
   
   \[ \text{A)} \quad \text{Domain: } (-\infty, +\infty) \quad \text{Range: } [3, +\infty) \quad \text{B)} \quad \text{Domain: } (-\infty, +\infty) \quad \text{Range: } [10, +\infty) \quad \text{C)} \quad \text{Domain: } [10, +\infty) \quad \text{Range: } (-\infty, 3] \quad \text{D)} \quad \text{Domain: } (-\infty, +\infty) \quad \text{Range: } (-\infty, 3] \]

Identify the vertex of the parabola.

6) \( f(x) = -5(x + 5)^2 - 4 \)
   
   \[ \text{A)} \quad (-5, -4) \quad \text{B)} \quad (5, -4) \quad \text{C)} \quad (-25, -4) \quad \text{D)} \quad (-5, 4) \]
Given the equation or other information for a parabola, find the matching description or graph.

7) \( f(x) = ax^2 + bx + c \)
   \( a > 0, b^2 - 4ac > 0 \)
   
   A) ![Graph A]  
   B) ![Graph B]  
   C) ![Graph C]  
   D) ![Graph D]  

Provide an appropriate response.

8) For what values of \( a \) does the quadratic function \( f(x) = ax^2 + 4x + 5 \) have two \( x \)-intercepts?
   
   A) \( a < \frac{16}{5} \)  
   B) \( a > \frac{16}{5} \)  
   C) \( a > \frac{4}{5} \)  
   D) \( a < \frac{4}{5} \)  

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Match the equation to the correct graph.

9) \( y = -\frac{1}{2}(x - 4)^2 + 5 \)

9) _____
Sketch the graph of the parabola.

10) \( y = -x^2 + 2x - 6 \)  

Solvable the problem.

11) John owns a hotdog stand. His profit is represented by the equation \( P(x) = -x^2 + 12x + 43 \), with \( P \) being profits and \( x \) the number of hotdogs sold. What is the most he can earn?
   A) $43  
   B) $6  
   C) $531  
   D) $79

12) The number of mosquitoes \( M(x) \), in millions, in a certain area depends on the June rainfall \( x \), in inches, according to the equation \( M(x) = 16x - x^2 \). What rainfall produces the maximum number of mosquitoes?
   A) 16 in.  
   B) 8 in.  
   C) 64 in.  
   D) 0 in.
Graph the function.
13) \( y = \frac{1}{3}(x + 5)^3 + 4 \)

A) 

Give the equations of any vertical asymptotes.
14) \( h(x) = \frac{5x - 1}{x^2 + 3x - 18} \)

A) \( x = -3, x = 6 \)  
B) \( x = \frac{1}{5} \)  
C) \( x = 3, x = -6 \)  
D) \( y = 0 \)
Give the equation of any oblique asymptotes.

15) \( f(x) = \frac{x^2 - 7x + 3}{x + 2} \)
   A) none  
   B) \( y = x - 9 \)  
   C) \( y = x - 5 \)  
   D) \( y = x + 2 \)

Sketch the graph of the rational function.

16) \( f(x) = \frac{x^2 - 9}{x - 3} \)
Solve the problem. Round your answer to two decimal places.

17) According to Ohm’s law, the electric current, I, in amperes, in a circuit varies directly as the voltage, V. When 19 volts are applied, the current is 4 amperes. What is the current when 16 volts are applied?
   A) 76 amperes   B) 4.75 amperes   C) 1 amperes   D) 3.37 amperes

Solve the problem.

18) The time it takes to complete a certain job varies inversely to the number of people working on that job. If it takes 32 hours for 7 carpenters to frame a house, then how long will it take 56 carpenters to do the same job?
   A) 56 hr   B) 31 hr   C) 4.0 hr   D) 12.3 hr

Decide if the function is one-to-one. If the function is one-to-one, give the equation of the inverse function.

19) \( f(x) = 8x^2 - 9 \)
   A) \( f^{-1}(x) = \sqrt{\frac{x + 9}{8}} \)
   B) \( f^{-1}(x) = \sqrt{\frac{8}{x + 4}} \)
   C) \( f^{-1}(x) = \sqrt{\frac{8}{x + 4}} \)
   D) not a one-to-one

20) \( h(x) = \frac{x + 1}{x - 4} \)
   A) not one-to-one   B) \( h^{-1}(x) = \frac{x - 4}{x + 1} \)
   C) \( h^{-1}(x) = \frac{4x + 1}{x - 1} \)
   D) \( h^{-1}(x) = \frac{4x - 1}{x + 1} \)
Graph the exponential function using transformations.

1) \( f(x) = 3^{x-1} - 5 \)
Graph the logarithmic function using transformations.

2) \( f(x) = \log_2(x + 4) \)
Solve the equation.

3) \( \left( \frac{1}{3} \right)^{3x+4} = 9^{x-5} \)

A) \( \left\{ \frac{1}{4} \right\} \)  
B) \( \left\{ \frac{1}{8} \right\} \)  
C) \( \left\{ \frac{16}{3} \right\} \)  
D) \( \left\{ \frac{4}{3} \right\} \)

Solve the equation. If necessary, round to the nearest thousandth.

4) \( \sum \frac{5x}{8} = \sum 8^{x+1} \)

A) \( [14.424] \)  
B) \( [7.56] \)  
C) \( [1.292] \)  
D) \( [2.292] \)

Solve the equation. If necessary, round to the nearest thousandth.

5) \( 5^{-x} \cdot 6^{-x} = 8^{-7x} \)

A) \( [0.333] \)  
B) \( [2.063] \)  
C) \( [-1.397] \)  
D) \( [9.622] \)

Solve the equation. If necessary, round to the nearest thousandth.

6) \( 2^{x-1} = 7 \)

A) \( [3.087] \)  
B) \( [9.300] \)  
C) \( [3.140] \)  
D) \( [9.087] \)

Solve the equation and express the solution in exact form.

7) \( \log_9 (x + 4) = \log_9 (x - 4) = 1 \)

A) \( \{ -\sqrt{17}, \sqrt{17} \} \)  
B) \( \{ \sqrt{17} \} \)  
C) \( \{ -2 \} \)  
D) \( \{ -1, 7 \} \)

Solve the equation and express the solution in exact form.

8) \( \log (5 + x) - \log (x - 2) = \log 2 \)

A) \( \{ 0 \} \)  
B) \( \emptyset \)  
C) \( \left\{ \frac{1}{2} \right\} \)  
D) \( \{ -9 \} \)

Solve the equation and express the solution in exact form.

9) \( \ln(x) + \ln 4 = \ln(3x - 9) \)

A) \( \left\{ \frac{2}{3} \right\} \)  
B) \( \emptyset \)  
C) \( \left\{ \frac{2}{7} \right\} \)  
D) \( \left\{ \frac{2}{7} \right\} \)

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Solve the equation and express the solution in exact form.

10) \( \log(x + 10) = 1 + \log(4x - 3) \)

\[ A) \left\{ \frac{12}{9} \right\}, \quad B) \{1\}, \quad C) \{\frac{40}{39}\}, \quad D) \{\frac{40}{39}, 1\} \]

Solve the system by substitution.

11) \( x + 3y = 21 \)
\( 2x + 3y = 15 \)

\[ A) \{(-5, -6)\}, \quad B) \{(-6, 9)\}, \quad C) \{(-6, 8)\}, \quad D) \emptyset \]

Solve the system by elimination.

12) \(-7x + 7y = 77\)
\(-3x + 2y = 25\)

\[ A) \{(-3, 8)\}, \quad B) \{(-3, 9)\}, \quad C) \{(0, 5)\}, \quad D) \emptyset \]

Solve the system. If the system has infinitely many solutions, write the solution set with x arbitrary.

13) \( 3x + 6y = 7 \)
\( 6x + 12y = 5 \)

\[ A) \left\{ x, \frac{2}{3} - \frac{1}{2}x \right\}, \quad B) \left\{ x, \frac{7}{6} - \frac{1}{3}x \right\}, \quad C) \{(0.5)\}, \quad D) \emptyset \]

Solve the system. If the system has infinitely many solutions, write the solution set with x arbitrary.

14) \( x - 3y = 9 \)
\(-3x + 9y = -27\)

\[ A) \left\{ x, \frac{3}{2} - \frac{x}{3} \right\}, \quad B) \left\{ x, \frac{3}{2} - \frac{x}{3} \right\}, \quad C) \left\{ x, \frac{3}{2} + \frac{x}{3} \right\}, \quad D) \emptyset \]

Give all solutions of the nonlinear system of equations, including those with nonreal complex components.

15) \( y - x^2 = 12x + 36 \)
\( x + y = 8 \)

\[ A) \{(-7, 15), (4, 12)\}, \quad B) \{(6, 2)\}, \quad C) \{(7, 1), (4, 3)\}, \quad D) \{(7, 15), (4, 4)\} \]
Graph the inequality.

16) \(-2x - 3y \leq 6\)
Graph the inequality.

17) \((x + 2)^2 + (y - 4)^2 \leq 9\)
Graph the solution set of the system of inequalities.

18) $x + 2y \leq 2$

$x + y \geq 0$

\[ \text{A) } \begin{array}{c}
\end{array} \]

\[ \text{B) } \begin{array}{c}
\end{array} \]

\[ \text{C) } \begin{array}{c}
\end{array} \]

\[ \text{D) } \begin{array}{c}
\end{array} \]

18) ______
Graph the solution set of the system of inequalities.

19) \( y \geq -x^2 \)
\( y \leq x + 1 \)
\( y \geq -5 \)
\( x \geq 4 \)
Graph the solution set of the system of inequalities.

20) \( x \leq 0 \)
\[ y \leq 0 \]
\[ x + y \leq 9 \]
\[ y + x + 5 \]

A)

B)

C)

D)
Appendix B

IRB Application
Notice of Exempt Review Status

From: Florida Tech Institutional Review Board
FWA00014359, IRB00001690

To: Dustin Files

Date: July 29, 2015

IRB Number: 15-102

Study Title: Instructional approach and mathematics achievement: An investigation of traditional, online, and flipped classrooms in college algebra

Dear Researcher:

Your research protocol was reviewed and approved by the IRB Chairperson. Per federal regulations, 45 CFR 46.101, your study has been determined to be minimal risk for human subjects and exempt from 45 CFR 46 federal regulations and further IRB review or renewal unless you change the protocol or add the use of participant identifiers. This study is approved for one year from the above date. If data collection continues past this date, a Continuing Review Form must be submitted.

All data, which may include signed consent form documents, must be retained in a locked file cabinet for a minimum of three years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained on a password-protected computer if electronic information is used. Access to data is limited to authorized individuals listed as key study personnel.

The category for which exempt status has been determined for this protocol is as follows:

1. Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as:
   a. Research on regular and special education instruction strategies, or
   b. Research on the effectiveness of or the comparison among instruction techniques, curricula, or classroom management methods.
Florida Institute of Technology

RESEARCH INVOLVING HUMAN SUBJECTS
Exempt Application

This form shall be used if there is minimal risk to human subjects and one or more of the conditions below apply, if there is more than minimal risk associated with the research (none of the conditions below apply) or if the research utilizes a special population (children, prisoners, institutionalized individuals, etc.). Please use the full application form found on the IRB website.

You should consult the university’s document “Principles, Policy, and Applicability for Research Involving Human Subjects” prior to completion of this form. Copies may be obtained from the Office of Sponsored Programs and on the IRB website.

Name: Dustin Files
Date: 

Academic Unit: Department of Education and Interdisciplinary Studies
Email: dfiles@fitt.edu

Title of Project: Instructional Approach and Mathematics Achievement: An Investigation of Traditional, Online, and Flipped Classrooms in College Algebra

☐ 1) Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as:
   a. research on regular and special education instruction strategies, or
   b. research on the effectiveness of or the comparison among instruction techniques, curricula, or classroom management methods.

☐ 2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior unless:
   a. the subjects can be identified, directly or through identifiers linked to the subjects and
   b. any disclosure of subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Note: This exemption does not apply to survey procedures or interviews involving minors.

☐ 3) Research involving the use of educational tests, survey or interview procedures, or observation of public behavior if:
   a. the subjects are elected or appointed public officials or candidates for public office or
   b. the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

☐ 4) Research involving the collection or study of existing data, documents, records, or specimens if these are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

☐ 5) Research and demonstration projects that are conducted by or subject to the approval of Department or Agency heads and that are designed to study, evaluate, or otherwise examine:
   a. public benefit or service programs,
   b. procedures for obtaining benefits or services under those programs,
   c. possible changes in or alternatives to those programs or procedures, or
   d. possible changes in methods or levels of payment for benefits or services under those programs.

☐ 6) Taste and food quality evaluation and consumer acceptance studies if:
   a. wholesome foods without additives are consumed or
   b. food is consumed that contains food ingredients found to be safe by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

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1. List the objectives of the proposed project.

The purpose of this study is to determine the relationship each of three different instructional models—traditional, online, and flipped—has with students' mathematics achievement. The traditional instructional model—also referred to as the traditional classroom—is defined as one in which students meet in a face-to-face classroom setting for 2.5 hours per week and the class follows a conventional protocol of a procedural lecture with students completing homework assignments outside of and independent of the classroom. The online instructional model—also referred to as the online classroom—presents videos, which students view independently of and outside the classroom at their leisure. Students view lectures and complete their homework completely outside the classroom. The flipped instructional model, which is sometimes referred to as the "flipped classroom" or the "inside-outside classroom," is the opposite of the traditional classroom. This reversed instructional model flips the manner in which instruction and homework are presented. Students view lectures outside of the classroom via online instructional videos, but they complete their homework assignments in a face-to-face setting guided by the teacher. This reversed model enables teachers to spend more personal time with students and promotes a collaborative learning environment where students ask questions and work through homework problems under the tutelage of the instructor or peers. For the purposes of the proposed study, the online instructional videos used will be the videos provided by the textbook author and used in conjunction with prepped notes and PDF handouts. In all three models, students will complete exactly the same homework assignments. Exams for the online model will be administered (a) at one of Eastern Florida State College’s (EFSC) testing labs, (b) through ProctorU, (c) with an instructor-approved outside proctor.

In addition to the group membership variable, I also propose to examine the relationship students' affective domain has with the type of instructional model and how student achievement. The affective domain measures have targeted are students' attitudes toward mathematics, mathematics self-efficacy relative to algebra, and locus of control. Within the context of the proposed study, mathematics achievement is defined as students' end-of-semester comprehensive final examination scores in college algebra.

2. Describe the research project design/methodology. Discuss how you will conduct your study, and what measurement instruments you are using. If your project will use a questionnaire or structured interview, attach. Please describe your study in enough detail so the IRB can identify what you are doing and why.

The proposed study will employ a quasi-experimental methodology, with a modified between-groups, pretest-posttest design involving a flipped classroom. The study will involve six intact sections of MAT 1005 at EFSC during Fall 2015. The face-to-face sections will be from the Palm Bay campus of EFSC, and the online sections will be from EFSC's eLearning campus. This research methodology and design are appropriate because I will be examining the effect of a group pretreatment that is available (traditional vs. flipped vs. online instructional models) on a dependent measure (mathematics achievement). Although I will not be administering pre- and posttests in the manner specified by the eXe design, I will be applying the concept and intent of a pretest-posttest design by administering a prerequisite skills instrument as a preassessment to demonstrate group equivalence prior to the implementation of the treatment as well as to mitigate the selection threat to internal validity. It is important to note that no actual treatment will be administered in the conventional sense of an experiment. Instead, the "treatment" in the proposed study refers to group membership, which denotes the manner in which MAC 1105 will be taught: traditional, online, or flipped.

The proposed study will be implemented during the 16-week Fall 2015 semester at EFSC. The four face-to-face sections will meet for two 75-minute class sessions each week. Two sections will be taught via the traditional classroom model, two sections will be taught via the flipped classroom model, and two classes will be taught online. I will be the sole implementer for all six sections. All sections will use EFSC's Learning Management (Canvas). A brief description of each instructional strategy follows:

Traditional classroom model. The traditional classroom will consist of tables arranged in four rows with two students seated at each. The classroom has three whiteboards and an instructor workstations consisting of a computer, document camera, and a digital projector. Students will be given an electronic syllabus the first class meeting contained in Canvas outlining all policy and procedures for the course. The first day of class will consist of an overview of the course. Students can expect during the semester, an introduction to MyMathLab, and a lecture on Section 1.8 (Absolute Value). Prior to beginning the lecture portion of the first class session, I will inform students about the research study. I will include an announcement on the implementation of the prerequisite skills instrument during the next (second) class session and the multicomponent questionnaire that will be administered online via Canvas following weeks. All class sessions will follow the standard protocols of didactic instruction; students will attend face-to-face lectures and complete assigned homework at home. Homework assignments assigned each week will be due on Sunday night at 11:59 p.m. All unit exams and the cumulative comprehensive final exam will be administered in class on the days identified on the syllabus. Flipped classroom model. A computer-equipped classroom or computer lab will be used for the flipped classroom. Similar to the traditional classroom, the computer lab consists of computer tables arranged in three rows with three desktop computers per table. The tables are designed with an attached lower shelf in front of the table for the computer monitor to be positioned below eye level so that it does not
interfere with students’ line of sight to the front of the classroom. The shelf is large enough to accommodate the keyboard and mouse so that students will have the same amount of workspace as students in the traditional classroom (this is important for days when assessments are administered). The instructor station is the same as the traditional classroom. First day of class activities will mirror that of the traditional class. The remaining class sessions will follow a different protocol than the traditional classroom model. To monitor attendance, students will be required to take notes on the lecture material viewed at home. I will begin each class by checking if students have the notes from the instructional video viewed outside of class. If they do not, they will be marked absent for that lecture just as if they did not attend an in-class lecture via the traditional model. I will use approximately 5 to 10 minutes at the beginning of each class to review the material they should have covered prior to attending class. When the review period is completed, students will log onto the computer and begin working on the assigned homework for the remainder of the class. While students are working, I will circulate throughout the room to ensure all students are on task and not having any issues with the lesson. I will also identify those students who seem to be struggling with the homework and give them more one-on-one attention.

All class sessions will follow a prescribed timeline found on the last page of the syllabus. All class sessions except for the first class session will follow the standard protocols of the flipped classroom: course material viewed outside of class followed by homework completed during face-to-face class time. Homework assignments will be designed so that they can be completed in one class session, however to be consistent with the traditional model all homework assignments assigned each week will be due on Sunday night at 11:59 p.m. All unit exams and the cumulative comprehensive final exam will be administered in class on the days identified on the syllabus. Online classroom model. EFSC’s LMS will be the virtual classroom for the online classroom. First day of class activities will mirror that of the traditional classes by way of video recording found under the assignments tab in the LMS. The remaining class sessions for the online classroom model will follow a different protocol than the traditional and flipped models. Attendance will be monitored via student activity in MyMathLab. Students will be required to view the section material then work homework on at least 2 different days during the week defined as Monday through Sunday. Similar to the other two instructional models students can receive up to two absences for the week. This will be determined by the number of days they were active in MyMathLab and the number of assignments they completed. All class sessions will follow a prescribed timeline found on the last page of the syllabus. Unlike the traditional and flipped models, students will not be required to view the course material and complete homework assignments on any specific day during the week. Students will be given the flexibility to complete their assignments at any time before they scheduled. To be consistent with the traditional and flipped models, all homework assignments assigned each week will be due on Sunday night at 11:59 p.m. All unit exams and the cumulative comprehensive final exam will be administered (a) at any of Eastern Florida State College’s (EFSC) five testing labs, (b) through Proctor-U (an online test proctoring service), or (c) with an instructor-approved outside proctor. Students will be given 1 week (specified on the syllabus) model to complete all unit exams and the comprehensive final exam. Students will decide on their own the day and time to take their exams.

Following is a list of instruments to be used in this study. Copies of all instruments with the exception of unit examinations are included with this application.

a. Multicomponent student questionnaire. The student questionnaire will consist of four sections:

   • Section 1 will contain Tajfel and Ford’s (1986) Attitudes Toward Mathematics Inventory (ATMI).
   • Section 2 will contain Rutter’s (1966) Locus of Control Personality Test (LCPT).
   • Section 3 will contain Buntin and Makkink’s (1983) and Kounin’s (1995) Mathematics Self-Efficacy Scale-Revised (MSES-R).
   • Section 4 will contain a researcher-conducted student demographics questionnaire.

b. Mathematical knowledge assessments. Several researcher-constructed instruments will be used to assess students’ mathematical knowledge. These include:

   • test of pre-requisite skills
   • unit examinations
   • comprehensive final examination

3. Describe the characteristics of the subject population, including number, age, sex, and recruitment strategy (attach actual recruitment email text, recruitment flyers etc).

The target population is all college students who take MAC 1105, college algebra, at a Florida state college that confer 2-year degree. According to the Florida Department of Education (FLDOE), students attending a Florida state college AY 2013–14 had a mean age of 26 years old. 58% of the population was female, and the race/ethnicity enrollment percentages were as follows: White 44.83%, Hispanic 25.56%, Black 18%, unknown 4.82%, other 3.03%, and 1.84% as two or more races. The FLDOE defines other as American Indian, Alaskan Native, Asian, Native Hawaiian, or Pacific Islanders.

The target population will be delimited to a smaller accessible population that will consist of students who enroll in MAC 1105 at Eastern Florida State College, which is located in Brevard County. EFSC has four main campuses located in Cocoa, Melbourne, Palm Bay, and Titusville, with online classes administered through e-learning. In Fall 2014 the college had an
annual enrollment of approximately 16,013 students and employed 233 full-time faculty members of whom 38 were mathematics teachers. For Fall 2014, the overall mean age of EPSC students was 25 years old, 58.9% of the students were female, and the race/ethnicity enrollment percentages were as follows: White 68.44%, Hispanic 11.67%, Black 11.55%, unknown 1.35%, other 3.00%, and 3.62% as two or more races.

I will use a convenience sampling strategy to select the sample from the accessible population. The sample will consist of intact classes from six sections of MAC 1105 offered during the 16-week Fall 2013 semester: four face-to-face sections from the Palm Bay campus and two online sections from e-Learning. Each section will consist of students who register for MAC 1105. I will purposively assign the four face-to-face sections to either traditional (flipped) or traditional (not flipped) and the sections are on the same days and times. The group assignments will be counter-balanced so that a traditional section meets on MW mornings and TR afternoons whereas a flipped group meets on MW afternoons and TR mornings. With the exception of dual-enrolled students who are younger than 18 years old, all students registered for the targeted sections will be included in the research. There will be no student recruitment.

4. Describe any potential risks to the subjects (physical, psychological, social, legal, etc.) and assess their likelihood and seriousness. Research involving children must carefully assess risks and describe the safeguards in place to minimize these risks.

There are no known risks to the students who will be participating in this study.

5. Describe the procedures you will use to maintain the confidentiality and privacy of your research subjects and project data.

Anonymity will be maintained as follows: The unique student IDs (called B numbers) assigned to students by Eastern Florida State College will be used to identify students so that no student names are used. This information will be stored in a computer file until the research is completed. Neither the researcher nor any member of the research team will have access to students’ personal information in a way that will identify them by name.

Confidentiality will be maintained as follows: All instruments will be collected by the primary researcher (Dustin Files) and stored in a private folder accessible only by the primary researcher. Although highly unlikely, it is possible that the information could be the target of an unauthorized access. To help prevent this from happening, folders containing information will be placed in a secure location. Any computer files will be accessible only by the researchers involved in this study. Furthermore, in the unlikely event that a file is compromised, the data stored cannot be associated with students. All of the stored data will be deleted from the computer at the conclusion of the study.

6. Describe your plan for informed consent (attach proposed form).

I am requesting a waiver to informed consent because of the potential of losing participants who choose not to sign an informed consent form. From my advisor’s experience, this is a very real concern when conducting studies involving college students within intact classes. Instead, I will explain to participants the nature of the study, the data I will collect, and the reason for doing the study. I will assure them of anonymity and confidentiality, and I will respond to their questions. Above all, I will inform them that their participation is voluntary and they may request not have their data included if they wish.

7. Discuss the importance of the knowledge that will result from your study and what benefits will accrue to your subjects (if any).

First, because there is little systematic research on the effectiveness of flipped classrooms in college-level mathematics classes, the proposed study will contribute to the current body of knowledge on mathematics learning and instructional strategies. Second, students will be provided an opportunity to engage in an autonomous learning through the flipped classroom model and will learn the effectiveness of this model with respect to their learning styles and mathematics affective domain.

8. Explain how your proposed study meets criteria for exemption from Institutional Review Board review (as outlined on page 1 of this form).

The study meets the criteria for exemption based on Section 1 from Page 1 of this form (research conducted in established or commonly accepted educational settings, involving normal educational practices).
Signature Assurances

I understand Florida Institute of Technology's policy concerning research involving human subjects and I agree:

1. to accept responsibility for the scientific and ethical conduct of this research study,
2. to obtain prior approval from the Institutional Review Board before amending or altering the research protocol or implementing changes in the approved consent form,
3. to immediately report to the IRB any serious adverse reactions and/or unanticipated effects on subjects which may occur as a result of this study,
4. to complete, on request by the IRB, a Continuation Review Form if the study exceeds its estimated duration.

PI Signature ________________________________ Date 7/12/2015

Advisor Assurance: If primary investigator is a student

This is to certify that I have reviewed this research protocol and that I attest to the scientific merit of the study, the necessity for the use of human subjects in the study to the student's academic program, and the competency of the student to conduct the project.

Major Advisor: ________________________________ Date 7/12/2015

Major Advisor (print): __________________________ Date 7/12/2015

Academic Unit Head: It is the PI's responsibility to obtain this signature

This is to certify that I have reviewed this research protocol and that I attest to the scientific merit of this study and the competency of the investigator(s) to conduct the study.

Academic Unit Head: __________________________ Date 7/12/2015

FOR IRB USE ONLY

IRB Approval ________________________________ Date 7/28/2015

IRB # 15-102

Florida Tech IRB: November 2005
Notice of Expedited Review Approval

From: Eastern Florida State College Institutional Review Board
To: Investigator
Date: August 25, 2015
IRB Number: 15-002
Study Title: Instructional Approach and Mathematics Achievement: An Investigation of Traditional, Online, and Flipped Classrooms in College Algebra

Dear Dustin:

Your research proposal was reviewed and approved by the IRB Chairperson. Per federal regulations, 45 CFR 46.110(b)(1) [Expedited Review] your proposed study has been determined to involve no more than minimal risk for human subjects. You have documented an appropriate consent process and have assured the EFSC IRB that collected data will be held confidential.

As the principal investigator, it is your responsibility to ensure the study is conducted as approved by the IRB. Any procedural changes or amendments must be reported to the IRB, and no changes may be made without IRB approval except to eliminate apparent immediate hazards.

It is the condition of this approval that you report unanticipated adverse events experienced by the participants that increase subjects’ level of risk in participation. Whether or not these events are directly related to the research, please report them promptly to the IRB.

This submission is approved for one year from the above date. When the research is complete, or if data collection may continue past this date, a request for Continuing Review must be made. The termination of research and continuing review forms are located on the EFSC IRB forms webpage (http://www.easternflorida.edu/administration-departments/irb/forms.cfm).

Congratulations on your progress toward your degree and good luck in completing your research.

Sincerely,

[Signature]

Dr. Mark Gauthamer
Chair, Institutional Review Board
Eastern Florida State College

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Appendix C

Course Related Materials
Course Coverage

Course: MAC 1105 - College Algebra


Required Sections:

Chapter 1: Equations and Inequalities
   1.8: Absolute Value

Chapter 2: Graphs and Functions
   2.1: Rectangular Coordinates and Graphs
   2.2: Circles
   2.3: Functions
   2.4: Linear Functions
   2.5: Equations of Lines; Curve Fitting
   2.6: Graphs of Basic Functions
   2.7: Graphing Techniques
   2.8: Function Operations and Composition

Chapter 3: Polynomial and Rational Functions
   3.1: Quadratic Functions and Models
   3.4*: Polynomial Functions/Graphs
   3.5: Rational Functions/Graphs
   3.6 Variation

Chapter 4: Inverse, Exponential and Logarithmic Functions
   4.1: Inverse Functions
   4.2: Exponential Functions
   4.3: Logarithmic Functions
   4.4: Evaluating Logarithms and the Change: of: Base Theorem
   4.5: Exponential and Logarithmic Equations
Chapter 5: Systems of Equations and Inequalities

5.1: Systems of Linear Equations
5.5: Non-linear systems of equations
5.6**: Systems of Inequalities

Note. *Only concepts through example one are covered in this section. **Only concepts through example three are covered in this section.
COLLEGE ALGEBRA SYLLABUS (TRADITIONAL MODEL)

ASSISTANT PROFESSOR: Dustin Files
COURSE: MAC 1105-05B
MEETING TIME: Mon & Wed – 1:40 p.m. to 2:55 p.m.
CLASSROOM: Building 1, Room 97
OFFICE: Building 2, Room 156N
PHONE: (321) 433-5153
E-MAIL ADDRESS: filesd@easternflorida.edu

REQUIRED MATERIALS:
MyMathLab Access Code
You have two options to purchase MyMathLab:

1. Purchase online. The cost is $95.20
2. Purchase it at the bookstore ISBN: 978-0-321-19991-1. The cost is $123.55

HOW TO REGISTER AND ENROLL IN YOUR MY MATH LAB COURSE:
Click the My Lab and Mastering link from the left tool bar in Canvas. Click the MyMathLab All assignments link and follow the prompts.

OPTIONAL MATERIALS:
(There is an electronic version of the textbook in MyMathLab)

ADVISEMENT HOURS:
Monday and Tuesday: 12:15 p.m. to 1:30 p.m., 3:05 p.m. to 4:15 p.m.
Wednesday and Thursday: 9:25 a.m. to 10:40 a.m., 12:15 p.m. to 1:30 p.m.
Or by appointment outside the above hours.

COURSE DESCRIPTION:
Prerequisite: MAT 1033 with a "C" or appropriate placement test scores. MAC 1105 meets the Gordon Rule requirement. This course prepares the student for pre-calculus, statistics, essentials of calculus, and other related disciplines. Includes functions and function notation; domain, range, and graphs of functions and relations; operations on functions; inverse functions; linear, quadratic, rational, radical, exponential and logarithmic equations and functions; piecewise and higher degree monomial functions; systems of equations and inequalities; applications.
CORE ABILITIES:
Think Critically and Solve Problems

LEARNING OUTCOMES:
Follow this link http://web12.easternflorida.edu/ecpr/displayPDF.cfm?id=2492 to view the competencies that are to be mastered during this course.

COURSE COVERAGE:
- Equations and Inequalities: Chapter 1 (1.8)
- Graphs and Functions: Chapter 2 (entire)
- Polynomial and Rational Functions: Chapter 3 (3.1 all, 3.4 to Ex. 2, 3.5 and 3.6 all)
- Systems of Equations and Inequalities: Chapter 5 (5.1, 5.5, and 5.6 through Ex. 2)
- Inverse, Exponential and Logarithmic Functions: Chapter 4 (4.1-4.5)

ATTENDANCE:
Attendance will be taken every class meeting. The maximum allowable number of absences for the course is 3. A student missing more than 3 classes could receive an F for the term. Students are expected to be on time for all classes and to remain for the entire period of instruction. Attendance is taken at the beginning of each class. If a student comes in late or leaves early, without prior permission, he/she will be charged with ½ of an absence. It is the student’s responsibility to notify me of any attendance conflicts prior to missing class.

PRE-ASSESSMENT:
The pre-assessment given the first week of class will measure your retention of select topics from intermediate algebra. This assessment will be an out of class assignment due August 23rd.

MULTICOMPONENT QUESTIONNAIRE:
The multicomponent questionnaire given the first week of class will measure your attitude toward mathematics, locus of control, mathematics self-efficacy, and ask for your demographic information. This questionnaire will be an out of class assignment due August 23rd.

HOMEWORK:
Homework is a vital part of the math learning process and students cannot expect to learn the material without having completed all assigned homework. Homework will be assigned from each section covered during the course. All homework will be completed using MyMathLab. Homework due dates can be found in MyMathLab.
PRACTICE EXAMS:
There are practice exams in *MyMathLab* for each unit exam and for the final exam. You may take each practice exam up to three times. The best of the three scores will count towards your overall grade.

GRADING:
Final course grades will be calculated using the following weighting:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weightage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Assessment &amp; Multicomponent Questionnaire</td>
<td>2% (1% each)</td>
</tr>
<tr>
<td>Homework</td>
<td>20%</td>
</tr>
<tr>
<td>4 Practice Exams</td>
<td>3% (0.75% each)</td>
</tr>
<tr>
<td>3 Unit Exams &amp; Final Exam</td>
<td>80% (20% each)</td>
</tr>
</tbody>
</table>

Final course letter grades will be assigned based on the following scores:

- 90% to 105% A
- 80% to < 90% B
- 70% to < 80% C
- 60% to < 70% D
- < 60% F

ADDITIONAL INFORMATION:
Any policies not covered in this syllabus will default to the policies of the college found in the student handbook.

**General:** No food or drinks are allowed in the classroom. Read and be aware of the student code of conduct found in the student handbook. Read especially the sections regarding academic honesty, disruption, breach of peace, and student parking.

**Cell Phones and Pagers:** No cell phones or pagers are to be turned on while in class, unless you have received permission from me. There is a clock on the wall if you need to know the time.

**Make-up Testing:** There will be no make-up testing. Any missed test will be replaced with your final exam score.

**Calculators:** You may use any non-graphing calculator you’d own. If you plan to purchase a calculator to use during this courses I suggest a TI-34X IIS.
Incomplete (I): An incomplete is an emergency grade assigned under special circumstances for a student who is passing (with a C or above) and has completed at least 75% of the course.

Recording Class Sessions: Students may request permission to record any class session delivered as part of their program of study. All such requests will be made in writing to the faculty member prior to the recording; the decision on whether to grant permission is at the sole discretion of the faculty member. Students may only record teaching sessions where the faculty member responsible for that session has given their consent. Covert recording of lectures is not permitted and will be treated as a disciplinary offense.

You can SUCCEED in this class if you attend each class, complete each assignment, take thorough notes (plenty will be provided), STUDY outside of class (6-8 hours per week), and ask for help when you need it. Practice exams are given in My Math Lab prior to each test detailing major topics you will be tested on. Extra help is available Monday through Saturday (see advisement hours and college math lab hours). Tutorial software is available for student use in our computer labs.

SOME IMPORTANT DATES:

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Day of Classes</td>
<td>August 17, 2015</td>
</tr>
<tr>
<td>Add/Drop Dates</td>
<td>August 17 - 20, 2015</td>
</tr>
<tr>
<td>Last day to Drop with Refund</td>
<td>August 20, 2015</td>
</tr>
<tr>
<td>Last day to Request Audit Status</td>
<td>August 20, 2015</td>
</tr>
<tr>
<td>Labor Day COLLEGE CLOSED</td>
<td>September 7, 2015</td>
</tr>
<tr>
<td>Last day to Withdraw with Grade of &quot;W&quot;</td>
<td>October 22, 2015</td>
</tr>
<tr>
<td>Last day to apply for December graduation</td>
<td>October 22, 2015</td>
</tr>
<tr>
<td>Web registration Spring Term 2016 begins</td>
<td>October 26, 2015</td>
</tr>
<tr>
<td>Walk-in registration Spring Term 2016 begins</td>
<td>November 9, 2015</td>
</tr>
<tr>
<td>Veterans Day COLLEGE CLOSED</td>
<td>November 11, 2015</td>
</tr>
<tr>
<td>Thanksgiving Holidays COLLEGE CLOSED</td>
<td>November 25 - 29, 2015</td>
</tr>
<tr>
<td>Final Exam Week</td>
<td>December 5 – 11, 2015</td>
</tr>
<tr>
<td>Final Day of Term</td>
<td>December 11, 2015</td>
</tr>
<tr>
<td>Commencement Ceremonies</td>
<td>December 17, 2015</td>
</tr>
<tr>
<td>Winter Break COLLEGE CLOSED</td>
<td>December 18, 2015 thru</td>
</tr>
<tr>
<td></td>
<td>January 3, 2016</td>
</tr>
</tbody>
</table>
## COURSE SCHEDULE (Tentative):

<table>
<thead>
<tr>
<th>Class Meeting Date</th>
<th>Section Covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-Aug</td>
<td>1.8-Absolute Value</td>
</tr>
<tr>
<td>19-Aug</td>
<td>2.1-Rectangular Coordinates and Graphs</td>
</tr>
<tr>
<td>24-Aug</td>
<td>2.2-Circles</td>
</tr>
<tr>
<td>26-Aug</td>
<td>2.3-Functions</td>
</tr>
<tr>
<td>31-Aug</td>
<td>2.4-Linear Functions</td>
</tr>
<tr>
<td>2-Sep</td>
<td>2.5-Equations of Lines; Curve Fitting</td>
</tr>
<tr>
<td>7-Sep</td>
<td><strong>Labor Day (No Class)</strong></td>
</tr>
<tr>
<td>9-Sep</td>
<td>2.6-Graphs of Basic Functions</td>
</tr>
<tr>
<td>14-Sep</td>
<td>Catch-up Review Day</td>
</tr>
<tr>
<td>16-Sep</td>
<td><strong>Test 1</strong></td>
</tr>
<tr>
<td>21-Sep</td>
<td>2.7-Graphing Techniques</td>
</tr>
<tr>
<td>23-Sep</td>
<td>2.8-Function Operations and Composition</td>
</tr>
<tr>
<td>28-Sep</td>
<td>3.1-Quadratic Functions and Models</td>
</tr>
<tr>
<td>30-Sep</td>
<td>3.4-Polynomial Functions/Graphs</td>
</tr>
<tr>
<td>5-Oct</td>
<td>3.5-Rational Functions/Graphs</td>
</tr>
<tr>
<td>7-Oct</td>
<td>3.6 Variation</td>
</tr>
<tr>
<td>12-Oct</td>
<td>4.1-Inverse Functions</td>
</tr>
<tr>
<td>14-Oct</td>
<td>Catch-up Review Day</td>
</tr>
<tr>
<td>19-Oct</td>
<td><strong>Test 2</strong></td>
</tr>
<tr>
<td>21-Oct</td>
<td>4.2-Exponential Functions</td>
</tr>
<tr>
<td>26-Oct</td>
<td>4.3-Logarithmic Functions</td>
</tr>
<tr>
<td>28-Oct</td>
<td>4.4-Evaluating Logarithms and the Change-of-Base Theorem</td>
</tr>
<tr>
<td>2-Nov</td>
<td>4.5- Exponential and Logarithmic Equations</td>
</tr>
<tr>
<td>4-Nov</td>
<td>5.1-Systems of Linear Equations</td>
</tr>
<tr>
<td>9-Nov</td>
<td>5.5-Non-Linear Systems of Equations</td>
</tr>
<tr>
<td>11-Nov</td>
<td><strong>Veterans Day (No Class)</strong></td>
</tr>
<tr>
<td>16-Nov</td>
<td>5.6-Systems of Inequalities</td>
</tr>
<tr>
<td>18-Nov</td>
<td>Catch-up Review Day</td>
</tr>
<tr>
<td>23-Nov</td>
<td><strong>Test 3</strong></td>
</tr>
<tr>
<td>25-Nov</td>
<td><strong>Thanksgiving Holiday (No Class)</strong></td>
</tr>
<tr>
<td>30-Nov</td>
<td>Catch-up Review Day</td>
</tr>
<tr>
<td>2-Dec</td>
<td>Catch-up Review Day</td>
</tr>
<tr>
<td>7-Dec</td>
<td><strong>FINAL EXAM IN CLASS at 1:00 p.m.</strong></td>
</tr>
</tbody>
</table>
COLLEGE ALGEBRA SYLLABUS (FLIPPED MODEL)

The flipped model syllabus is the same as the traditional model syllabus with the exception of the following sections:

ATTENDANCE:
Attendance will be taken every class meeting. The maximum allowable number of absences for the course is 3. A student missing more than 3 classes could receive an F for the term. Students are expected to be on time for all classes and to remain for the entire period of instruction. Attendance is taken at the beginning of each class. If a student comes in late or leaves early, without prior permission, he/she will be charged with ½ of an absence. It is the student’s responsibility to notify me of any attendance conflicts prior to missing class. This course will make use of the flipped classroom approach to teaching. This approach has students watch lecture videos outside of class and complete homework assignments in class. Because you are completing your assignments in class it is important that you attend every class meeting.

COURSE VIDEOS:
Prior to attending class you will be required to view the course videos for the section covered during class time listed on the course schedule at the end of this syllabus. You will be given preprinted notes to help you follow along with the videos. You will need to bring those notes to class with you as proof that you have watch the videos.

HOMEWORK:
Since we are making use of the flipped classroom, homework can also be thought of as classwork, henceforth I will refer to homework as classwork. Classwork is a vital part of the math learning process and students cannot expect to learn the material without having completed all assigned classwork. Classwork will be assigned from each section covered during the course. All classwork will be completed using MyMathLab. Classwork due dates can be found in MyMathLab.
COLLEGE ALGEBRA SYLLABUS (ONLINE MODEL)

The online model syllabus is the same as the traditional model syllabus with the exception of the following sections:

ATTENDANCE:
The maximum allowable number of absences for the course is 3. A student missing more than 3 classes could receive an F for the term. Attendance will be monitored via student activity in MyMathLab. Students will be required to view the section material then work homework on at least 2 different days during the week, defined as Monday through Sunday. Students can receive up to two absences each week determined by the number of number of days active in MyMathLab:

- 2 absences for no activity
- 1 absence for only one day of activity
- 0 absences for two or more days of activity

COURSE VIDEOS AND NOTES:
You will need to view the course videos prior to working the homework problems for each section covered. You can download the notes from canvas under the modules tab where you will also find the powerpoint lecture slides that correspond to each section that we cover. The videos and notes are an important part of the learning process. Skipping them and going directly to the homework is a receipt of disaster.

PROCTORED EXAMS:
Unit Exams and the Final Exam will be administered by an official proctor. Proctors are available in all EFSC Labs by appointment. If you reside outside of Brevard County, or cannot use EFSC’s Learning Labs to take your tests, it is your responsibility to find a suitable proctor. You are responsible for all fees incurred for testing services. Suitable proctors include college testing labs, public libraries, Proctor-U, or government agencies. Other individuals may qualify on a per-case basis. The instructor’s decision about the suitability of proctors is final. If you are NOT using an EFSC testing lab or Proctor-U, you will need to submit a proctor request form. Instructions for doing this are found under the modules tab. Once you have decided who your proctor will be you will need to schedule an appointment to take your test. First identify when the tests will be; see the course schedule at the end of this syllabus. Second if you are using an EFSC testing lab go to the modules tab for instructions on how to schedule a proctored test. If you are using anything besides an EFSC testing lab you will need to contact your proctor once they are approved and schedule an appointment with them.
<table>
<thead>
<tr>
<th>Class Meeting Date</th>
<th>Section Covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-Aug</td>
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<td>19-Aug</td>
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<tr>
<td>24-Aug</td>
<td>2.2-Circles</td>
</tr>
<tr>
<td>26-Aug</td>
<td>2.3-Functions</td>
</tr>
<tr>
<td>31-Aug</td>
<td>2.4-Linear Functions</td>
</tr>
<tr>
<td>2-Sep</td>
<td>2.5-Equations of Lines; Curve Fitting</td>
</tr>
<tr>
<td>7-Sep <strong>Labor Day (No Class)</strong></td>
<td></td>
</tr>
<tr>
<td>9-Sep</td>
<td>2.6-Graphs of Basic Functions</td>
</tr>
<tr>
<td>14-Sep</td>
<td>Catch-up Review Day</td>
</tr>
<tr>
<td>16-Sep <strong>Test 1</strong></td>
<td></td>
</tr>
<tr>
<td>21-Sep</td>
<td>2.7-Graphing Techniques</td>
</tr>
<tr>
<td>23-Sep</td>
<td>2.8-Function Operations and Composition</td>
</tr>
<tr>
<td>28-Sep</td>
<td>3.1-Quadratic Functions and Models</td>
</tr>
<tr>
<td>30-Sep</td>
<td>3.4-Polynomial Functions/Graphs</td>
</tr>
<tr>
<td>5-Oct</td>
<td>3.5-Rational Functions/Graphs</td>
</tr>
<tr>
<td>7-Oct</td>
<td>3.6 Variation</td>
</tr>
<tr>
<td>12-Oct</td>
<td>4.1-Inverse Functions</td>
</tr>
<tr>
<td>14-Oct</td>
<td>Catch-up Review Day</td>
</tr>
<tr>
<td>19-Oct <strong>Test 2</strong></td>
<td></td>
</tr>
<tr>
<td>21-Oct</td>
<td>4.2-Exponential Functions</td>
</tr>
<tr>
<td>26-Oct</td>
<td>4.3-Logarithmic Functions</td>
</tr>
<tr>
<td>28-Oct</td>
<td>4.4-Evaluating Logarithms and the Change-of-Base Theorem</td>
</tr>
<tr>
<td>2-Nov</td>
<td>4.5- Exponential and Logarithmic Equations</td>
</tr>
<tr>
<td>4-Nov</td>
<td>5.1-Systems of Linear Equations</td>
</tr>
<tr>
<td>9-Nov</td>
<td>5.5-Non-Linear Systems of Equations</td>
</tr>
<tr>
<td>11-Nov <strong>Veterans Day (No Class)</strong></td>
<td></td>
</tr>
<tr>
<td>16-Nov</td>
<td>5.6-Systems of Inequalities</td>
</tr>
<tr>
<td>18-Nov</td>
<td>Catch-up Review Day</td>
</tr>
<tr>
<td>23-Nov <strong>Test 3</strong></td>
<td></td>
</tr>
<tr>
<td>25-Nov <strong>Thanksgiving Holiday (No Class)</strong></td>
<td></td>
</tr>
<tr>
<td>30-Nov</td>
<td>Catch-up Review Day</td>
</tr>
<tr>
<td>2-Dec</td>
<td>Catch-up Review Day</td>
</tr>
<tr>
<td>7-Dec <strong>(10:50 am class) FINAL EXAM IN CLASS at 10:10 a.m.</strong></td>
<td></td>
</tr>
<tr>
<td>7-Dec</td>
<td><strong>(1:40 am class) FINAL EXAM IN CLASS at 1:00 p.m.</strong></td>
</tr>
</tbody>
</table>
### Table C.2

**Tuesday/Thursday Course Schedule**

<table>
<thead>
<tr>
<th>Class Meeting Date</th>
<th>Section Covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-Aug</td>
<td>1.8-Absolute Value</td>
</tr>
<tr>
<td>20-Aug</td>
<td>2.1-Rectangular Coordinates and Graphs</td>
</tr>
<tr>
<td>25-Aug</td>
<td>2.2-Circles</td>
</tr>
<tr>
<td>27-Aug</td>
<td>2.3-Functions</td>
</tr>
<tr>
<td>1-Sep</td>
<td>2.4-Linear Functions</td>
</tr>
<tr>
<td>3-Sep</td>
<td>2.5-Equations of Lines; Curve Fitting</td>
</tr>
<tr>
<td><strong>8-Sep</strong></td>
<td><strong>(No Class)</strong></td>
</tr>
<tr>
<td>10-Sep</td>
<td>2.6-Graphs of Basic Functions</td>
</tr>
<tr>
<td>15-Sep</td>
<td>Catch-up Review Day</td>
</tr>
<tr>
<td><strong>17-Sep</strong></td>
<td><strong>Test 1</strong></td>
</tr>
<tr>
<td>22-Sep</td>
<td>2.7-Graphing Techniques</td>
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Appendix D

Anecdotal Data
Two additional follow-up questions were asked of the students in the flipped model after the final exam was administered:

Question 1: Using the scale below, rate your preference for the model in which you would have preferred to have taken this course if you had the choice.

1–Strong preference for traditional classroom

2–Preference for traditional classroom

3–Neutral preference

4–Preference for flipped classroom

5–Strong preference for flipped classroom

Question 2: Please provide any likes or dislikes that you had with regards to the use of the flipped classroom during the semester.

Listed below (relative to their row number in the raw data provided in Appendix E) are student responses to question two. The reader will note that these statements are expressed in the students’ own words and have not been edited for grammatical errors.

2 I found that the flipped classroom was ok at first. I prefer a traditional classroom only because I find it is easier to understand the materials.

4 I liked the one in which we did it last time, I think it is traditional, I really don't know much about it. I liked that one at the building 1, 3rd floor.
Very well structured class; loved the flipped classroom. I have never felt so comfortable in a math class before. I hope to take another course with you.

The flipped classroom worked well for me because I was able to take the notes at my own pace and replay the parts that I didn’t quite get until I fully understood them. It was also effective because whatever the videos couldn’t explain well enough to me, in the next class, my professor was able to expand on the problems or show me a different way of doing them.

I liked the flip classroom. I think it worked well for that topic.

Also for dislike I extremely dislike the flipped classroom. There is no point to a flipped classroom, you are not being taught anything. So unless you want to teach yourself, I would not recommend one to anyone.

I really hope that I can take my next math class in this manner. This was way more fun than sitting in class and listening to the professor lecture every class. The brief reviews at the beginning of class were very helpful.

I disliked that the time spent in the classroom didn’t feel very useful, it felt like an online class that I still had to show up for. I liked the notes
we were given to fill out, they were really organized and easy to study from.

19 The one on one help during class really helped me understand the material.

22 This was a flipped classroom that I didn't know about until I was in the class. I'm already not good at math and didn't want to be in a flipped classroom.

24 I would have liked to have done group assignments rather than just work on homework while in class.

25 Didn't really like the flipped classroom.

26 The idea of a flipped classroom was great, however it didn't cover the different ways people learn. This doesn't mean I didn't learn anything, I just prefer a more traditional classroom way of teaching.

31 It was cool.

32 I enjoyed the way the flipped classroom worked and I found somethings were a lot easier. Overall I did enjoy the way the class was set up and would take a class like that again.

35 I liked that I could ask questions if I had trouble with the homework and the notes for home were straight-forward and informative. Overall, it felt better than the traditional style.

38 I liked the way that you taught intermediate algebra.
I personally would have had more of an issue with the class if I hadn't already learned the material. Flipped classroom means doing quite a bit at home, having to teach yourself. Seems redundant to do the work in class that can easily be done at home. It was nice however, to have you available to answer any issues that may have arisen with the material.

I really enjoyed the flipped classroom and I believe you provided amazing help if we didn't understand the lesson. In other classes I mostly have questions when it comes to the homework. so it worked for me to do that in class while I used you as a resource if I did not understand the material.
Appendix E

Raw Data
Table E.1
Raw Data: Participants 1-49

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Note. Y = College algebra final exam scores, X1 = Flipped, X2 = Online, X3 = Female, X4 = Age, X5 = Black, X6 = Hispanic, X7 = Asian, X8 = Other, X9 = ATMI scores, X10 = MSES-R scores, X11 = LCPT scores.

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*Note. Y = College algebra final exam scores, X₁ = Flipped, X₂ = Online, X₃ = Female, X₄ = Age, X₅ = Black, X₆ = Hispanic, X₇ = Asian, X₈ = Other, X₉ = ATMI scores, X₁₀ = MSES-R scores, X₁₁ = LCPT scores.*
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Note. Y = College algebra final exam scores, X₁ = Flipped, X₂ = Online, X₃ = Female, X₄ = Age, X₅ = Black, X₆ = Hispanic, X₇ = Asian, X₈ = Other, X₉ = ATMI scores, X₁₀ = MSES-R scores, X₁₁ = LCPT scores.
Table E.4

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*Note. Y = College algebra final exam scores, X_1 = Flipped, X_2 = Online, X_3 = Female, X_4 = Age, X_5 = Black, X_6 = Hispanic, X_7 = Asian, X_8 = Other, X_9 = ATMI scores, X_10 = MSES-R scores, X_11 = LCPT scores.*